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: ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY (PCS) (ISSUES HARRELS)

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: $114.52
Standardized Feeder-to-Finish Farm with 4,320 head (Tables PCS.24- PCS.29)
10-Year Amortization, Pit-Recharge, N limited Irrigation onto Forage

Includes:	Permeable Cover/Lagoon Modification:	$ 37.71 / 1,000 lbs. SSLW / Yr.
	Aeration Cell:	$ 53.31 / 1,000 lbs. SSLW / Yr.
	Polishing/Storage Basin:	$ 26.01 / 1,000 lbs. SSLW / Yr.
	Decreased Land Application Cost:	$ -2.51 / 1,000 lbs. SSLW / Yr.

Range:	Across Farm Sizes and Types (Pit-Recharge):	$77.03 To 320.17 / 1,000 lbs. SSLW / Yr.
	Across Farm Sizes and Types (Flush):	$82.06 To 434.64 / 1,000 lbs. SSLW / Yr.

Confidence in Estimates:

Medium

Based on 11 months evaluation, real commercial setting data for treatment effects, electricity use, electricity prices, construction and operating expense. No flow data were received by the cost and returns team.

Costs by Category:

Direct Construction:	$ 62.62 / 1,000 lbs. SSLW / Yr.
Contractor Overhead	$ 25.24 / 1,000 lbs. SSLW / Yr.
Total Operating:	$ 29.17 / 1,000 lbs. SSLW / Yr.
Increased Land Application Cost:	$ -2.51 / 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	$53.16	$62.50
Baseline Cost Projection (10-year economic life, 8 % interest rate)	0.1490	$74.33	**$87.86***
High-Cost Projection (7-year economic life, 10 % interest rate)	0.2054	$100.19	$118.83

* 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)	$23.99
Baseline Cost of Electricity ($0.08 / kWh)	**$29.17***
High-Cost Electricity ($0.10 / kWh)	$34.35

* 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, $74.54, is the predicted 2004 annual construction and overhead cost for the ISSUES permeable cover system 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 permeable cover system 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 $5.18 per 1,000 pounds SSLW per year or about 18%) on the predicted annual cost reflecting significant electricity use by the blower in the aerobic cell.

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. As constructed and demonstrated at Harrells Farm, the ISSUES permeable cover system technology has no marketable by-products.

1. Introduction and Farm Description

The Innovative Sustainable Systems Utilizing Economical Solutions (ISSUES) technology was a three-component program in which three distinct systems were each constructed and tested at separate farm sites. The economic analyses for the ISSUES systems are reported in three separate documents. The following economic analysis is for the permeable cover system (PCS) component of the ISSUES technology.

The permeable cover system technology was constructed on Harrells Farm in Sampson County, North Carolina. Harrells Farm is owned and operated by Murphy Farms, LLC. Harrells Farm had 5 naturally-ventilated finishing houses with the flush system of manure removal. Each of the five houses had a capacity of 1,224 head, for a total of 6,120 finishing head. The permeable cover system treated the flushed manure from two of the five houses at Harrells Farm (2,448 head, or 330, 480 pounds SSLW) (Bull, et. al).

2. Technology Description (Proposed Design)

Flushed manure from two finishing houses (18,850 gallons per day) was sent to an existing primary lagoon at Harrells Farm. This lagoon received a total of 33,700 gallons per day, but only 18,850 of the gallons were treated using the permeable cover system technology. The lagoon was equipped with a floating polypropylene permeable cover (the BioCap ML developed and supplied by Baumgartner Environics, Inc.). The purpose of the cover was to act as a biofilter and a physical barrier to lagoon emissions to the air. A 10-inch pipe was also installed in the primary lagoon to gravity feed lagoon effluent into a wet well (with a diameter of 6 feet). The wet well was equipped with two 1.5-HP submersible pumps: one to pump effluent from the wet well to the aeration cell and one to pump effluent from the wet well to the polishing/storage basin. Effluent from the covered lagoon was pumped to the aeration cell at a rate of 31,700 gallons per day. The aeration cell was equipped with a 10-HP blower to provide dissolved oxygen. A fine bubble diffusion system was installed in the aeration cell by lining the bottom of the cell with perforated LDPE tubing. Of the 18,850 gallons per day entering the aeration cell at Harrells Farm, 13,219 gallons were intended to be returned to the houses for flushing. The remaining 5,630 gallons were intended to be pumped to the polishing/storage basin for denitrification and eventual land application. As operated, 28,000 gallons per day from the aeration cell were returned to the barns for flushing with the remaining 3,700 gallons per day entering the polishing/storage basin (Bull, et. al). The aeration cell was equipped with 2 submersible pumps: a 1.5-HP pump to return effluent to the flush tanks and a 0.5-HP pump to send effluent to the polishing/storage basin. The aeration cell was designed to contain 30 days of flushed manure from the houses (18,850 gpd * 30 days = 565,500 gallons of liquid storage volume). The polishing/storage basin was intended to contain 180 days of excess manure volume (5,630 gpd * 180 days = 1,013,400 gallons of liquid storage volume) (Dugba(a)).

The unit processes associated with the ISSUES permeable cover system can be summarized as follows:

1.) permeable cover
2.) wet well and pumps
3.) aeration cell
4.) return to barns (return pump located in the aeration cell)
5.) polishing/storage basin
6.) land application of liquid effluent

3. Mass Balances and Performance Data (Tables PCS.1-PCS.2)

Evaluation and performance verification of the ISSUES permeable cover system technology began in July, 2003 and concluded in May, 2004. A total of 15 sampling events occurred during this time period. Evaluation of the technology was extended to September, 2004 to include sampling of an evaporative system that was added over the permeable covered lagoon. The evaporative system was not considered part of the technology and was not included in the costs and returns reporting. Table PCS.1 reports the nutrient and dry matter content of the wastewater stream at different stages of the ISSUES permeable cover system technology. Total TKN concentration (ppm) in the wastewater stream was reduced by 79.8% from house effluent samples to storage basin samples. Phosphorus concentrations were reduced by 87.1% and potassium concentrations were reduced by 51.6% by the ISSUES permeable cover system technology. Table PCS.2 reports the mass balance of nutrients for the ISSUES permeable cover system technology. TKN was reduced by 54% and P was reduced by 82% by the permeable cover system at Harrells 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 (Bull, Worley-Davis).

4. Invoiced Electricity Costs of the ISSUES Permeable Cover System Technology as Constructed and Operated at Harrells Farm (Table PCS.3)

Table PCS.3 reports the actual electricity costs of the ISSUES permeable cover system technology. This data was provided by Cavanaugh and Associates and was based on actual Harrells Farm electricity invoices. Electricity data was available from July, 2003 through October, 2004. Usage and cost data for this 16-month period is summarized in Table PCS.3. The average electricity usage per month at Harrells Farm was 3,653 kilowatt-hours. Average electrical bills associated with the ISSUES permeable cover system technology as operated at Harrells Farm were $327.38. During September and October 2003, the technology was not operating as intended. Power bills for these two months were low, and not representative of steady-state operation. After removing these two months from Table PCS.3, the average electricity consumption per month becomes 4,128 kWh and the average monthly electricity cost is $366.86 for the ISSUES permeable cover system technology as operated at Harrells Farm.

5. Costs of the ISSUES Permeable Cover System Technology as Constructed at Harrells Farm

5.1. Invoiced Construction Costs at Harrells Farm (Tables PCS.4-PCS.8)

Reported cost estimates (Tables PCS.4-PCS.8) were based on cost invoices provided by Cavanaugh and Associates. The invoiced costs for the ISSUES permeable cover system technology as constructed at Harrells Farm were separated into unit processes by Cavanaugh. Table PCS.4 reports the costs associated with the permeable cover/lagoon modification. Aeration pond construction costs are reported in Table PCS.5. Table PCS.6 reports the costs associated with the polishing/storage basin. Table PCS.7 lists the invoiced consulting fees associated with the ISSUES permeable cover system technology. Table PCS.8 summarizes the invoiced construction costs of the ISSUES permeable blanket system technology as demonstrated at Harrells Farm. Total invoiced cost of the ISSUES permeable cover system technology was $162,423 (Table PCS.8). The aeration pond accounted for the largest percentage of this total invoiced cost, with a unit process cost of $69,137 (see Table PCS.5), or 43% of the ISSUES permeable cover system technology's total invoiced construction cost.

5.2. Modified Construction Costs at Harrells Farm (Tables PCS.9-PCS.10)

Tables PCS.9 and PCS.10 describe cost modifications that were made to the invoiced costs listed in Tables PCS.4-PCS.8. 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 PCS.9 lists the costs that were modified as well as the reason for the change. In Table PCS.10, a revised invoiced cost summary is shown. The total modified invoiced costs for the ISSUES permeable cover system technology decreased to $151,999; a $10,425 reduction (~ 6.4%) from the total reported in Table PCS.8.

6. Cost Modeling (Tables PCS.11-PCS.43)

6.1. Introduction

Original invoice costs were reported detailing the construction costs of the ISSUES permeable cover system technology as it was built on Harrells Farm. These costs are reported by unit process in Tables PCS.4-PCS.7 and summarized in total in Table PCS.8. 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 PCS.9 and total modified construction costs are summarized in Table PCS.10. In the next step, the economic modeling team examined the data reported in Tables PCS.4-PCS.7 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 PCS.12-PCS.17. 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 6.2 and in Table PCS.11. These costs are presented in Tables PCS.18-PCS.23 for a 4,320-head feeder-to-finish facility using a flush system of manure removal. Tables PCS.24-PCS.29 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 PCS.30-PCS.35. 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 PCS.36-PCS.41 list the costs associated with using the ISSUES permeable cover system technology at this representative facility.

6.2. Standardized Modeling Assumptions (Table PCS.11)

Table PCS.11 lists some assumptions that were used in constructing the cost models for the ISSUES permeable cover system technology. These assumptions were based on design equations found in the permit application and obtained in meetings that the economics team had with the principal investigators and technology providers.

The permeable cover cost was scaled based on size and the cover cost ranged from $0.47-$0.615 per square foot. These costs and the scaling function were based on information provided by Wade Jager at Baumgartner Environics, Inc. The primary lagoon was sized in the same manner as for the baseline model. For more details on lagoon costs and sizing assumptions, see Appendix A of the Combined Appendices Report and the Lagoon-Sprayfield Final Technology Report. At Harrells Farm, the existing lagoon was oversized based on the amount of liquid volume it was intended to receive daily (the flushed wastewater from two 1,224-head houses). The aeration cell was sized using a 30-day hydraulic retention time. It was assumed that 100% of the manure flushed from the houses would enter the aeration cell (after first entering the first-stage covered lagoon). The aeration cell had a total depth of 12 feet, including 11 feet of treatment depth and a 1-foot freeboard. The HDPE liner cost for the aeration cell was modeled using a function used in other standardized models for technologies with HDPE liners. The calculated liner cost was a function of liner surface area and the number of penetrations made to the liner. Fine bubble diffuser lines were assumed to be placed every 13 feet along the bottom the aeration cell. This was determined based on the number of diffuser lines used in the Carroll's Farm #2529 aeration pond and the amount of wastewater/COD that was being treated in that pond (Westerman and Arogo). No data was available for the number or length of diffuser lines/linear feet of tubing in the Harrells Farm aeration pond. A 10-

HP blower was used in the Harrells Farm aeration pond. Based on design equations in the permit application, it was shown that a 6.4-HP blower would have been sufficient to aerate the amount of wastewater/COD entering this cell (Dugba(a)). Using the design equation (and the 6.4-HP estimate), the HP capacity for a given-sized aeration cell was modeled based on COD production levels at the barns. Blowers were added to the aeration cell in multiples of 10-HP. The polishing/storage basin was sized using a hydraulic retention time of 180 days of excess manure volume. Like the aeration pond, the polishing/storage basin was modeled to be 12-feet in depth (including a 1-foot freeboard) with a standard 40-mil. HDPE liner. There are no costs associated with the excavation or construction of the first-stage lagoon in either the actual or the standardized costs and returns models. All permitted North Carolina hog farms will have an existing lagoon, so no incremental costs will be incurred for this unit process.

6.3. Estimated Adjusted Invoice Costs for ISSUES Permeable Cover System Technology at Harrells Farm (Tables PCS.12-PCS.17)

Table PCS.12 lists the assumptions (2,448-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 PCS.12 presents annualized incremental costs for each of the four land application scenarios that range from $125.97 (phosphorus-based application to row crops) to $159.18 (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 permeable cover system technology as modeled at Harrells Farm. Tables PCS.13-PCS.15 summarize costs associated with individual unit processes of the ISSUES permeable cover system technology. Costs are reported for the following unit processes: permeable cover/lagoon modification (PCS.13), aeration cell (PCS.14), and polishing/storage basin (PCS.15). Table PCS.15 also reports the total costs associated with the unit processes listed above. Total construction costs are predicted as $220,729, while annual operating costs are estimated as $10,843. The total annualized cost of the ISSUES permeable blanket system technology before land application is estimated to be $44,275 for the 2,448-head feeder-to-finish facility at Harrells Farm. Table PCS.16 (lagoon effluent) reports land application costs associated with the ISSUES permeable cover system technology. Used in conjunction with the numbers reported at the end of Table PCS.15, the total annualized and incremental cost estimates are calculated and reported in Table PCS.12 for each of the four scenarios of land application. Table PCS.17 details the mass balance of nutrients associated with the ISSUES permeable cover system technology. The mass balance estimates are used to derive additional land application costs in Table PCS.16.

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

6.4. Standardized Costs for ISSUES Permeable Cover System Technology at a 4,320-Head Feeder-to-Finish Farm with Flush System (Tables PCS.18-PCS.23)

Tables PCS.18 to PCS.23 provide estimates of the cost of constructing and operating the ISSUES permeable cover 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 PCS.18 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for retrofitting the farm with standardized ISSUES permeable cover system technology. The standardized incremental costs range from $105.79 (phosphorus-based application to row crops) to $120.17 (nitrogen-based application to forages), with an average incremental cost of $113.79 per 1,000 lbs. SSLW per year across the four land application scenarios. In the standardized ISSUES permeable cover system 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 PCS.19-PCS.21 report standardized costs for the same unit processes (in the same order) as seen in Tables PCS.13-PCS.15. Within certain unit processes, there are differences in individual components between the actual and standardized models. In these cases, the technology as it was constructed at Harrells Farm was not indicative of how it would be constructed on a representative NC farm. Table PCS.21 also summarizes the predicted total costs associated with the standardized ISSUES permeable cover system technology for a 4,320-head finishing facility with a flush system. Total construction costs are estimated at $348,243, while total annual operating costs are predicted as $17,276. Total annualized costs before land application are estimated at $71,547 for this representative farm size and type. Table PCS.22 (lagoon effluent) summarizes the land application costs predicted for this model for each of four scenarios. Table PCS.23 provides an estimated mass balance of nutrients for this representative NC farm size and type.

6.5. Standardized Costs for ISSUES Permeable Cover System Technology at a 4,320-Head Feeder-to-Finish Farm with Pit-Recharge System (Tables PCS.24-PCS.29)

Tables PCS.24- PCS.29 provide estimates of the cost of constructing and operating the ISSUES permeable cover 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 PCS.24-PCS.29 versus the one chosen to estimate the numbers in Tables PCS.18-PCS.23 is the type of manure removal system used. Table PCS.24 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for the standardized ISSUES permeable cover system technology. The standardized incremental costs of retrofitting the farm with the ISSUES permeable cover system technology range from $100.14 (phosphorus-based application to row crops) to $114.52 (nitrogen-based application to forages), with an average incremental cost across the four scenarios of $108.14 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 5% for a 4,320-head finishing facility as compared to using a flush system on the same facility. Tables PCS.25-PCS.27 list the costs of individual unit processes in this standardized model. The set of unit processes and components are identical to those in Tables PCS.19-PCS.21, while some of the costs change between the two sets of tables. Table PCS.27 also summarizes the total costs associated with the standardized ISSUES permeable cover system technology for a 4,320-head finishing facility with a pit-recharge system. Total construction costs are estimated at $327,897, while total annual operating costs are reported as $17,011. Total annualized costs before land application are estimated at $68,250 for this representative farm size and type. Table PCS.28 (lagoon effluent) summarizes the land application costs associated with this standardized model for each of four scenarios. Table PCS.29 provides an estimated mass balance of nutrients for the representative farm modeled in these tables.

6.6. Standardized Costs for ISSUES Permeable Cover System Technology at an 8,800-Head Feeder-to-Finish Farm (Tables PCS.30-PCS.35)

Tables PCS.30- PCS.35 provide estimates of the cost of constructing and operating the ISSUES permeable cover system technology on a standard (representative) North Carolina 8,800-head feeder-to-finish facility using a flush system for manure removal. Table PCS.30 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for retrofitting a farm with the standardized ISSUES permeable cover system technology. The standardized incremental costs for the 8,800-head finishing facility range from $87.21 (phosphorus-based application to row crops) to $98.75 (nitrogen-based application to forages), with an average incremental cost of $94.09 per 1,000 lbs. SSLW per year across the four scenarios. This average incremental cost is about 17% 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 permeable cover 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). The aeration cell demonstrates the largest economies of scale, with lesser economies of scale present in both the permeable cover and storage basin unit processes. Tables PCS.31-PCS.33 list the costs of individual unit processes in this standardized model. The set of unit processes and components are identical to those in Tables PCS.19-PCS.26 and PCS.25-PCS.27 although some of the costs change between the sets of tables. Table PCS.33 also summarizes the total costs associated with the standardized ISSUES permeable cover system technology for an 8,800-head finishing facility. Total construction costs are estimated at $629,428, while total operating costs are reported as $27,277. Total annualized costs before land application are estimated at $124,371 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 PCS.34 (lagoon effluent) summarizes the land application costs associated with

this standardized model for each of four scenarios. Table PCS.35 provides predicted mass balance of nutrients for the representative farm modeled here.

6.7. Standardized Costs for ISSUES Permeable Cover System Technology at a 4,000-Sow Farrow-to-Wean Farm (Tables PCS.36-PCS.41)

Tables PCS.36- PCS.41 provide estimates of the cost of constructing and operating the ISSUES permeable cover 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 ISSUES permeable cover system technology. Table PCS.36 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for the standardized ISSUES permeable cover system technology. The standardized incremental costs range from $79.00 (phosphorus-based application to row crops) to $89.67 (nitrogen-based application to forages), with an average incremental cost of $85.11 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 application to forages was modeled to be more costly than application to row crops. Tables PCS.37-PCS.39 provide details of the costs of individual unit processes in this standardized model. Table PCS.39 also summarizes the total costs of the standardized ISSUES permeable cover system technology for a 4,000-sow farrow-to-wean operation. Total construction costs are estimated at $925,169, while total annual operating costs are reported as $24,592. Total annualized costs before land application are estimated at $165,298 for this representative farm size and type. Table PCS.40 (lagoon effluent) summarizes the land application costs associated with this standardized model for each of four scenarios. Table PCS.41 provides an estimated mass balance of nutrients for the 4,000-sow farrow-to-wean operation modeled for the ISSUES permeable cover system technology.

6.8. Extrapolation to Other Farm Types and Sizes (Tables PCS.42-PCS.43)

Table PCS.42 summarizes the per unit incremental costs ($ / 1,000 lbs. SSLW) of retrofitting the ISSUES permeable cover 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 PCS.42's costs assume nitrogen-based land application to forages. Table PCS.43 is analogous to Table PCS.42, 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 PCS.42, the costs in Table PCS.43 assume that a nitrogen-based land application to forages is chosen. Tables PCS.42 and PCS.43 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 PCS.42 and

PCS.57 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). Wean-to-feeder farms are also the most expensive types of operations within a given size category for the ISSUES permeable cover system technology.

7. Summary

The ISSUES permeable cover system (PCS) technology was installed on Harrells Farm. It was operated to treat 18,850 gallons per day of lagoon effluent from two flush type finishing barns each with 1,224-head capacity. Performance evaluation occurred between July, 2004 and May, 2004. The system includes an anaerobic lagoon covered with permeable material, an aeration pond, and a polishing / storage pond. The design prescribed that of the 18,850 gallons pumped into the aeration pond every day, approximately 13,220 gallons were returned to the flush tanks and 5,630 gallons were sent to the polishing / storage pond for eventual land application. As actually operated, 31,700 gallons per day were pumped to the aeration pond. From the aeration pond, 28,000 gallons per day was returned to the flush tanks, while the remaining 3,700 gallons per day was pumped to the polishing / storage basin. Fifteen sampling events occurred during the evaluation period. Sample averages were used in this report to characterize the performance of the system. Principal investigators indicated that the liquid in the storage pond has an 80% lower concentration of TKN and an 87% lower concentration of P than the barn effluent (Table PCS.1.). Invoices provided to the costs and returns team were fairly complete. The initial investment predicted for installation of the ISSUES aerobic blanket system on a standardized 4,320-head flush type finishing farm is $348,243. Electricity bills for the system were submitted for the evaluation period. The annual operating costs for the system are predicted at $17,276 and total annualized cost of the system is predicted at $120.17 per 1,000 pounds Steady State Live Weight per year over a 10-year amortization period. A considerable range of predicted costs ($77 to $435 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.

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Tables PCS.1 through PCS.2: Performance Data and Mass Balance Tables for the ISSUES Permeable Cover System Technology as Constructed and Demonstrated at Harrells Farm

Table PCS.1. Nutrient Content of the Wastewater Stream at Various Sampling Points for the ISSUES Permeable Cover System Technology (Bull, Worley-Davis)

Sampling Point	TKN (ppm)	P (ppm)	K (ppm)	DM %
House effluent	1,019	240	1,131	1.00%
Permeable covered lagoon liquid	682	85	907	0.25%
Aeration cell	566	51	893	0.21%
Storage basin	206	31	547	0.12%
% total concentration (ppm) reduction for technology	**79.8%**	**87.1%**	**51.6%**	**--**

Note: These nutrient analyses are based on the average of 15 sampling events taken between the dates of 7/03 and 5/04 at Harrells Farm.

Table PCS.2. Mass Balance of Nutrients for the ISSUES Permeable Cover System Technology (Bull, Worley-Davis)

Sampling Point	TKN (lbs. / day)	P (lbs. / day)
House effluent	288.7	68.0
Permeable covered lagoon influent	288.7	68.0
Permeable covered lagoon effluent	181.8	22.7
Aeration cell influent	181.7	22.7
Aeration cell effluent	150.7	13.6
Storage basin influent	17.3	1.6
Storage basin effluent	6.4	0.96
House influent	133.3	12.0
% total mass reduction for technology	**53.8%**	**82.4%**

Table PCS.3: Actual Electricity Cost and Usage Invoices for the Permeable Cover System Technology as Constructed and Operated at Harrells Farm

Table PCS.3. Actual Electricity Cost and Usage Invoices for the Permeable Cover System Technology as Constructed and Operated at Harrells Farm (Cavanaugh)

Month	Electricity Usage (kWh)	Electricity Cost
July ‘03	2,111	$215.00
August ‘03	4,610	$391.00
September ‘03	333	$52.00
October ‘03	316	$50.00
November ‘03	3,495	$318.00
December ‘03	6,059	$486.00
January ‘04	4,944	$413.00
February ‘04	4,890	$409.00
March ‘04	2,992	$296.00
April ‘04	5,811	$490.00
May ‘04	3,686	$344.00
June ‘04	3,959	$363.00
July ‘04	1,204	$145.00
August ‘04	4,945	$431.00
September ‘04	5,278	$483.00
October ‘04	3,812	$352.00
Monthly Average	**3,653**	**$327.38**

Tables PCS.4 through PCS.8: Invoiced Cost Tables for the ISSUES Permeable Cover System Technology as Constructed at Harrells Farm

Table PCS.4. Invoiced Permeable Cover/Lagoon Modification Costs for the Permeable Cover System Technology (Cavanaugh)

Component	Invoiced Cost
Permeable cover (labor and materials)	$29,000.00
Wetwell (6’ diameter)	$1,765.00
Labor	$2,029.66
Electrical	$1,442.37
Plumbing	$1,466.21
Total Invoiced Cost of Permeable Cover/Lagoon Modification	**$35,703.24**

Table PCS.5. Invoiced Aeration Cell Costs for the Permeable Cover System Technology (Cavanaugh)

Component	Invoiced Cost
Construction	$3,726.63
Liner	$13,545.44
Fine bubble diffusion system	$42,200.00
Fence	$1,752.29
Fine grading and seeding	$999.34
Labor	$2,841.52
Electrical	$2,019,32
Plumbing	$2,052.69
Total Invoiced Cost of Aeration Cell	**$69,137.23**

Table PCS.6. Invoiced Polishing/Storage Basin Costs for the Permeable Cover System Technology (Cavanaugh)

Component	Invoiced Cost
Construction	$7,087.73
Liner	$21,997.56
Fence	$3,332.71
Fine grading and seeding	$1,900.66
Labor	$5,277.11
Electrical	$3,750.16
Plumbing	$3,812.14
Total Invoiced Cost of Polishing/Storage Basin	**$47,158.07**

Table PCS.7. Invoiced Consulting Fees for the Permeable Blanket System Technology (Cavanaugh)

Component	Invoiced Cost
Elmer Environmental (consulting fees)	$10,424.90
Total Invoiced Cost of Control System and Miscellaneous Expenses	**$10,424.90**

Table PCS.8. Summary of Invoiced Costs for the ISSUES Permeable Cover System Technology

Unit Process	Invoiced Cost	% of Total Invoiced Cost
Permeable cover/lagoon modification	$35,703.24	21.98%
Aeration cell	$69,137.23	42.57%
Polishing/storage basin	$47,158.07	29.03%
Consulting fees	$10,424.90	6.42%
Total Invoiced Costs	**$162,423.44**	**100.00%**

Tables PCS.9 through PCS.10: Modified Invoiced Construction Costs for the ISSUES Permeable Cover System Technology as Constructed at Harrells Farm

Table PCS.9. Summary of Modified Costs for the ISSUES Permeable Cover System Technology

Unit Process	System Component	Invoiced Cost	Modified Cost	Reason for Modification
Consulting fees	Elmer Environmental	$10,424.90	$0.00	Replaced by overhead/engineering services in the model

Table PCS.10. Summary of Modified Invoiced Costs for the ISSUES Permeable Cover System Technology

Unit Process	Invoiced Cost	% of Total Invoiced Cost
Permeable cover/lagoon modification	$35,703.24	23.49%
Aeration cell	$69,137.23	45.49%
Polishing/storage basin	$47,158.07	31.02%
Total Modified Invoiced Costs	**$151,998.54**	**100.00%**

Table PCS.11: Modeling Assumptions for Standardized Cost Models

Table PCS.11. Modeling and Operating Assumptions for Standardized Cost Models

Permeable cover cost*	ranging from $0.47-$0.615 per square foot depending on the size of the lagoon
Aeration cell hydraulic retention time**	30 days of flush volume
Aeration cell depth	12 feet (including 1-foot freeboard)
Aeration cell HDPE liner cost	modeled using liner surface area and number of penetrations
Number of lines of air tubing***	aeration cell length (in feet) divided by 13
Blower operating time per day	24 hours
Blower HP****	modeled using COD production rates and loading rates into the aeration cell
Polishing/storage basin hydraulic retention time	180 days of excess manure volume*****
Polishing/storage basin hydraulic depth	12 feet (including 1-foot freeboard)
Polishing/storage basin HDPE liner cost	modeled using liner surface area and number of penetrations

* Based on price quotes provided by Wade Jager of Baumgartner Environics, Inc.
** Dugba(b)
*** Based on aeration cell design at Carroll's Farm #2529 (Westerman and Arogo)
**** A 10-HP blower was used in the aeration cell at Harrells Farm and sufficiently aerated the wastewater stream produced by 2,448 finishing head.
***** Excess manure volume is total wastewater minus recycled flush volume; for a 2,448-head feeder-finish farm with a flush system, excess manure volume equals 5,630 gallons per day

Tables PCS.12 through PCS.17: Costs and Returns Estimates Based on Actual Cost and Performance Data for ISSUES Permeable Cover System On-Farm Technology: 2,448 Feeder to Finish Operation with Flush System

Table PCS.12. ISSUES Permeable Cover System Technology Assumptions and Predicted Total Annualized Costs: Actual Costs and Performance Data

Number of Animals	**2,448**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Flush System**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 52,604.99**	**$ 44,589.87**
	If Phosphorus-Based Application	**$ 45,347.55**	**$ 41,630.96**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 159.18**	**$ 134.93**
	If Phosphorus-Based Application	**$ 137.22**	**$ 125.97**

Note: Daily volume discharged from barns is 18,986 gallons / day including recharge liquid.
SSLW equals 330,480 pounds.

Table PCS.13. ISSUES Permeable Cover System Technology Permeable Cover and Lagoon Modification Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Permeable Cover	$ 29,000.00	$ 4,321.86
Wetwell	$ 1,765.00	$ 263.04
Pumps (wetwell)	$ 1,270.00	$ 492.80
Labor	$ 2,029.66	$ 302.48
Electrical	$ 1,442.37	$ 214.96
Plumbing	$ 1,466.21	$ 218.51
Contractor & Engineering Services & Overhead	$ 15,935.46	$ 2,374.85
Total Construction Cost	$ 52,908.70	$ 8,188.49
Electric Power Cost		$ 79.06
Maintenance Cost		$ 736.97
Property Taxes		$ 187.83
Total Operating Cost		$ 924.80
TOTAL ANNUALIZED COST OF PERMEABLE COVER AND LAGOON MODIFICATION		**$ 9,113.29**

Table PCS.14. ISSUES Permeable Cover System Technology Aeration Cell Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Excavation	$ 3,726.63	$ 555.38
Liner (40-mil. HDPE)	$ 13,545.44	$ 2,018.67
Fine Bubble Diffusion System (blower and tubing)	$ 42,200.00	$ 6,289.04
Fence	$ 1,752.29	$ 261.14
Fine Grading and Seeding	$ 999.34	$ 148.93
Submersible Pumps	$ 979.25	$ 379.98
Labor	$ 2,841.52	$ 423.47
Electrical	$ 2,019.32	$ 300.94
Plumbing	$ 2,052.69	$ 305.91
Contractor & Engineering Services & Overhead	$ 30,220.20	$ 4,503.70
Total Construction Cost	$ 100,336.68	$ 15,187.17
Electric Power Cost		$ 6,059.93
Maintenance Cost		$ 2,566.34
Property Taxes		$ 356.20
Total Operating Cost		$ 8,982.47
TOTAL ANNUALIZED COST OF AERATION CELL		**$ 24,169.64**

Table PCS.15 ISSUES Permeable Cover System Technology Polishing/Storage Basin Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Excavation	$ 7,087.73	$ 1,056.28
Liner (40-mil. HDPE)	$ 21,997.56	$ 3,278.29
Fence	$ 3,332.71	$ 496.67
Fine Grading and Seeding	$ 1,900.66	$ 283.25
Labor	$ 5,277.11	$ 786.45
Electrical	$ 3,750.16	$ 558.88
Plumbing	$ 3,812.14	$ 568.12
Contractor & Engineering Services & Overhead	$ 20,325.13	$ 3,029.04
Total Construction Cost	$ 67,483.20	$ 10,056.99
Maintenance Cost		$ 695.86
Property Taxes		$ 239.57
Total Operating Cost		*$ 935.43*
TOTAL ANNUALIZED COST OF POLISHING/STORAGE BASIN		**$ 10,992.42**

TOTAL CONSTRUCTION COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**220,728.59**
TOTAL OPERATING COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**10,842.69**
TOTAL ANNUALIZED COSTS OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**44,275.34**

Table PCS.16 ISSUES Permeable Cover System 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	$	18,935.50	$	8,677.07
If Phosphorus-Based Application	$	13,244.00	$	6,267.66
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		3.43		11.13
If Phosphorus-Based Application		6.20		16.56
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	205.98		-
If Phosphorus-Based Application	$	371.88		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	18,729.52	$	9,090.27
If Phosphorus-Based Application	$	12,406.56	$	7,882.51
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(413.20)
If Phosphorus-Based Application		-	$	(1,614.85)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	465.56		-

Note: 2,552,907 gallons / year of effluent land applied at Harrells Farm.

Table PCS.17. 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	49,547.52	14,198.40	24,357.60
Removed in Covered Lagoon	18,347.45	9,458.97	4,954.34
Entering Aeration cell	31,200.07	4,739.43	19,403.26
Removed in Aeration Cell	5,338.33	1,900.04	298.81
Removed in PS basin	1,870.91	129.49	-
Land Applied in Liquid Effluent	1,993.16	299.94	5,292.51

Tables PCS.18 through PCS.23: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES Permeable Cover System On-Farm Technology: 4,320-Head Feeder to Finish Operation with Flush System

Table PCS.18. ISSUES Permeable Cover System Technology Assumptions and Predicted 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	**$ 70,083.90**	**$ 67,134.53**
	If Phosphorus-Based Application	**$ 66,537.31**	**$ 61,698.38**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 120.17**	**$ 115.11**
	If Phosphorus-Based Application	**$ 114.09**	**$ 105.79**

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

Table PCS.19. ISSUES Permeable Cover System Technology Permeable Cover and Lagoon Modification Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Permeable Cover	$ 80,693.70	$ 12,025.74
Wetwell	$ 1,765.00	$ 263.04
Pumps (wetwell)	$ 1,270.00	$ 492.80
Labor	$ 3,581.76	$ 533.79
Electrical	$ 2,545.37	$ 379.34
Plumbing	$ 2,587.44	$ 385.60
Contractor & Engineering Services & Overhead	$ 38,215.45	$ 5,695.23
Total Construction Cost	$ 132,286.32	$ 20,018.10
Electric Power Cost		$ 139.51
Maintenance Cost		$ 1,815.33
Property Taxes		$ 469.62
Total Operating Cost		$ 2,284.95
TOTAL ANNUALIZED COST OF PERMEABLE COVER AND LAGOON MODIFICATION		**$ 22,303.04**

Table PCS.20. ISSUES Permeable Cover System Technology Aeration Cell Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Excavation	$ 12,906.11	$ 1,923.39
Liner (40-mil. HDPE)	$ 21,096.54	$ 3,144.01
Blower	$ 7,678.00	$ 2,979.32
Blower Package and Installation	$ 12,000.00	$ 1,788.35
LDPE Aeration Tubing	$ 1,828.77	$ 272.54
LDPE Air Feeder Tubing	$ 2,704.62	$ 403.07
Diffuser System Installation	$ 8,307.25	$ 1,238.03
Submersible Pumps	$ 979.25	$ 379.98
Grass Seeding	$ 68.49	$ 10.21
Labor	$ 5,014.47	$ 747.30
Electrical	$ 3,563.52	$ 531.07
Plumbing	$ 3,622.41	$ 539.85
Contractor & Engineering Services & Overhead	$ 32,101.99	$ 4,784.14
Total Construction Cost	$ 114,150.06	$ 19,080.84
Electric Power Cost		$ 12,104.80
Maintenance Cost		$ 1,329.18
Property Taxes		$ 405.23
Total Operating Cost		$ 13,839.21
TOTAL ANNUALIZED COST OF AERATION CELL		**$ 32,920.06**

Table PCS.21. ISSUES Permeable Cover System Technology Polishing/Storage Basin Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Excavation	$ 22,229.33	$ 3,312.83
Liner (40-mil. HDPE)	$ 26,171.35	$ 3,900.30
Grass Seeding	$ 84.85	$ 12.65
Labor	$ 9,312.59	$ 1,387.85
Electrical	$ 6,617.96	$ 986.27
Plumbing	$ 6,727.33	$ 1,002.57
Contractor & Engineering Services & Overhead	$ 30,662.81	$ 4,569.66
Total Construction Cost	$ 101,806.22	$ 15,172.13
Maintenance Cost		$ 790.33
Property Taxes		$ 361.41
Total Operating Cost		$ 1,151.74
TOTAL ANNUALIZED COST OF POLISHING/STORAGE BASIN		**$ 16,323.87**

TOTAL CONSTRUCTION COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**348,242.60**
TOTAL OPERATING COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**17,275.90**
TOTAL ANNUALIZED COSTS OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**71,546.97**

Table PCS.22. ISSUES Permeable Cover System Technology 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	$	12,080.11	$	6,558.08
If Phosphorus-Based Application	$	12,075.43	$	2,266.39
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		13.17		42.70
If Phosphorus-Based Application		23.79		63.55
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	790.49		-
If Phosphorus-Based Application	$	1,427.18		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	11,289.62	$	8,143.87
If Phosphorus-Based Application	$	8,861.54	$	8,463.80
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(1,585.78)
If Phosphorus-Based Application		-	$	(6,197.42)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	1,786.71		-

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

Table PCS.23. 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 Covered Lagoon	32,377.85	16,692.31	8,742.95
Entering Aeration cell	55,058.95	8,363.69	34,241.05
Removed in Aeration Cell	9,420.59	3,353.00	527.31
Removed in PS basin	3,301.61	228.51	-
Land Applied in Liquid Effluent	7,649.28	1,151.10	20,311.43

Tables PCS.24 through PCS.29: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES Permeable Cover System On-Farm Technology: 4,320-Head Feeder to Finish Operation with Pit-Recharge System

Table PCS.24. ISSUES Permeable Cover System Technology Assumptions and Predicted 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	**$ 66,786.60**	**$ 63,837.23**
	If Phosphorus-Based Application	**$ 63,240.01**	**$ 58,401.08**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 114.52**	**$ 109.46**
	If Phosphorus-Based Application	**$ 108.44**	**$ 100.14**

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

Table PCS.25. ISSUES Permeable Cover System Technology Permeable Cover and Lagoon Modification Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Permeable Cover	$ 80,693.70	$ 12,025.74
Wetwell	$ 1,765.00	$ 263.04
Pumps (wetwell)	$ 1,270.00	$ 492.80
Labor	$ 3,031.87	$ 451.84
Electrical	$ 2,154.59	$ 321.10
Plumbing	$ 2,190.20	$ 326.40
Contractor & Engineering Services & Overhead	$ 38,215.45	$ 5,695.23
Total Construction Cost	$ 130,371.78	$ 19,732.78
Electric Power Cost		$ 118.09
Maintenance Cost		$ 1,799.57
Property Taxes		$ 462.82
Total Operating Cost		$ 2,262.39
TOTAL ANNUALIZED COST OF PERMEABLE COVER AND LAGOON MODIFICATION		**$ 21,995.17**

Table PCS.26. ISSUES Permeable Cover System Technology Aeration Cell Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Excavation	$ 11,020.41	$ 1,642.37
Liner (40-mil. HDPE)	$ 18,509.15	$ 2,758.41
Blower	$ 7,678.00	$ 2,979.32
Blower Package and Installation	$ 12,000.00	$ 1,788.35
LDPE Aeration Tubing	$ 1,607.81	$ 239.61
LDPE Air Feeder Tubing	$ 2,377.83	$ 354.37
Diffuser System Installation	$ 7,303.52	$ 1,088.44
Submersible Pumps	$ 979.25	$ 379.98
Grass Seeding	$ 64.56	$ 9.62
Labor	$ 4,244.62	$ 632.57
Electrical	$ 3,016.43	$ 449.54
Plumbing	$ 3,066.28	$ 456.97
Contractor & Engineering Services & Overhead	$ 30,975.04	$ 4,616.19
Total Construction Cost	$ 102,842.90	$ 17,395.74
Electric Power Cost		$ 12,083.38
Maintenance Cost		$ 1,244.41
Property Taxes		$ 365.09
Total Operating Cost		$ 13,692.89
TOTAL ANNUALIZED COST OF AERATION CELL		**$ 31,088.63**

Table PCS.27. ISSUES Permeable Cover System Technology Polishing/Storage Basin Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Excavation	$ 22,229.33	$ 3,312.83
Liner (40-mil. HDPE)	$ 24,671.35	$ 3,676.76
Grass Seeding	$ 84.85	$ 12.65
Labor	$ 7,882.87	$ 1,174.78
Electrical	$ 5,601.94	$ 834.85
Plumbing	$ 5,694.52	$ 848.65
Contractor & Engineering Services & Overhead	$ 28,517.06	$ 4,249.88
Total Construction Cost	$ 94,681.92	$ 14,110.40
Maintenance Cost		$ 719.36
Property Taxes		$ 336.12
Total Operating Cost		$ 1,055.48
TOTAL ANNUALIZED COST OF POLISHING/STORAGE BASIN		**$ 15,165.87**

TOTAL CONSTRUCTION COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**327,896.60**
TOTAL OPERATING COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**17,010.75**
TOTAL ANNUALIZED COSTS OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**68,249.67**

Table PCS.28. ISSUES Permeable Cover System Technology 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	$	12,080.11	$	6,558.08
If Phosphorus-Based Application	$	12,075.43	$	2,266.39
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		13.17		42.70
If Phosphorus-Based Application		23.79		63.55
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	790.49		-
If Phosphorus-Based Application	$	1,427.18		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	11,289.62	$	8,143.87
If Phosphorus-Based Application	$	8,861.54	$	8,463.80
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(1,585.78)
If Phosphorus-Based Application		-	$	(6,197.42)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	1,786.71		-

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

Table PCS.29. 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 Covered Lagoon	32,377.85	16,692.31	8,742.95
Entering Aeration cell	55,058.95	8,363.69	34,241.05
Removed in Aeration Cell	9,420.59	3,353.00	527.31
Removed in PS basin	3,301.61	228.51	-
Land Applied in Liquid Effluent	7,649.28	1,151.10	20,311.43

Tables PCS.30 through PCS.35: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES Permeable Cover System On-Farm Technology: 8,800-Head Feeder to Finish Operation with Flush System

Table PCS.30. ISSUES Permeable Cover System Technology Assumptions and Predicted 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 System**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 117,319.49**	**$ 114,157.55**
	If Phosphorus-Based Application	**$ 112,026.22**	**$ 103,603.81**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 98.75**	**$ 96.09**
	If Phosphorus-Based Application	**$ 94.30**	**$ 87.21**

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

Table PCS.31. ISSUES Permeable Cover System Technology Permeable Cover and Lagoon Modification Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Permeable Cover	$ 156,310.24	$ 23,294.83
Wetwell	$ 1,765.00	$ 263.04
Pumps (wetwell)	$ 1,270.00	$ 492.80
Labor	$ 7,296.19	$ 1,087.35
Electrical	$ 5,185.01	$ 772.72
Plumbing	$ 5,270.70	$ 785.49
Contractor & Engineering Services & Overhead	$ 76,328.87	$ 11,375.25
Total Construction Cost	$ 253,426.00	$ 38,071.48
Electric Power Cost		$ 284.19
Maintenance Cost		$ 3,434.12
Property Taxes		$ 899.66
Total Operating Cost		$ 4,333.78
TOTAL ANNUALIZED COST OF PERMEABLE COVER AND LAGOON MODIFICATION		**$ 42,405.26**

Table PCS.32. ISSUES Permeable Cover System Technology Aeration Cell Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Excavation	$ 25,228.89	$ 3,759.85
Liner (40-mil. HDPE)	$ 30,744.53	$ 4,581.84
Blower	$ 11,517.00	$ 4,468.98
Blower Package and Installation	$ 18,000.00	$ 2,682.53
LDPE Aeration Tubing	$ 3,184.81	$ 474.63
LDPE Air Feeder Tubing	$ 4,710.11	$ 701.95
Diffuser System Installation	$ 14,467.15	$ 2,156.03
Submersible Pumps	$ 979.25	$ 379.98
Grass Seeding	$ 89.42	$ 13.33
Labor	$ 10,214.66	$ 1,522.29
Electrical	$ 7,259.02	$ 1,081.81
Plumbing	$ 7,378.98	$ 1,099.69
Contractor & Engineering Services & Overhead	$ 57,656.52	$ 8,592.52
Total Construction Cost	$ 191,430.35	$ 31,515.42
Electric Power Cost		$ 18,217.84
Maintenance Cost		$ 2,050.36
Property Taxes		$ 679.58
Total Operating Cost		$ 20,947.78
TOTAL ANNUALIZED COST OF AERATION CELL		**$ 52,463.20**

Table PCS.33. ISSUES Permeable Cover System Technology Polishing/Storage Basin Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Excavation	$ 42,878.38	$ 6,390.14
Liner (40-mil. HDPE)	$ 39,834.92	$ 5,936.58
Grass Seeding	$ 112.68	$ 16.79
Labor	$ 18,970.08	$ 2,827.10
Electrical	$ 13,481.03	$ 2,009.07
Plumbing	$ 13,703.83	$ 2,042.27
Contractor & Engineering Services & Overhead	$ 55,590.78	$ 8,284.66
Total Construction Cost	$ 184,571.70	$ 27,506.63
Maintenance Cost		$ 1,340.40
Property Taxes		$ 655.23
Total Operating Cost		$ 1,995.62
TOTAL ANNUALIZED COST OF POLISHING/STORAGE BASIN		**$ 29,502.25**

TOTAL CONSTRUCTION COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**629,428.05**
TOTAL OPERATING COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**27,277.19**
TOTAL ANNUALIZED COSTS OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**124,370.72**

Table PCS.34. ISSUES Permeable Cover System Technology 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	$	13,519.13	$	6,996.86
If Phosphorus-Based Application	$	16,493.54	$	(989.56)
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		26.60		86.20
If Phosphorus-Based Application		48.02		128.28
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	1,595.72		-
If Phosphorus-Based Application	$	2,880.98		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	11,923.41	$	10,198.01
If Phosphorus-Based Application	$	10,005.82	$	11,520.88
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(3,201.15)
If Phosphorus-Based Application		-	$	(12,510.44)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	3,606.74		-

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

Table PCS.35. 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 Covered Lagoon	65,954.87	34,002.85	17,809.70
Entering Aeration cell	112,157.13	17,037.15	69,750.30
Removed in Aeration Cell	19,190.08	6,830.19	1,074.15
Removed in PS basin	6,725.51	465.48	-
Land Applied in Liquid Effluent	15,441.24	2,323.68	41,001.74

Tables PCS.36 through PCS.41: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES Permeable Cover System On-Farm Technology: 4,000-Sow Farrow to Wean Operation with Flush System

Table PCS.36. ISSUES Permeable Cover System Technology Assumptions and Predicted 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 System**

Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 155,312.47**	**$ 152,042.84**
	If Phosphorus-Based Application	**$ 145,478.46**	**$ 136,824.56**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 89.67**	**$ 87.79**
	If Phosphorus-Based Application	**$ 83.99**	**$ 79.00**

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

Table PCS.37. ISSUES Permeable Cover System Technology Permeable Cover and Lagoon Modification Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Permeable Cover	$ 165,455.37	$ 24,657.73
Wetwell	$ 1,765.00	$ 263.04
Pumps (wetwell)	$ 2,540.00	$ 985.61
Labor	$ 16,952.86	$ 2,526.48
Electrical	$ 12,047.50	$ 1,795.43
Plumbing	$ 12,246.61	$ 1,825.11
Contractor & Engineering Services & Overhead	$ 90,944.16	$ 13,553.36
Total Construction Cost	$ 301,951.50	$ 45,606.75
Electric Power Cost		$ 660.31
Maintenance Cost		$ 3,957.29
Property Taxes		$ 1,071.93
Total Operating Cost		$ 5,029.22
TOTAL ANNUALIZED COST OF PERMEABLE COVER AND LAGOON MODIFICATION		**$ 50,635.96**

Table PCS.38. ISSUES Permeable Cover System Technology Aeration Cell Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Excavation	$ 54,409.36	$ 8,108.60
Liner (40-mil. HDPE)	$ 44,011.25	$ 6,558.97
Blower	$ 7,678.00	$ 2,979.32
Blower Package and Installation	$ 12,000.00	$ 1,788.35
LDPE Aeration Tubing	$ 6,501.31	$ 968.89
LDPE Air Feeder Tubing	$ 9,614.97	$ 1,432.91
Diffuser System Installation	$ 29,532.44	$ 4,401.20
Submersible Pumps	$ 1,614.25	$ 626.38
Grass Seeding	$ 125.94	$ 18.77
Labor	$ 23,734.01	$ 3,537.07
Electrical	$ 16,866.50	$ 2,513.61
Plumbing	$ 17,145.25	$ 2,555.15
Contractor & Engineering Services & Overhead	$ 96,213.54	$ 14,338.65
Total Construction Cost	$ 319,446.80	$ 49,827.88
Electric Power Cost		$ 12,575.11
Maintenance Cost		$ 2,587.40
Property Taxes		$ 1,134.04
Total Operating Cost		$ 16,296.54
TOTAL ANNUALIZED COST OF AERATION CELL		**$ 66,124.42**

Table PCS.39. ISSUES Permeable Cover System Technology Polishing/Storage Basin Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Excavation	$ 58,659.05	$ 8,741.93
Liner (40-mil. HDPE)	$ 46,246.88	$ 6,892.15
Grass Seeding	$ 130.59	$ 19.46
Labor	$ 44,077.44	$ 6,568.84
Electrical	$ 31,323.50	$ 4,668.12
Plumbing	$ 31,841.18	$ 4,745.27
Contractor & Engineering Services & Overhead	$ 91,492.09	$ 13,635.02
Total Construction Cost	$303,770.72	$ 45,270.80
Maintenance Cost		$ 2,188.23
Property Taxes		$ 1,078.39
Total Operating Cost		$ 3,266.62
TOTAL ANNUALIZED COST OF POLISHING/STORAGE BASIN		**$ 48,537.41**

TOTAL CONSTRUCTION COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**925,169.02**
TOTAL OPERATING COST OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY	**$**	**24,592.38**
TOTAL ANNUALIZED COSTS OF ISSUES PERMEABLE COVER SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**165,297.80**

Table PCS.40. ISSUES Permeable Cover System Technology 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	$	14,541.78	$	7,308.68
If Phosphorus-Based Application	$	19,633.29	$	(3,303.41)
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		36.13		117.11
If Phosphorus-Based Application		65.24		174.29
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	2,167.96		-
If Phosphorus-Based Application	$	3,914.13		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	12,373.82	$	11,657.79
If Phosphorus-Based Application	$	10,819.00	$	13,693.41
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(4,349.11)
If Phosphorus-Based Application		-	$	(16,996.82)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	4,900.16		-

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

Table PCS.41. 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 Covered Lagoon	43,325.10	24,676.05	15,661.80
Entering Aeration cell	73,674.90	12,363.95	61,338.20
Removed in Aeration Cell	12,605.78	4,956.71	944.61
Removed in PS basin	4,417.92	337.80	-
Land Applied in Liquid Effluent	20,978.64	3,156.98	55,705.41

Tables PCS.42 and PCS.43: Predicted Costs of Retrofitting Various Representative Farm Sizes and Farm Types with the ISSUES Permeable Cover System Technology: DWQ Permitted Farms and SF/PSF Owned Farms

Table PCS.42. Predicted Costs ($ / 1,000 Pounds of Steady-State Live Weight (SSLW) per Year) of Retrofitting DWQ Permitted Representative Farm Type / Farm Size Combinations: ISSUES Permeable Cover System 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	$152.90	$109.34	$93.51	$87.66	$78.87
Flush system	$158.64	$114.50	$98.42	$92.43	$83.90
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
Pit-recharge system	$171.31	$112.23	$103.01	$91.49	$85.11
Flush system	$191.02	$131.24	$122.52	$109.73	$102.86
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
Pit-recharge system	$193.68	$104.10	$90.37	$91.23	$82.64
Flush system	$205.62	$114.89	$101.38	$102.05	$93.08
Wean-feeder					
Rep. head capacity	3,840	20,000	N/A	N/A	N/A
Pit-recharge system	$293.90	$125.97	N/A	N/A	N/A
Flush system	$405.64	$230.34	N/A	N/A	N/A
Feeder-finish					
Rep. head capacity	2,448	5,280	8,800	12,240	17,136
Pit-recharge system	$142.67	$110.91	$97.18	$91.30	$85.19
Flush system	$148.66	$116.46	$102.78	$96.78	$90.52

Table PCS.43. 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 Permeable Cover System 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	$166.47	$105.25	$93.51	$87.66	$79.67
Flush system	$171.77	$110.32	$98.42	$92.43	$84.36
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
Pit-recharge system	$145.69	$112.23	$103.01	$87.76	$85.11
Flush system	$165.07	$131.24	$122.52	$105.77	$102.86
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
Pit-recharge system	N/A	$104.10	$90.37	$91.23	$82.64
Flush system	N/A	$114.89	$101.38	$102.05	$93.08
Wean-feeder					
Rep. head capacity	2,808	N/A	N/A	N/A	N/A
Pit-recharge system	$374.46	N/A	N/A	N/A	N/A
Flush system	$488.94	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	$220.88	$112.93	$97.18	$91.28	$85.19
Flush system	$227.75	$118.54	$102.78	$96.76	$90.52