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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: SUPER SOILS COMPOSTING FACILITY

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 (on a per dry ton of separated solids received basis)

Total Annualized Cost per Dry Ton of Separated Solids Received: $221.69

Includes:	Composting Building:	$ 72.43 / dry ton of separated solids / yr.
	Composting Equipment:	$ 149.26 / dry ton of separated solids / yr.

Excludes: Any Revenue from Compost Sales: instead, breakeven prices are presented below to indicate the price needed to exactly cover predicted costs
Cost Savings from Avoided Land Application of Solids: $27.13 / dry ton of separated solids / yr. (nitrogen-based application to forage)

Confidence in Estimates:

Medium
Based on 6.5 months evaluation at a farm scale facility.

Costs by Category:

Direct Construction:	$132.56 / dry ton of separated solids / yr.
Contractor Overhead	$ 37.42 / dry ton of separated solids / yr.
Total Operating:	$ 51.71 / dry ton of separated solids / yr.

Sensitivity Analysis

Effect of Expected Economic Life, Interest Rate, and Overhead Rate on Predicted Annualized Construction and Overhead Cost ($ / dry ton of separated solids received)

Capital Recovery Factor (CRF)		Overhead Rate 20 %	Overhead Rate 43.1 %
Low-Cost Projection (15-year economic life, 6 % interest rate)	0.1030	$123.84	$137.70
Baseline Cost Projection (10-year economic life, 8 % interest rate)	0.1490	$149.93	**$169.98***
High-Cost Projection (7-year economic life, 10 % interest rate)	0.2054	$181.29	$208.93

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

Effect of Electricity Price on Predicted Annual Operating Cost ($ / dry ton of separated solids received)

Electricity Price ($ / kWh)	Predicted Annual Operating Cost ($ / dry ton of separated solids)
Low-Cost Electricity ($0.06 / kWh)	$49.65
Baseline Cost of Electricity ($0.08 / kWh)	**$51.71***
High-Cost Electricity ($0.10 / kWh)	$53.77

* This predicted cost was calculated 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 ($**169.98**) is the actual predicted 2004 construction and overhead cost for the Super Soils composting facility expressed in a $ / dry ton of separated solids metric. 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 value of annual construction and overhead costs.

Similarly, predicted **annual operating costs** of the Super Soils composting facility are recalculated using higher and lower prices for electricity. The 25% increase or decrease in electricity price has a moderate effect (+/- 4%) on the predicted annual cost per unit reflecting moderate use of electricity by the composting facility.

Effect of Manure Production Rates[1] on Standardized Costs ($ / 1,000 lbs. SSLW)

Level of Manure Production per 4,320-Head Finishing Farm	# of Head Needed to Produce 10,880 Wet Lbs. of Solids / Day[2]	Predicted Annual Cost ($ / 1,000 lbs. SSLW)
Low Production[3] (4,094 lbs. of separated solids / day / farm)	9,133	$65.02
Medium Production[4] (14,661 lbs. of separated solids / day / farm)	3,206	$185.23
High Production[5] (19,960 lbs. of separated solids / day / farm)	2,355	$252.19

1. Assuming a 94 % separation efficiency as demonstrated in the Super Soils on-farm system (see final Super Soils on-farm system report)
2. 10,880 wet lbs. / day of separated solids (at 18.2% solids content) are needed as feedstock to operate the standardized Super Soils composting facility at full capacity.
3. Low production rate based on actual separated solids data collected at Goshen Ridge farm (Vanotti)
4. Medium production rate based on the lowest of 5 theoretical values for solids production (see Appendix A, Table A.25 in the Combined Appendices report)
5. High production rate based on the average of 5 theoretical values for solids production (see Appendix A, Table A.25 in the Combined Appendices report)

The costs per dry ton of manure solids are converted to costs per 1,000 pounds steady state live weight (SSLW) by multiplying by the dry tons of manure solids collected per 1,000 pounds SSLW per year. The costs per 1,000 pounds SSLW increase with the quantity of solids produced and with the efficiency of solids separation or collection. Composting costs range from $65 to $252 per 1,000 pounds SSLW in the example in the table above.

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. Bulk compost is the marketable product produced by the Super Soils composting facility. It has yet to be determined whether the bulk compost produced at this facility will be marketed as a fertilizer input, a potting soil amendment, or a combination of these and other emerging markets for compost. Therefore, this break-even analysis is conducted using bulk compost as the marketable product.

Break-even Analysis on Bulk Compost Prices (per cubic yard of bulk compost produced)

Cost to be Recovered	($ / dry ton of separated solids received)	Breakeven Price @ 5.90 cubic yards of bulk compost / dry ton of separated solids
		($ / cubic yard)
Predicted cost of standardized Super Soils composting facility	$221.69	$37.57
Predicted cost of standardized Super Soils composting facility less cost savings from avoided land application of solids	$194.56	$32.97

Break-even Analysis on Bulk Compost Prices (per wet ton of bulk compost produced)

Cost to be Recovered	($ / dry ton of separated solids received)	Breakeven Price @ 3.38 wet tons of bulk compost / dry ton of separated solids
		($ / wet ton)
Predicted cost of standardized Super Soils composting facility	$221.69	$65.59
Predicted cost of standardized Super Soils composting facility less cost savings from avoided land application of solids	$194.56	$57.56

The first line in the above tables shows the break-even price for bulk compost necessary to offset the cost of the entire composting operation. The second line in the tables shows the break-even price for bulk compost necessary to cover the costs of adding a composting operation to one of the candidate Environmentally Superior Technologies that already produces separated solids. For example, in the Super Soils on-farm system report, separated solids were assumed to be land applied on-farm. If the solids were instead composted, the solids land application cost would no longer pertain to this system. The cost savings from avoided land application of solids can be viewed as similar to a “tipping fee” for the composting facility.

1. Composting as a Biological Process

Composting can be defined as the aerobic decomposition of organic materials under controlled conditions into a soil-like substance. During this process, microorganisms break down complex organic compounds into simpler substances including carbon dioxide, water, minerals, and stabilized organic matter (compost). Composting is a heat-producing process that enables the destruction of pathogens and weed seeds that may be present in the organic feedstock (Sherman). The most efficient composting occurs when conditions that encourage the growth of microorganisms are established and maintained. Specifically, some of these conditions include: the proper ratio of carbon and nitrogen in the blended organic materials to promote microbial activity and growth, sufficient oxygen levels to support aerobic organisms, moisture levels that uphold biological activity without hindering aeration, and the proper temperature (a warm environment) to promote microorganism growth (Sherman).

The composting process has a thermophilic active stage during which oxygen consumption and heat generation attain their highest levels. Following this active period, there is a mesophilic curing stage during which organic materials compost at a much slower rate. Left unattended, the process will continue until all of the available nutrients are consumed by microorganisms and most of the carbon is converted to carbon dioxide. Generally, however, depending on its desired end use, compost is judged to be "finished" at some earlier point (prior to total decomposition) as determined by factors like C:N ratio, temperature, oxygen demand, and odor (Sherman). Depending on the type of feedstock used, the acceptable range for C:N ratio will vary. Ranges of between 20:1 and 25:1 are often cited as indicative of "mature" compost. The preferred range for moisture content during the composting process is between 50-60 %. At moisture contents below 40 %, composting efficiency is hindered by slowed microbial growth. When moisture levels exceed 65 %, water begins to displace air within the organic material which leads to anaerobic conditions. Oxygen levels in the range of 16-18.5 % are ideal for efficient composting. When oxygen levels fall below 6 %, the composting process slows and odor levels rise. To increase oxygen during the composting process, the compost pile can be turned mechanically or aerated by force via blowers. The most effective composting occurs with pH levels between 6.5 and 8.0. A pH level below 6.0 can slow the process, while a pH level above 8.0 can produce odor and the release of ammonia. The ideal temperature range during the active composting stage is between 130-140° F. As active composting slows, the temperature within the compost pile will fall to 100° F and, ultimately, level out to the ambient air temperature (Sherman).

2. Site and Technology Overview

The Super Soils composting facility was constructed at the Hickory Grove site in Sampson County, NC. The facility received separated swine manure solids from the Super Soils on-farm site at Goshen Ridge Farm in Duplin County, NC, approximately 30 miles away from the Hickory Grove site. The separated solids were transported daily via trailers from Goshen Ridge to Hickory Grove.

The Super Soils composting facility was evaluated over a 6.5-month period from June 1, 2004 to January 15, 2005. During this evaluation period, the separated swine manure solids were mixed with either or both of two bulking agents: cotton gin trash residues and wood chips. Two distinct mixtures or recipes were tested at the Super Soils composting facility. Recipe 1 used one part separated swine solids (SS), mixed with two parts cotton gin trash (CGT) and four parts wood chips (WC): (1 SS: 2 CGT: 4WC). Recipe 2 used one part separated swine solids, mixed with two parts cotton gin trash: (1 SS: 2 CGT).

The Super Soils composting facility as constructed at Hickory Grove consisted of an open shed, with dimensions of 250 feet in length by 40 feet in width. Within the shed, five composting bins were housed, as well as designated areas for loading, unloading, and mixing. A concrete pad was used for unloading manure solids and subsequently mixing the manure solids with bulking agents. A front-end loader was used to carry loads of the manure/bulking agent mixture from the mixing pad to the composting bins. Each of the 5 composting bins (or channels) measured 192 feet in length, 6.46 feet in width, and 3.04 feet in depth. A mechanical mixer (automated bin composter) with a 7.5-HP motor moved daily through each of the bins to agitate the compost and advance it through the length of the bin. Retention time in the bins was reported as 30 days (assuming that the composter agitated and advanced the compost in each bin daily), meaning that the mixer advanced the compost by about 6.4 feet (192 feet / 30 days) per day. If the composter was only used 5 days per week, retention time in the bins would increase from 30 days to about 40 days. After advancing the length of the bin (30 days), compost was moved into uncovered windrows for at least 30 days of additional curing. Once 30 days of curing was completed, the composting process was finished and the compost product is considered stable and mature. This economic analysis does not consider the costs or revenues of mixing, blending, or product formulation of bulk compost, and regards bulk compost (after 30 days of active composting and 30 days of curing) to be the final product of the Super Soils facility.

At the Hickory Grove composting facility, two of the five bins were used in the composting process. Bin 1 was loaded with each of the two compost recipes: the 1 SS: 2 CGT: 4 WC mixture from July 16 to October 27, and the 1 SS: 2 CGT mixture from October 28 to January 15. Bin 2 used exclusively the 1 SS: 2 CGT recipe throughout the length of the evaluation. Loading of this bin began on April 1 and, when performance verification began on June 1, Bin 2 was operating at steady-state.

3. Physical Characteristics and Mass Balance at Hickory Grove

Table SSCF.1 details the monthly loading rates of separated swine solids that occurred at the Super Soils Hickory Grove composting facility. Performance verification and testing for this facility ran from June 2004 to January 2005. In total, 10,589 cubic feet of swine solids were loaded into the bins at a weight of 550,000 pounds. The separated swine solids had an average density of 51.94 lbs. / $ft.^3$ and an average solids content of 16.7 % (83.3 % moisture content).

Table SSCF.2 describes the operating conditions of the composting process. Volume load is defined as a mixture of swine solids and bulking agents (cotton gin trash and/or wood chips). Retention time will equal 30 days when number of turns per week equals 7. In September 2004, low pig weight at Goshen Ridge Farms resulted in fewer separated solids available for composting. As a result, loading rates and mixing intensity (turns per week) were decreased during this month at Hickory Grove. Conversely, loading rates and mixing intensity were increased during January 2005. This was in response to market-size pigs at Goshen Ridge, and the corresponding increase in available solids. During the other 5 months of evaluation, loading rates and mixing intensity fell between these two extremes. The compost was generally turned between 4 and 6 times per week during the performance verification process.

Table SSCF.3 shows some physical characteristics of the swine solids and bulking agents. The swine solids have a relatively high moisture content and bulk density and a relatively low carbon-to-nitrogen ratio (C:N). Conversely, the cotton gin trash and wood chips have lower moisture contents and bulk densities with higher carbon-to-nitrogen ratios. By combining the bulking agents with the separated swine solids, the optimal aerobic composting conditions can be achieved.

Tables SSCF.4, SSCF.5, and SSCF.6 detail the mass balance of compost materials and nutrients during the composting process at Hickory Grove composting facility. The data in the first column describes the composting feedstock (swine solids mixed with bulking agents) after mixing, but before active composting begins. The data in the second column describes the compost product after it reaches the end of the bin (after ~30 days or 30 turns of the mechanical mixer), but before the 30 day curing process. The third column of Tables SSCF.4-SSCF.6 lists the percent reduction in compost weight and volume, as well as percent reduction in selected nutrients. There is about a 45 % reduction in compost weight and a 70 % reduction in compost volume during the 30 days of active composting. These types of reductions are normal during composting due to the relatively high moisture content of the organic feedstock. Total carbon is reduced by about 40 % during the composting process, while total nitrogen is reduced by about 5 %. Total phosphorus remains virtually unchanged during the composting process (Vanotti).

Table SSCF.7 lists the physical characteristics associated with the Hickory Grove facility's final compost products (after 30 days of curing). Table SSCF.7 reports data for two final compost products—one for each recipe/mixture used at the facility. Recipe 1 (1 SS: 2 CGT: 4 WC) produced a final compost that was intended to target the potting soil market. Recipe 2 (1 SS: 2 CGT) produced a final compost that was intended to target the fertilizer manufacturing market. Recipe 2 produced a heavier final compost than Recipe 1 as a result of a higher moisture content. Recipe 2 also had higher levels of N, P, and K.

4. Invoiced Construction and Equipment Costs at Hickory Grove Farm

Table SSCF.8 lists the invoiced construction costs associated with the Super Soils composting facility at Hickory Grove Farm. Table SSCF.9 lists this facility's invoiced equipment costs. The cost of constructing the covered composting shed (including electrical costs) at Hickory Grove Farm was $109,768. The cost of composting-related equipment at this facility was $100,895, with the largest equipment expense being for the agitated bin composter ($69,095). Total invoiced construction and equipment costs for the Super Soils composting facility at the Hickory Grove site equaled $210,663.

5. Standardized Hickory Grove Economic Model

5.1 Engineering Assumptions and Description of the Physical Process

As described in Section 2, the Hickory Grove composting facility includes five composting bins. However, due to a limited incoming supply of separated swine solids, only two of these bins were used during the performance verification. With the existing equipment and design at Hickory Grove, five bins can be loaded and composting at a time, assuming that enough swine solids are available. The economic model assumes that all five bins are used at maximum composting capacity based on the existing facility size and equipment specifications (e.g., operating speed of the composter). Maximizing compost production provides the lowest predicted cost per unit composted for this facility, as construction and equipment costs are fixed. Operating costs rise when composting in five bins versus two bins while total construction and equipment costs remain unchanged.

Table SSCF.10 shows the volume of each of the five bins, as well as the amount of compost that can be added daily to each bin. The front-end loader used at the Hickory Grove site had a scooping capacity of 16 $ft.^3$, meaning that a Recipe 2 mixture contained 16 $ft.^3$ of separated swine solids and 32 $ft.^3$ of cotton gin trash. It is assumed for the economic analysis that all five bins were loaded with Recipe 2 (1 SS: 2 CGT) feedstock.

Table SSCF.11 lists the equipment operating times for activities that are necessary for the composting process at the Hickory Grove site. Total times in the far right column are calculated assuming that all five bins will be actively composting, and that each of the five bins will be agitated daily. Daily composting activities include: mixing of swine solids and bulking agent, unloading the compost bin, composting time, composter backtracking time (re-positioning the composter), and moving the composter to the proper bin. Cleaning of the composter (20 minutes) can be done during the backtracking procedure and requires no additional time. The total daily time required to compost 5 bins is calculated to be 18.92 hours. The majority of this time (10.67 hours) is spent composting/agitating, with backtracking time (4 hours) being the second most time-consuming activity at Hickory Grove.

Table SSCF.12 calculates the amount of finished compost that will be produced at the Hickory Grove site assuming that all five bins are composting, and that each bin is agitated every day (30 day retention time in bins). Volume is reduced by 74.9 % during the 30 days of retention in the composting bins. It is assumed that volume remains unchanged during the 30 days of curing, although it is likely that additional volume reductions will occur during this period. No data was provided on volume loss during curing at Hickory Grove, but industry experts have cited volume reductions in the range of 10 % during the curing stage (Coker). The compost product volumes used in this economic model should be viewed as upper bounds for a facility of this size, as the 0 % volume loss during curing is a lower bound. As indicated in Table SSCF.12, 158 cubic feet (5.84 cubic yards) of finished compost are produced each day in the standardized composting model. This is equivalent to annual production of 57,613 cubic feet (2,134 cubic yards). At a density of 42.43 lbs. / $ft.^3$ (and a moisture content of 54.7 %), 6,693 wet pounds (3.35 wet tons) of finished compost are produced each day. Annually, 2,444,578 wet pounds (1,222 wet tons) of compost are produced in the standardized Hickory Grove model.

5.2 Standardized Costs of the Hickory Grove Composting Model

Tables SSCF.13-SSCF.19 report the standardized costs associated with the Hickory Grove composting facility. Costs, mass balances, and physical parameters are based on the experiment as conducted at the Hickory Grove site. While only two bins were used during the performance verification, the standardized economic model (as reported in Tables SSCF.13-SSCF.18) makes use of all five bins available at the facility (while maintaining the demonstrated mass balance and physical parameters). Costs are reported in several ways for this technology, including as: 1.) total annualized costs; 2.) total annualized cost per dry ton of separated solid leaving the farm/entering the facility; 3.) total annualized cost per 1,000 lbs. SSLW (for various rates of manure production); and 4.) total annualized cost per cubic yard or wet ton of compost produced (break-even price of bulk compost).

Table SSCF.13 shows the total construction cost of the facility to be $301,660, resulting in an annualized construction cost of $61,470. Annual operating costs are listed as $18,699. Total annualized costs for the standardized Hickory Grove composting facility sum to $80,169. Following in Tables SSCF.14 and SSCF.15 are the annualized costs for the composting building ($26,193) and the composting equipment ($56,976). Table SSCF.16 reports the land application costs that would be associated with spreading

3,973,938 pounds (wet-weight basis) of separated solids rather than composting them. The avoided land application costs ($9,810 for nitrogen-based application to forage) are reported in Table SSCF.13. The final line of Table SSCF.13 reports the annualized cost of the composting system as $70,359. This cost represents the annualized cost of the composting operation minus the avoided land application costs.

Table SSCF.17 reports the annualized costs of the facility using the metric of $ / dry ton of separated solids received. A standardized composting facility of this size can handle 361.63 dry tons of separated solids per year. The predicted average annualized composting cost is $221.69 per dry ton of solids that leaves the farm to be treated at the standardized Hickory Grove facility. Subtracting the avoided cost of solids land application, the predicted annualized composting cost per dry ton of separated solids is $194.56 in addition to the predicted costs for technologies that produce separated solids.

Table SSCF.18 lists the annualized composting cost of the standardized facility using a metric of $ / 1,000 lbs. SSLW. Using SSLW as a denominator for annualized costs is dependent on a couple of key assumptions. The first assumption is the amount of solids that are being generated per pig per year. The second assumption is the collection efficiency of the solids separator. For the second assumption, a collection efficiency of 94% was used to reflect the performance of the Super Soils separator during the on-farm (Goshen Ridge) technology verification (see Super Soils Final Report). For the first assumption, a range of possible manure production rates are given. Low production rate reflects the actual amount of separated solids leaving Goshen Ridge Farm per day. Medium production rate represents the lowest of five theoretical values for per farm manure production (see Appendix A, Table A.25 in the Combined Appendices Report). The value used for high production rate is the average of five theoretical values for per farm manure production (see Appendix A, Table A.25 in the Combined Appendices Report). The numbers reported in the first column of Table SSCF.18 assume a 4,320-head feeder-finish farm. The second column of Table SSCF.18, indicates that 2,355 to 9,133 finishing pigs (depending on assumed manure production rate) are required to provide the amount of separated solids necessary to operate the standardized composting facility at full capacity. Predicted total annualized cost / 1,000 lbs. SSLW can range from $65.02 (low production rate) to $252.19 (high production rate). These $ / 1,000 SSLW cost estimates do not take into account the avoided cost of land applying solids nor the cost of separating solids. Neither the predicted annualized cost / dry ton of separated solids nor the predicted annualized cost / cubic yard of finished compost are affected by the assumed rate of manure production or the assumed efficiency of the separator in this model.

Table SSCF.19 reports the break-even prices associated with the standardized Hickory Grove composting facility. The first part of Table SSCF.19 lists the break-even prices for bulk compost on a per cubic yard basis. At Hickory Grove, 5.90 cubic yards of bulk compost were produced for every dry ton of separated solids entering the facility. Using this conversion factor, a break-even price of $37.57 / cubic yard can be calculated. When taking into account the avoided cost of land applying solids, the break-even price of compost for the total system will fall to $32.97 / cubic yard. The second part of Table

SSCF.19 reports the break-even price of bulk compost on a per wet ton basis. For every dry ton of separated solids entering the Hickory Grove facility, 3.38 wet tons of finished bulk compost are produced. The predicted break-even price is $65.59 / wet ton calculated by using this conversion factor. When subtracting the avoided cost of land applying solids, the predicted break-even price of the composting system falls to $57.56 / wet ton.

6. Economic Models for Proposed Super Soils Composting Facility Expansion Plans

The technology providers have proposed a couple of expansion scenarios for the Hickory Grove composting facility that they hope to incorporate in the near future. Because invoiced costs and/or cost estimates were provided for these scenarios, as well as proposed changes to engineering parameters (e.g., the backtracking speed of the composter), the economics team was able to construct cost models to represent the "next generation" costs of a standardized Hickory Grove composting facility. The annualized cost predictions for each of two expansion plans are reported in the following sections. It is important to note that these proposed expansion systems have not undergone any performance verification. It is assumed that all physical parameters associated with the composting process will remain unchanged unless explicitly indicated. The economics team treats this as a reasonable assumption but stresses that all cost estimates that follow are not supported by performance verification data.

6.1. Expansion Plan 1: Increasing the Backtracking Speed of the Composter from 4 ft. / min. to 10 ft. / min.

Expansion Plan 1 consists simply of increasing the backtracking speed of the agitated bin composter from 4 ft. / min. to 10 ft. / min. As a result of this increased backtracking speed, the composter will be able to handle seven bins per day as compared to the five bins per day that were being agitated in the standardized model. The facility will still be comprised of five bins, but two of these five bins will be agitated twice per day, with the remaining three bins being agitated only once. This will have the effect of shortening the retention time in each bin to about 21 days. As the feedstock will be moving through the bins more quickly, the facility will produce a higher annual volume (or weight) of bulk compost. Improving the backtracking speed of the composter will have a retrofitting cost of $13,333 (in addition to the initial equipment cost of $69,000) and will require an increase in the horsepower of the unit's motor from 7.5-HP to 10-HP.

6.1.1. Engineering Assumptions and Description of the Physical Process for Expansion Plan 1

Tables SSCF.20-SSCF.22 list the engineering assumptions and describe the physical parameters that are associated with Expansion Plan 1. These tables are analogous to Tables SSCF.10-SSCF.12 in the preceding section for the standardized Hickory Grove model. Table SSCF.20 displays an average of 175.98 cubic feet of feedstock being added daily to each bin. This is 40% more than the feedstock amount being added to the bins in the standardized model (see Table SSCF.10). That is because twice in every five-day period, each of the five bins will be agitated twice (as opposed to only once during the other three days). The two days with double agitation will result in 251.4 cubic feet of feedstock entering the bin, as compared to 125.7 cubic feet during the days when the bin is composted only once. The calculated weighted average is 175.98 cubic feet per day of feedstock entering each bin under the assumptions of Expansion Plan 1.

Table SSCF.21 lists the operating times for each step in the composting process for Expansion Plan 1. Due to the increased backtracking speed of the composter, backtracking time will decrease from 4 hours (see Table SSCF.11) in the standardized model to 2.24 hours in Expansion Plan 1 (despite the increase in bins composted per day from 5 to 7). All other times associated with the composting process will increase by 40% to reflect the increase in number of bins agitated per day.

Table SSCF.22 reports the amount of finished compost produced under the assumptions of Expansion Plan 1. Annually, 2,987 cubic yards (or 1,711 wet tons) of bulk compost is produced under this scenario: a 40% increase over the finished compost produced in the standardized Hickory Farm model (see Table SSCF.12). It is assumed that the finished compost produced in Expansion Plan 1 has the same physical characteristics as the finished compost produced in the standardized model, even though retention time has been reduced from 30 days to 21 days. There is no performance verification of Expansion Plan 1 to support this assumption.

6.1.2. Standardized Costs of Expansion Plan 1

Tables SSCF.23-SCF.29 report the standardized predicted costs associated with Expansion Plan 1. Costs are reported in several ways for this technology, including as: 1.) total annualized costs; 2.) total annualized cost per dry ton of separated solid leaving the farm/entering the facility; 3.) total annualized cost per 1,000 lbs. SSLW (for various rates of manure production); and 4.) total annualized cost per cubic yard or wet ton of compost produced (break-even price of bulk compost). Tables SSCF.23-SSCF.29 are analogous to Tables SSCF.13-SSCF.19 for the standardized Hickory Grove composting facility

Table SSCF.23 shows the predicted total construction cost of the Expansion Plan 1 facility to be $320,740, resulting in an annualized construction cost of $67,500. Annual operating costs are predicted as $24,223. Total annualized costs for the Expansion Plan 1 composting facility sum to $91,723. Tables SSCF.24 and SSCF.25 list the predicted annualized costs for the composting building ($26,193) and the composting equipment ($65,530). The annualized cost of the composting building remains unchanged from the standardized model (see Table SSCF.14), but the annualized cost of composting equipment increases by about 21% for Expansion Plan 1. This increase is primarily due to the higher cost of the retrofitted composter, plus increased electricity costs (more bins composted per day and higher motor HP for the composter) and tractor operating costs (more tractor hours as a result of more tons composted). Table SSCF.26 reports the land application costs that would be associated with spreading 5,563,513 pounds (wet-weight basis) of separated solids rather than composting them. The avoided land application costs ($11,425 for nitrogen-based application to forage) are reported in Table SSCF.23. The final line of Table SSCF.23 reports the predicted annualized cost of the composting system as $80,294. This cost represents the annualized cost of the facility minus the avoided land application costs for Expansion Plan 1.

Table SSCF.27 reports the annualized costs of the facility using the metric of $ / dry ton of separated solids received. The Expansion Plan 1 composting facility can process 506.28 dry tons of separated solids per year. The Expansion Plan 1 facility will have a predicted annualized composting cost of $181.17 per dry ton of manure solids. Subtracting the avoided cost of land application, predicted annualized composting cost is $156.80 per dry ton of separated solids under the assumptions of Expansion Plan 1.

Table SSCF.28 lists the annualized composting cost of the standardized facility using a metric of $ / 1,000 lbs. SSLW. The same assumptions as in the standardized model are used for separator efficiency and manure production rate. The second column of Table SSCF.28 indicates that 3,297 to 12,786 feeder pigs (depending on assumed manure production rate) are required to provide the amount of separated solids necessary to operate the Expansion Plan 1 facility at full capacity. Predicted total annualized cost / 1,000 lbs. SSLW ranges from $53.14 (low production rate) to $206.10 (high production rate). These $ / 1,000 SSLW cost predictions do not subtract the avoided cost of land applying solids. Neither the predicted annualized cost / dry ton of separated solids nor the annualized cost / cubic yard of finished compost will be affected by the assumed rate of manure production or the assumed efficiency of the separator in this model.

Table SSCF.29 reports the predicted break-even prices associated with the Expansion Plan 1 composting facility. The first part of Table SSCF.29 lists the break-even prices for bulk compost on a per cubic yard basis. At Hickory Grove, 5.90 cubic yards of bulk compost are produced for every dry ton of separated solids entering the facility. Using this conversion factor, a break-even price of $30.70 / cubic yard is calculated for the Expansion Plan 1 facility. Subtracting the avoided cost of land applying solids, the predicted break-even price of compost for the total system falls to $26.88 / cubic yard. The second part of Table SSCF.29 reports the break-even price of bulk compost on a per wet ton basis. For every dry ton of separated solids entering the Hickory Grove facility, 3.38 wet tons of finished bulk compost were produced. A break-even price of $53.60 / wet ton is calculated using this conversion factor. Subtracting the avoided cost of land applying solids, the break-even price of the total composting system falls to $46.92 / wet ton.

6.2 Expansion Plan 2: Increasing the Width of Each Bin from 6.46 Feet to 19.6 Feet

Expansion Plan 2 consists of widening each of the five bins from 6.46 feet (as constructed at Hickory Grove) to 19.6 feet. The length and depth of each bin will remain unchanged. As in Expansion Plan 1, backtracking speed of the composter will be increased from 4 ft. / min. to 10 ft. / min. Each bin will be agitated once per day, so the retention time in the bins will be 30 days. The additional mixing time that is necessary as a result of higher feedstock volumes per bin will result in only five bins per day being composted (as in the standardized Hickory Grove model and in contrast to seven bins per day in Expansion Plan 1). A larger agitated bin composter will be needed to fit the wider bins. The larger composter price was quoted at $135,723.66 and it has a 15-HP motor.

6.2.1. Engineering Assumptions and Description of the Physical Process for Expansion Plan 2

Tables SSCF.30-SSCF.32 list the engineering assumptions and describe the physical parameters that are associated with Expansion Plan 2. These tables are analogous to Tables SSCF.10-SSCF.12 and SSCF.20-SSCF.22 in the preceding sections for the standardized Hickory Grove model and Expansion Plan 1. Table SSCF.30 shows that an average of 381.3 cubic feet of feedstock is added daily to each bin. This is 203% more than the average feedstock amount being added to the bins in the standardized model (see Table SSCF.10), and 117% more than is being added in Expansion Plan 1 (see Table SSCF.20).

Table SSCF.31 lists the operating times for each step in the composting process for Expansion Plan 2. As in Expansion Plan 1, backtracking time will decrease due to the increased backtracking speed of the composter. Mixing time will increase because a larger volume of feedstock will be entering the bins each day. All other times associated with the Expansion Plan 2 composting process will be identical to those in the standardized Hickory Grove model (each model agitates five bins per day).

Table SSCF.32 reports the amount of finished compost that is produced under the assumptions of Expansion Plan 2. Annually, 6,484 cubic yards (or 3,708 wet tons) of bulk compost is produced in this scenario. It is assumed that the finished compost produced in Expansion Plan 2 has the same physical characteristics as the finished compost produced in the standardized model. There is no performance verification of Expansion Plan 2 to support this assumption.

6.2.2. Standardized Costs of Expansion Plan 2

Tables SSCF.33-SCF.39 report the predicted costs associated with Expansion Plan 2. Costs are reported in several ways for this technology, including as: 1.) total annualized costs; 2.) total annualized cost per dry ton of separated solid leaving the farm/entering the facility; 3.) total annualized cost per 1,000 lbs. SSLW (for various rates of manure production); and 4.) total annualized cost per cubic yard or wet ton of compost produced (break-even price of bulk compost). Tables SSCF.33-SSCF.39 are analogous to Tables SSCF.13-SSCF.19 and SSCF.23-SSCF.29 for the standardized Hickory Grove composting facility and Expansion Plan 1.

Table SSCF.33 reports the predicted total construction cost of the Expansion Plan 2 facility as $564,022, resulting in an annualized construction cost of $116,494. Annual operating costs are listed as $37,750. Total annualized costs for the Expansion Plan 1 composting facility sum to $154,244. Tables SSCF.34 and SSCF.35 report the predicted annualized costs for the composting building ($54,010) and the composting equipment ($100,234). The width of the composting building increases from 40 feet to 100 feet in Expansion Plan 2 to accommodate five bins of 19.6 feet in width. Accordingly, the total covered area of the composting building is increased from 9,940 feet (in the standardized model and Expansion Plan 1) to 24,850 feet. Costs for site preparation/concrete slab and the compost building are multiplied by a factor of 2.5 to reflect the increased covered area (the costs are assumed to increase linearly). Expansion Plan 2 also has a larger, more expensive composter as listed in Table SSCF.35. Equipment operating costs will increase in Expansion Plan 2 due to increased tractor hours (for mixing larger volumes of feedstock) and a larger horsepower motor for the composter. Table SSCF.36 reports the land application costs that would be associated with spreading 12,057,149 pounds (wet-weight basis) of separated solids rather than composting them. The avoided land application costs ($17,921 for nitrogen-based application to forage) are reported in Table SSCF.33. The final line of Table SSCF.33 reports the predicted annualized cost of the composting system as $136,323. This cost represents the annualized cost of the facility minus the avoided land application costs for Expansion Plan 2.

Table SSCF.37 reports the predicted annualized costs of the facility using the metric of $ / dry ton of separated solids received. The Expansion Plan 2 composting facility can process 1,097.20 dry tons of separated solids per year. Predicted cost of composting at the Expansion Plan 2 facility is $140.58 per dry ton of manure solids that leaves the farm to be treated. Subtracting the avoided cost of land application, predicted annualized composting cost is $124.25 per dry ton of separated solids under the assumptions of Expansion Plan 2.

Table SSCF.38 lists the annualized composting cost of the standardized facility using a metric of $ / 1,000 lbs. SSLW. The same assumptions as in the standardized model and Expansion Plan 2 are used for separator efficiency and manure production rate. The second column of Table SSCF.38 shows that 7,145 to 27,711 feeder pigs (depending on assumed manure production rate) are required to provide the amount of separated solids necessary to operate the Expansion Plan 2 facility at full capacity. Predicted total annualized cost / 1,000 lbs. SSLW can range from $41.23 (low production rate) to $159.92 (high production rate). These $ / 1,000 SSLW cost estimates do not take into account the avoided cost of land applying solids nor the costs of separating and transporting solids. Neither the annualized cost / dry ton of separated solids nor the annualized cost / cubic yard of finished compost will be affected by the assumed rate of manure production or the assumed efficiency of the separator.

Table SSCF.39 reports the break-even prices associated with the Expansion Plan 2 composting facility. The first part of Table SSCF.39 lists the break-even prices for bulk compost on a per cubic yard basis. At Hickory Grove, 5.90 cubic yards of bulk compost were produced for every dry ton of separated solids entering the facility. Using this conversion factor, a break-even price of $23.82 / cubic yard was calculated for the Expansion Plan 2 facility. Subtracting the avoided cost of land applying solids reduces the predicted break-even price of the Expansion Plan 2 composting system to $21.06 / cubic yard of bulk compost. The second part of Table SSCF.39 reports the break-even price of bulk compost on a per wet ton basis. For every dry ton of separated solids entering the Hickory Grove facility, 3.38 wet tons of finished bulk compost were produced. A break-even price of $41.59 / wet ton is calculated using this conversion factor. Subtracting the avoided cost of land applying solids, the break-even price of the total composting system falls to $36.76 / wet ton.

7. Summary

The Super Soils Composting technology was installed at the Hickory Grove site. The composting facility is full scale. Separated swine manure solids were transported from the Super Soils Goshen Ridge farm to the Hickory Grove composting facility during the evaluation period. Manure solids were mixed with other material in two recipes. The recipe that was used to model the costs and returns of the composting system included one part manure solids and two parts cotton gin trash. The other recipe included one part manure solids, two parts cotton gin trash, and four parts wood chips. Data from the composting evaluation (mass, volume, concentrations of moisture, carbon, nitrogen, phosphorus, and potassium) were used to define the models in this analysis. Construction and equipment prices and costs reported for the Hickory Grove facility were used in the models presented here. Input use (tractor hours, composter hours, ingredient quantities, electricity) in the models is based on information provided by the Super Soils Composting technology providers.

The composting facility includes 5 bins although only two were used in the evaluation. The standardized models and the models of proposed future designs presented here assume that facilities are used at full capacity (e.g. all 5 bins are loaded daily). The models assume that the composter is used to capacity (e.g. the compost is turned 7 days a week in the standardized model) and that the maximum quantity of mixed compost feedstock is loaded into each bin each day. The maximum loading rate and turns per day were not always attained during the evaluation. An important consideration in the costs and returns of the system is the price of bulking agents (e.g. cotton gin trash) delivered to the composting site. In the standardized model, $1,592 per year is charged for 152,935 cubic feet (= 83.8 x 5 x 365) of cotton gin trash at the composting site. The cost and returns predictions are contingent on a sufficient supply of comparable bulking agent being available at this price. Another important consideration will be the price received for the bulk compost at the composting facility. The model results presented here include no revenue for compost. Instead this report lists the price per ton or cubic yard that would be necessary to cover the predicted costs of the composting system. Note that if the operators of the composting facility can obtain the breakeven price at the facility for all the compost predicted to be produced by the facility, then the net cost of the composting operation would be zero. Note also that two breakeven price estimates have been provided for each composting facility model: one price that covers the total cost of the composting operation and another price that is reduced to reflect avoided costs of land applying solids for those on-farm technologies that have already been “charged” that cost in previous reports. The second lower breakeven price can be interpreted as the net additional cost that would be incurred by adding the composting operation to a farm that had already installed another of the technologies to separate solids. The cost of on-farm solid separation is not included in this composting cost and returns analysis.

The standardized costs and returns model (Tables SSCF.10 through SSCF.19) is very similar to the actual facility built at the Hickory Grove site; the main difference being that it is assumed to operate at design capacity on a year round basis. The facility installation cost is predicted to be $301,660. Annualized cost of the facility and equipment is predicted to be $61,470 of which about 62% is for equipment. Annual operating costs are predicted to be $18,699 so total annual costs are $80,169. The facility is assumed to receive 1,986.97 wet tons of manure solids per year (361.63 tons dry weight) and produce 1,222 wet tons (2,134 yd.[3] @54.7 % moisture) per year. The total annual costs of the operation divided by the quantities of manure and compost produce the following breakeven price estimates: $41 per wet ton ($222 per dry ton) of manure solids, $66 per wet ton of bulk compost, or $38 per cubic yard of bulk compost. The model also calculates the net cost of adding the composting operation to one of the candidate EST technologies that produces separated solids by subtracting the cost of land application of solids that was assumed in the previous reports. Land application of solids is predicted to cost $9,810 per year for the quantity used by the composting operation. The reduced net cost of the composting operation is $70,359 per year. The reduced net breakeven costs are $35 per wet ton ($195 per dry ton) of manure solids, $58 per wet ton of compost, or $33 per cubic yard of bulk compost for the standardized composting operation.

Cost estimates are converted to $ per 1,000 pounds SSLW in this report although the interpretation of those estimates differs significantly from on-farm technologies. The cost per 1,000 pounds SSLW is calculated as the cost per wet ton of manure divided by the wet tons of manure collected per 1,000 pounds SSLW per year. Therefore, efficient collection of solids at a farm results in higher composting costs per 1,000 pounds SSLW. This result is correct but it may conceal the greater benefits at a farm of improved solids removal. The estimates for $ / 1,000 pounds SSLW are reported in Table SSCF.18 and range from $65 to $252 in proportion to the quantity of wet solids collected per 1,000 pounds SSLW per year. Again, any revenue from compost sales reduces this cost.

Finally, predicted costs were calculated for two expansion scenarios proposed by the Super Soils Composting technology providers. No performance verification data accompanied these proposals so they remain speculative. Expansion Plan 1 included increased return speed for the composter resulting in a 40 percent increase over the standardized model in compost turning rate and in the volume of material composted. Breakeven costs under Expansion Plan 1 fell to $33 per wet ton ($181 per dry ton) of manure solids, $54 per wet ton of bulk compost, or $31 per cubic yard of finished compost. Expansion Plan 2 included wider composting bins and a larger composter resulting in triple the volume of material composted compared to the standardized model. Breakeven costs under Expansion Plan 2 fell to $26 per wet ton ($141 per dry ton) of manure solids, $42 per wet ton of bulk compost, or $24 per cubic yard of finished compost. Economies of scale and throughput are evident in composting cost estimates.

Tables SSCF.1-SSCF.7: Physical Characteristics and Mass Balance of Compost Produced at Hickory Grove Farm

Table SSCF.1. Monthly Separated Solids Loading Rates at Hickory Grove Farm Composting Facility (Vanotti)

	6/04	**7/04**	**8/04**	**9/04**	**10/04**	**11/04**	**12/04**	**1/05**	**Total (average)**
Manure volume ($ft.^3$)	1,275	1,607	1,518	625	1,493	1,700	1,082	1,289	**10,589**
Manure weight (x 1,000 lbs.)	65.11	83.33	77.56	32.89	79.78	88.00	55.78	67.33	**550.00**
Manure density (lbs. / $ft.^3$)	51.07	51.85	51.09	52.62	53.44	51.76	51.55	52.23	**(51.94)**
Solids content (%)	17.3	16.8	17.2	16.3	15.8	16.8	17.0	16.5	**(16.7)**
Manure total N (lbs.)	558	720	742	309	716	824	496	520	**4,885**
Manure total P (lbs.)	520	651	624	231	487	556	320	331	**3,720**
% loaded into Bin 1*	0.0	15.1	40.0	37.0	33.0	53.2	57.0	50.0	**(35.7)**
% loaded into Bin 2**	100.0	84.9	60.0	63.0	67.0	46.8	43.0	50.0	**(64.3)**

* Bin 1 used a 1 SS: 2 CGT: 4 WC mixture from 7/16/04 to 10/27/04, and a 1 SS: 2 CGT mixture from 10/28/04 to 1/15/05.

** Bin 2 used a 1 SS: 2 CGT mixture for the duration of the evaluation.

Table SSCF.2. Operating Conditions of the Hickory Grove Farm Composting Process (Vanotti)

	6/04	7/04	8/04	9/04	10/04	11/04	12/04	1/05	Average
Bin # 1									
Volume load ($ft.^3$ / day)	N/A	106	137	62	148	121	80	172	**118**
Turns / week	N/A	5.7	4.7	2.6	5.9	5.6	5.6	7.0	**5.3**
Retention time (days)	N/A	36.9	44.3	81.8	35.8	37.5	37.2	30.0	**43.4**
Moving velocity (ft./ day)	N/A	5.18	4.33	2.36	5.38	5.12	5.15	6.40	**4.85**
Bin # 2									
Volume load ($ft.^3$ / day)	128	132	88	44	129	106	60	172	**107**
Turns / week	4.4	4.5	5.9	3.3	6.3	4.4	5.0	6.5	**5.0**
Retention time (days)	47.4	46.5	35.8	64.3	33.2	47.4	42.3	32.1	**43.6**
Moving velocity (ft./ day)	4.07	4.13	5.38	2.99	5.77	4.07	4.53	5.97	**4.61**

Table SSCF.3. Physical Characteristics of Separated Swine Solids and Bulking Agents Used at Hickory Grove Farm Composting Facility (Vanotti)

	Swine Solids (SS)	Cotton Gin Trash (CGT)	Wood Chips (WC)
Density (lbs. / $ft.^3$)	51.9	5.8	28.7
Moisture content (%)	83.3	12.7	66.1
Total nitrogen (%)*	5.3	1.0	0.7
Total phosphorus (%)*	4.0	0.2	0.3
C : N*	7.2	42.0	62.9

* Dry weight basis

Table SSCF.4. Mass Balance of Compost Materials at Hickory Grove Composting Facility: Bin #1* (Vanotti)

	Feedstock (swine solids + bulking agent)	Compost product (before curing)	Percent Reduction
Material weight (x 1,000 lbs.)	410.7	227.1	44.7
Material volume ($ft.^3$)	19,367.9	6,289.3	67.5
Total carbon (lbs.)	57,573.3	30,224.4	47.5
Total nitrogen (lbs.)	2,520.0	2,500.0	0.8
Total phosphorus (lbs.)	1,402.2	1,400.0	0.2
C:N	22.8	12.1	46.9

* Bin 1 used a 1 SS: 2 CGT: 4 WC mixture from 7/16/04 to 10/27/04, and a 1 SS: 2 CGT mixture from 10/28/04 to 1/15/05.

Table SSCF.5. Mass Balance of Compost Materials at Hickory Grove Composting Facility: Bin #2* (Vanotti)

	Feedstock (swine solids + bulking agent)	Compost product (before curing)	Percent Reduction
Material weight (x 1,000 lbs.)	451.6	251.6	44.3
Material volume ($ft.^3$)	23,614.3	5,928.6	74.9
Total carbon (lbs.)	58,200.0	35,297.8	39.4
Total nitrogen (lbs.)	4,000.0	3,793.3	5.2
Total phosphorus (lbs.)	2,633.3	2,682.2	-1.9
C:N	14.6	9.3	36.3

* Bin 2 used a 1 SS: 2 CGT mixture for the duration of the evaluation.

Table SSCF.6. Mass Balance of Compost Materials at Hickory Grove Composting Facility: All Composts (Bin #1 + Bin #2) (Vanotti)

	Feedstock (swine solids + bulking agent)	Compost product (before curing)	Percent Reduction
Material weight (x 1,000 lbs.)	862.2	478.7	44.5
Material volume ($ft.^3$)	43,000.0	12,217.9	71.6
Total carbon (lbs.)	115,773.3	65,522.2	43.4
Total nitrogen (lbs.)	6,520.0	6,293.3	3.5
Total phosphorus (lbs.)	4,035.6	4,082.2	-1.2
C:N	17.8	10.4	41.6

Table SSCF.7. Physical Characteristics of Compost Product at Hickory Grove Composting Facility After 30 Days of Curing (Vanotti)

	Compost Produced Using Mix 1 (1 SS: 2 CGT: 4WC)	Compost Produced Using Mix 2 (1 SS: 2 CGT)
Moisture content (%)	44.6	54.7
Bulk density (lbs. / $ft.^3$)	29.6-32.8	42.8-45.4
Total carbon (%)*	28.6	28.8
Total nitrogen (%)*	2.01	3.22
Total phosphorus (%)*	1.25	2.96
Potassium (%)*	0.90	2.01
C:N*	14.2	8.9
pH	6.50	6.71

* Dry weight basis

Tables SSCF.8-SSCF.9: Invoiced Construction and Equipment Costs at Hickory Grove

Table SSCF.8. Invoiced Construction Costs of Super Soils Composting Facility (Campbell)

Component	Cost
Site preparation and concrete slab	$27,224
Compost bins	$16,135
Compost building (covered shed)	$50,570
Electrical costs	$15,839
Total Cost of Composting Facility	**$109,768**

Table SSCF.9. Invoiced Costs of Super Soils Composting Facility Equipment (Campbell)

Component	Cost
Agitated bin composter (7.5-HP motor)	$69,095
Front-end loader (IH Tractor—60-HP)	$4,000
Truck (1/2-ton pick-up)	$21,000
Trailers (2)	$6,600
Thermometers (2)	$200
Total Cost of Composting Equipment	**$100,895**

Tables SSCF.10-SSCF.12 : Engineering Assumptions and Physical Parameters for the Economic Model: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 4 ft. / min.

Table SSCF.10. Bin Volumes and Loading Rates at Hickory Grove (Vanotti, Campbell)

Length of bin (ft.)	192.0
Width of bin (ft.)	6.46
Depth of bin (ft.)	3.04
Volume of bin ($ft.^3$)	3,771
Retention time in bin (days)	30
Maximum daily volume added to bin ($ft.^3$)	125.7
Daily volume of swine solids added to bin ($ft.^3$)	41.9
Daily volume of cotton gin trash added to bin ($ft.^3$)	83.8

Table SSCF.11. Equipment Operating Times for Hickory Grove Composting Activities (Campbell)

Activity	Equipment	Per Unit Speed	Hours Needed for 5 Bins
Mixing of feedstock	front-end loader	120 $ft.^3$ of swine solids / hr.	1.75
Unloading compost bins	front-end loader	15 min. / bin	1.25
Composting time	agitated bin composter	18 in. / min. (128 min. / bin)	10.67
Composter backtracking time	agitated bin composter	4 ft. / min. (48 min. / bin)	4.00
Moving the composter to the proper bin	agitated bin composter	15 min. / bin	1.25
Total Time in Hours	--	--	**18.92**

Table SSCF.12. Assumed Amount (Volume and Weight) of Finished Compost Produced at Hickory Grove*

Feedstock added per bin per day	125.7 $ft.^3$
Total feedstock added per day	628.5 $ft.^3$
Volume reduction in bins	74.9 %
Compost volume removed from bins per day	157.7 $ft.^3$ (5.84 $yd.^3$)
Compost volume removed from bins per year	57,613 $ft.^3$ (2,134 $yd.^3$)
Density of compost product (before curing)	42.43 lbs. / $ft.^3$
Compost weight** removed from bins per day	6,693 wet lbs. (3.35 wet tons)
Compost weight** removed from bins per year	2,444,578 wet lbs. (1,222 wet tons)

* Assuming that all 5 bins are used for composting and that each bin is agitated daily

** In wet lbs. / tons, with a moisture content of 54.7

Tables SSCF.13-SSCF.19 : Predicted Standardized Costs of the Hickory Grove Composting Model: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 4 ft. / min.

Table SSCF.13. Predicted Cost Summary for the Standardized Hickory Grove Farm Composting Facility: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 4 ft. / min.

TOTAL CONSTRUCTION COST OF HICKORY GROVE COMPOSTING FACILITY	**$**	**301,660.32**
TOTAL OPERATING COST OF HICKORY GROVE FARM COMPOSTING FACILITY	**$**	**18,699.21**
TOTAL ANNUALIZED COSTS OF HICKORY GROVE FARM COMPOSTING FACILITY	**$**	**80,169.48**
TOTAL ANNUALIZED LAND APPLICATION SAVINGS*	**$**	**9,810.43**
TOTAL ANNUALIZED COSTS OF TOTAL COMPOSTING SYSTEM**	**$**	**70,359.05**

* Assuming nitrogen-based land application to forages

** Costs of total composting system are comprised of composting facility costs less avoided costs of land applying separated solids

Table SSCF.14. Predicted Standardized Costs of Hickory Grove Farm Composting Building: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 4 ft. / min.

Component	Total Cost		Annualized Cost	
Site Preparation and Concrete Slab	$	27,224.00	$	4,057.18
Compost Building	$	50,570.00	$	7,536.42
Compost Bins	$	16,135.00	$	2,404.59
Electrical Costs	$	15,839.00	$	2,360.48
Grass Seeding (for 50-foot buffer)	$	201.56	$	30.04
Contractor & Engineering Services & Overhead	$	47,310.01	$	7,050.59
Total Construction Cost	$	157,279.57	$	23,439.29
Maintenance Cost			$	2,195.36
Property Taxes			$	558.34
Total Operating Cost			$	2,753.70
TOTAL ANNUALIZED COST OF COMPOSTING BUILDING			**$**	**26,193.00**

Table SSCF.15. Predicted Standardized Costs of Hickory Grove Farm Composting Equipment: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 4 ft. / min.

Component	Total Cost	Annualized Cost
Agitated Bin Composter (7.5-HP)	$ 69,095.00	$ 26,811.18
Front-end Loader (IH Tractor-- 60-HP)	$ 4,000.00	$ 596.12
Truck (1/2-ton pick-up)	$ 21,000.00	$ 3,129.62
Trailers	$ 6,600.00	$ 983.59
Thermometers	$ 200.00	$ 29.81
Contractor & Engineering Services & Overhead	$ 43,485.75	$ 6,480.66
Total Construction Cost	$ 144,380.75	$ 38,030.97
Maintenance Cost		$ 4,840.75
Electric Power Cost		$ 2,982.36
Tractor Operating Cost		$ 6,017.86
Bulking Agent Cost (cotton gin trash)		$ 1,591.99
Property Taxes		$ 512.55
Total Operating Cost		$ 15,945.51
TOTAL ANNUALIZED COST OF COMPOSTING EQUIPMENT		**$ 53,976.48**

Table SSCF.16. Predicted Solids Application Cost Savings at Hickory Grove Farm Composting Facility: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 4 ft. / min.

Annual Cost of Applying Solids	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 9,810.43	$ 12,378.66
If Phosphorus-Based Application	$ 91,248.03	$ 40,772.96
Acres Needed For Application	**Forages**	**Row Crops**
If Nitrogen-Based Application	72.97	236.50
If Phosphorus-Based Application	631.61	1,687.42
Application Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 13,851.17	$ 15,975.32
If Phosphorus-Based Application	$ 21,189.02	$ 35,863.06
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ (8,269.00)	$ (4,396.28)
If Phosphorus-Based Application	$ (19,055.71)	$ (16,081.14)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 4,228.27	$ 799.63
If Phosphorus-Based Application	$ 89,114.73	$ 20,991.03

Note: Assuming that 3,973,938 lbs. / year of solids (at 16.7 % solids content, with a dry weight-basis nutrient content of 5.32 % N, 4.03 % P, and 0.54 % K) would be composted rather than land applied

Table SSCF.17. Cost per Dry Ton of Separated Solids Received for the Standardized Hickory Grove Farm Composting Facility: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 4 ft. / min.

Amount of separated solids composted per year (dry tons)	361.63
Predicted total annualized cost of composting facility / dry ton received	$221.69
Predicted total annualized cost of composting system less land application / dry ton received	$194.56

Table SSCF.18. Effect of Manure Production Rates[1] on Standardized Costs ($ / 1,000 lbs. SSLW) for the Standardized Hickory Grove Composting Facility: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 4 ft. / min.

Level of Manure Production per Farm[2]	# of Head Needed to Produce 10,880 Wet Lbs. of Solids / Day[3]	Predicted Annual Cost ($ / 1,000 lbs. SSLW)
Low Production[4] (4,094 lbs. of separated solids / day / farm)	9,133	$65.02
Medium Production[5] (14,661 lbs. of separated solids / day / farm)	3,206	$185.23
High Production[6] (19,960 lbs. of separated solids / day / farm)	2,355	$252.19

1. Assuming a 94 % separation efficiency as demonstrated in the Super Soils on-farm system (see final Super Soils report)
2. Assuming a 4,320-head feeder-finish farm
3. 10,880 wet lbs. / day of separated solids (at 18.2% solids content) are needed as feedstock to operate the standardized Super Soils composting facility at full capacity.
4. Low production rate based on actual separated solids data collected at Goshen Ridge farm (Vanotti)
5. Medium production rate based on the lowest of 5 theoretical values for solids production (see Appendix A, Table A.25 in the Combined Appendices report)
6. High production rate based on the average of 5 theoretical values for solids production (see Appendix A, Table A.25 in the Combined Appendices report)

Table SSCF.19. Break-even Analysis for the Standardized Hickory Grove Farm Composting Facility: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 4 ft. / min.

Cost to be Recovered	($ / dry ton of separated solids received)	Breakeven Price @ 5.90 cubic yards of bulk compost / dry ton of separated solids ($ / cubic yard)
Predicted cost of standardized Super Soils composting facility	$221.69	$37.57
Predicted cost of standardized Super Soils composting facility less cost savings from avoided land application of solids	$194.56	$32.97

Cost to be Recovered	($ / dry ton of separated solids received)	Breakeven Price @ 3.38 wet tons of bulk compost / dry ton of separated solids ($ / wet ton)
Predicted cost of standardized Super Soils composting facility	$221.69	$65.59
Predicted cost of standardized Super Soils composting facility less cost savings from avoided land application of solids	$194.56	$57.56

Tables SSCF.20-SSCF.22 : Engineering Assumptions and Physical Parameters for Expansion Plan 1: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Table SSCF.20. Bin Volumes and Loading Rates for Expansion Plan 1 (Vanotti, Campbell)

Length of bin (ft.)	192.0
Width of bin (ft.)	6.46
Depth of bin (ft.)	3.04
Volume of bin ($ft.^3$)	3,771
Retention time in bin (days)	21.4
Average daily volume added to bin ($ft.^3$)	175.98
Daily volume of swine solids added to bin ($ft.^3$)	58.66
Daily volume of cotton gin trash added to bin ($ft.^3$)	117.32

Table SSCF.21. Equipment Operating Times for Expansion Plan 1 (Campbell)

Activity	Equipment	Per Unit Speed	Hours Needed for 7 Bins
Mixing of feedstock	front-end loader	120 $ft.^3$ of swine solids / hr.	2.44
Unloading compost bins	front-end loader	15 min. / bin	1.75
Composting time	agitated bin composter	18 in. / min. (128 min. / bin)	14.93
Composter backtracking time	agitated bin composter	10 ft. / min. (19.2 min. / bin)	2.24
Moving the composter to the proper bin	agitated bin composter	15 min. / bin	1.75
Total Time in Hours	**--**	**--**	**23.11**

Table SSCF.22. Amount (Volume and Weight) of Finished Compost Produced with Expansion Plan 1*

Average feedstock added per bin per day	175.98 $ft.^3$
Total feedstock added per day	879.9 $ft.^3$
Volume reduction in bins	74.9 %
Compost volume removed from bins per day	220.8 $ft.^3$ (8.18 $yd.^3$)
Compost volume removed from bins per year	80,658 $ft.^3$ (2,987 $yd.^3$)
Density of compost product (before curing)	42.43 lbs. / $ft.^3$
Compost weight** removed from bins per day	9,370 wet lbs. (4.69 wet tons)
Compost weight** removed from bins per year	3,442,409 wet lbs. (1,711 wet tons)

* Assuming that all 5 bins are agitated once per day, and that 2 of the 5 bins are agitated twice per day (7 total bins can be agitated in one day with Expansion Plan 1)
** In wet lbs. / tons, with a moisture content of 54.7 %

Tables SSCF.23-SSCF.29 : Predicted Standardized Costs of Expansion Plan 1: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Table SSCF.23. Predicted Cost Summary for Expansion Plan 1: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

TOTAL CONSTRUCTION COST OF HICKORY GROVE COMPOSTING FACILITY	**$**	**320,739.84**
TOTAL OPERATING COST OF HICKORY GROVE FARM COMPOSTING FACILITY	**$**	**24,222.81**
TOTAL ANNUALIZED COSTS OF HICKORY GROVE FARM COMPOSTING FACILITY	**$**	**91,723.13**
TOTAL ANNUALIZED LAND APPLICATION SAVINGS*	**$**	**11,429.42**
TOTAL ANNUALIZED COSTS OF TOTAL COMPOSTING SYSTEM**	**$**	**80,293.71**

* Assuming nitrogen-based land application to forages
** Costs of total composting system are comprised of composting facility costs less avoided costs of land applying separated solids

Table SSCF.24. Predicted Standardized Costs of Composting Building for Expansion Plan 1: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Component	Total Cost		Annualized Cost	
Site Preparation and Concrete Slab	$	27,224.00	$	4,057.18
Compost Building	$	50,570.00	$	7,536.42
Compost Bins	$	16,135.00	$	2,404.59
Electrical Costs	$	15,839.00	$	2,360.48
Grass Seeding (for 50-foot buffer)	$	201.56	$	30.04
Contractor & Engineering Services & Overhead	$	47,310.01	$	7,050.59
Total Construction Cost	$	157,279.57	$	23,439.29
Maintenance Cost			$	2,195.36
Property Taxes			$	558.34
Total Operating Cost			$	2,753.70
TOTAL ANNUALIZED COST OF COMPOSTING BUILDING			**$**	**26,193.00**

Table SSCF.25. Predicted Standardized Costs of Composting Equipment for Expansion Plan 1: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Component	Total Cost	Annualized Cost
Agitated Bin Composter (10-HP)	$ 82,428.00	$ 31,984.83
Front-end Loader (IH Tractor-- 60-HP)	$ 4,000.00	$ 596.12
Truck (1/2-ton pick-up)	$ 21,000.00	$ 3,129.62
Trailers	$ 6,600.00	$ 983.59
Thermometers	$ 200.00	$ 29.81
Contractor & Engineering Services & Overhead	$ 49,232.27	$ 7,337.06
Total Construction Cost	$ 163,460.27	$ 44,061.02
Maintenance Cost		$ 5,507.40
Electric Power Cost		$ 4,727.64
Tractor Operating Cost		$ 8,425.00
Bulking Agent Cost (cotton gin trash)		$ 2,228.79
Property Taxes		$ 580.28
Total Operating Cost		$ 21,469.11
TOTAL ANNUALIZED COST OF COMPOSTING EQUIPMENT		**$ 65,530.13**

Table SSCF.26. Predicted Solids Application Cost Savings for Expansion Plan 1: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Annual Cost of Applying Solids	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 11,429.42	$ 14,985.36
If Phosphorus-Based Application	$ 125,470.67	$ 55,816.31
Acres Needed For Application	**Forages**	**Row Crops**
If Nitrogen-Based Application	102.16	331.10
If Phosphorus-Based Application	884.25	2,362.39
Application Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 17,086.45	$ 20,020.68
If Phosphorus-Based Application	$ 27,388.05	$ 48,942.46
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ (11,576.60)	$ (6,154.79)
If Phosphorus-Based Application	$ (26,678.00)	$ (22,513.59)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 5,919.57	$ 1,119.48
If Phosphorus-Based Application	$ 124,760.62	$ 29,387.44

Note: Assuming that 5,563,513 lbs. / year of solids (at 16.7 % solids content, with a dry weight-basis nutrient content of 5.32 % N, 4.03 % P, and 0.54 % K) would be composted rather than land applied

Table SSCF.27. Cost per Dry Ton of Separated Solids Received for Expansion Plan 1: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Amount of separated solids composted per year (dry tons)	506.28
Predicted total annualized cost of composting facility / dry ton received	$181.17
Predicted total annualized cost of total composting system / dry ton received	$158.60

Table SSCF.28. Effect of Manure Production Rates[1] on Standardized Costs ($ / 1,000 lbs. SSLW) for Expansion Plan 1: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Level of Manure Production per Farm[2]	# of Head Needed to Produce 15,232 Wet Lbs. of Solids / Day[3]	Predicted Annual Cost ($ / 1,000 lbs. SSLW)
Low Production[4] (4,094 lbs. of separated solids / day / farm)	12,786	$53.14
Medium Production[5] (14,661 lbs. of separated solids / day / farm)	4,488	$151.38
High Production[6] (19,960 lbs. of separated solids / day / farm)	3,297	$206.10

1. Assuming a 94 % separation efficiency as demonstrated in the Super Soils on-farm system (see final Super Soils report)
2. Assuming a 4,320-head feeder-finish farm
3. 15,232 wet lbs. / day of separated solids (at 18.2% solids content) are needed as feedstock to operate the standardized Super Soils composting facility at full capacity under the assumptions of Expansion Plan 1.
4. Low production rate based on actual separated solids data collected at Goshen Ridge farm (Vanotti)
5. Medium production rate based on the lowest of 5 theoretical values for solids production (see Appendix A, Table A.25 in the Combined Appendices report)
6. High production rate based on the average of 5 theoretical values for solids production (see Appendix A, Table A.25 in the Combined Appendices report)

Table SSCF.29. Break-even Analysis for Expansion Plan 1: 5 Bins at 6.46 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Cost to be Recovered	**($ / dry ton of separated solids received)**	**Breakeven Price @ 5.90 cubic yards of bulk compost / dry ton of separated solids** ($ / cubic yard)
Predicted cost of standardized Super Soils composting facility	$181.17	$30.70
Predicted cost of standardized Super Soils composting facility less cost savings from avoided land application of solids	$158.60	$26.88

Cost to be Recovered	**($ / dry ton of separated solids received)**	**Breakeven Price @ 3.38 wet tons of bulk compost / dry ton of separated solids** ($ / wet ton)
Predicted cost of standardized Super Soils composting facility	$181.17	$53.60
Predicted cost of standardized Super Soils composting facility less cost savings from avoided land application of solids	$158.60	$46.92

Tables SSCF.30-SSCF.32 : Engineering Assumptions and Physical Parameters for Expansion Plan 2: 5 Bins at 19.6 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Table SSCF.30. Bin Volumes and Loading Rates for Expansion Plan 2 (Vanotti, Campbell)

Length of bin (ft.)	192.0
Width of bin (ft.)	19.6
Depth of bin (ft.)	3.04
Volume of bin ($ft.^3$)	11,440
Retention time in bin (days)	30.0
Average daily volume added to bin ($ft.^3$)	381.3
Daily volume of swine solids added to bin ($ft.^3$)	127.1
Daily volume of cotton gin trash added to bin ($ft.^3$)	254.2

Table SSCF.31. Equipment Operating Times for Expansion Plan 2 (Campbell)

Activity	Equipment	Per Unit Speed	Hours Needed for 5 Bins
Mixing of feedstock	front-end loader	120 $ft.^3$ of swine solids / hr.	5.30
Unloading compost bins	front-end loader	15 min. / bin	1.25
Composting time	agitated bin composter	18 in. / min. (128 min. / bin)	10.67
Composter backtracking time	agitated bin composter	10 ft. / min. (19.2 min. / bin)	1.60
Moving the composter to the proper bin	agitated bin composter	15 min. / bin	1.25
Total Time in Hours	**--**	**--**	**20.07**

Table SSCF.32. Amount (Volume and Weight) of Finished Compost Produced with Expansion Plan 2*

Average feedstock added per bin per day	381.3 $ft.^3$
Total feedstock added per day	1,906.5 $ft.^3$
Volume reduction in bins	74.9 %
Compost volume removed from bins per day	478.6 $ft.^3$ (17.73 $yd.^3$)
Compost volume removed from bins per year	174,801 $ft.^3$ (6,474 $yd.^3$)
Density of compost product (before curing)	42.43 lbs. / $ft.^3$
Compost weight** removed from bins per day	20,307 wet lbs. (10.15 wet tons)
Compost weight** removed from bins per year	7,416,986 wet lbs. (3,708 wet tons)

* Assuming that all 5 bins are agitated once per day

** In wet lbs. / tons, with a moisture content of 54.7 %

Tables SSCF.33-SSCF.39: Predicted Standardized Costs of Expansion Plan 2: 5 Bins at 19.6 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Table SSCF.33. Predicted Cost Summary for Expansion Plan 2: 5 Bins at 19.6 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

TOTAL CONSTRUCTION COST OF HICKORY GROVE COMPOSTING FACILITY	**$**	**564,021.88**
TOTAL OPERATING COST OF HICKORY GROVE FARM COMPOSTING FACILITY	**$**	**37,749.97**
TOTAL ANNUALIZED COSTS OF HICKORY GROVE FARM COMPOSTING FACILITY	**$**	**154,244.36**
TOTAL ANNUALIZED LAND APPLICATION SAVINGS*	**$**	**17,921.10**
TOTAL ANNUALIZED COSTS OF TOTAL COMPOSTING SYSTEM**	**$**	**136,323.27**

* Assuming nitrogen-based land application to forages
** Costs of total composting system are comprised of composting facility costs less avoided costs of land applying separated solids

Table SSCF.34. Predicted Standardized Costs of Composting Building for Expansion Plan 2: 5 Bins at 19.6 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Component	Total Cost		Annualized Cost	
Site Preparation and Concrete Slab	$	68,060.00	$	10,142.95
Compost Building	$	126,425.00	$	18,841.05
Compost Bins	$	16,135.00	$	2,404.59
Electrical Costs	$	15,839.00	$	2,360.48
Grass Seeding (for 50-foot buffer)	$	232.69	$	34.68
Contractor & Engineering Services & Overhead	$	97,603.83	$	14,545.85
Total Construction Cost	$	324,295.52	$	48,329.60
Maintenance Cost			$	4,529.18
Property Taxes			$	1,151.25
Total Operating Cost			$	5,680.43
TOTAL ANNUALIZED COST OF COMPOSTING BUILDING			**$**	**54,010.02**

Table SSCF.35. Predicted Standardized Costs of Composting Equipment for Expansion Plan 2: 5 Bins at 19.6 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Component	Total Cost	Annualized Cost
Agitated Bin Composter (15-HP)	$ 135,723.66	$ 52,665.33
Front-end Loader (IH Tractor-- 60-HP)	$ 4,000.00	$ 596.12
Truck (1/2-ton pick-up)	$ 21,000.00	$ 3,129.62
Trailers	$ 6,600.00	$ 983.59
Thermometers	$ 200.00	$ 29.81
Contractor & Engineering Services & Overhead	$ 72,202.70	$ 10,760.33
Total Construction Cost	$ 239,726.36	$ 68,164.80
Maintenance Cost		$ 8,172.18
Electric Power Cost		$ 5,065.32
Tractor Operating Cost		$ 13,150.81
Bulking Agent Cost (cotton gin trash)		$ 4,830.20
Property Taxes		$ 851.03
Total Operating Cost		$ 32,069.54
TOTAL ANNUALIZED COST OF COMPOSTING EQUIPMENT		**$ 100,234.34**

Table SSCF.36. Predicted Solids Application Cost Savings for Expansion Plan 2: 5 Bins at 19.6 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Annual Cost of Applying Solids	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 17,921.10	$ 26,058.48
If Phosphorus-Based Application	$ 267,539.10	$ 127,335.54
Acres Needed For Application	**Forages**	**Row Crops**
If Nitrogen-Based Application	221.40	717.56
If Phosphorus-Based Application	1,916.33	5,119.73
Application Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 30,180.91	$ 36,970.94
If Phosphorus-Based Application	$ 54,976.14	$ 112,438.66
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ (25,088.61)	$ (13,338.56)
If Phosphorus-Based Application	$ (57,816.09)	$ (48,791.07)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 12,828.80	$ 2,426.11
If Phosphorus-Based Application	$ 270,379.05	$ 63,687.95

Note: Assuming that 12,057,149 lbs. / year of solids (at 16.7 % solids content, with a dry weight-basis nutrient content of 5.32 % N, 4.03 % P, and 0.54 % K) would be composted rather than land applied

Table SSCF.37. Cost per Dry Ton of Separated Solids Received for Expansion Plan 2: 5 Bins at 19.6 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Amount of separated solids composted per year (dry tons)	1,097.20
Predicted total annualized cost of composting facility / dry ton received	$140.58
Predicted total annualized cost of composting system less land application / dry ton received	$124.25

Table SSCF.38. Effect of Manure Production Rates[1] on Standardized Costs ($ / 1,000 lbs. SSLW) for Expansion Plan 2: 5 Bins at 19.6 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Level of Manure Production per Farm[2]	# of Head Needed to Produce 33,011 Wet Lbs. of Solids / Day[3]	Predicted Annual Cost ($ / 1,000 lbs. SSLW)
Low Production[4] (4,094 lbs. of separated solids / day / farm)	27,711	$41.23
Medium Production[5] (14,661 lbs. of separated solids / day / farm)	9,727	$117.46
High Production[6] (19,960 lbs. of separated solids / day / farm)	7,145	$159.92

1. Assuming a 94 % separation efficiency as demonstrated in the Super Soils on-farm system (see final Super Soils report)
2. Assuming a 4,320-head feeder-finish farm
3. 33,011 wet lbs. / day of separated solids (at 18.2% solids content) are needed as feedstock to operate the standardized Super Soils composting facility at full capacity under the assumptions of Expansion Plan 2.
4. Low production rate based on actual separated solids data collected at Goshen Ridge farm (Vanotti)
5. Medium production rate based on the lowest of 5 theoretical values for solids production (see Appendix A, Table A.25 in the Combined Appendices report)
6. High production rate based on the average of 5 theoretical values for solids production (see Appendix A, Table A.25 in the Combined Appendices report)

Table SSCF.39. Break-even Analysis for Expansion Plan 2: 5 Bins at 19.6 ft. in Width, Composting Speed of 18 in. / min. and Backtracking Speed of 10 ft. / min.

Cost to be Recovered	**($ / dry ton of separated solids received)**	**Breakeven Price @ 5.90 cubic yards of bulk compost / dry ton of separated solids** ($ / cubic yard)
Predicted cost of standardized Super Soils composting facility	$140.58	$23.82
Predicted cost of standardized Super Soils composting facility less cost savings from avoided land application of solids	$124.25	$21.06

Cost to be Recovered	**($ / dry ton of separated solids received)**	**Breakeven Price @ 3.38 wet tons of bulk compost / dry ton of separated solids** ($ / wet ton)
Predicted cost of standardized Super Soils composting facility	$140.58	$41.59
Predicted cost of standardized Super Soils composting facility less cost savings from avoided land application of solids	$124.25	$36.76

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