Development of Environmentally Superior Technologies

Phase 3 Report

for Technology Determinations per Agreements
Between the Attorney General of North Carolina and Smithfield Foods,
Premium Standard Farms, and Frontline Farmers

March 8, 2006

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TO ALL INTERESTED PARTIES:

This report was compiled pursuant to Sections III.B.5 and III.B.6 of Agreements, dated July 25, 2000 and September 30, 2000 between the Attorney General of North Carolina and Smithfield Foods, Inc. and Premium Standard Farms, Inc., respectively.

Copies of this report are transmitted on this date to the North Carolina Attorney General, Smithfield Foods, Premium Standard Farms, and Frontline Farmers. A copy is also transmitted to the North Carolina Environmental Review Commission. A full copy of this report is on file in the North Carolina State University (NCSU) Animal & Poultry Waste Management Center (APWMC) administrative office located in room 134 Scott Hall on the NCSU north campus.

A complete electronic copy of this report will be posted on the NCSU College of Agriculture and Life Sciences Waste Management Programs web site http://www.cals.ncsu.edu/waste_mgt/ within 30 business days of today's date.

Respectfully submitted,

C.M. (Mike) Williams, Ph.D.
Agreements' Designee

PREFACE

This report comprises the third in a series of technology determinations for candidate Environmentally Superior Technologies made by the Designee as described and mandated by agreements between the Attorney General of North Carolina, Smithfield Foods, Premium Standard Farms, and Frontline Farmers. Phase 1 and 2 technology determination reports were previously published.[1]

The determinations reported are based on environmental performance data and economic feasibility analyses. Research teams comprised of faculty and staff from North Carolina State University, the University of North Carolina – Chapel Hill, Duke University, University of Georgia, and the United States Department of Agriculture conducted the studies reported and referenced herein. A full-service environmental and agricultural engineering firm, Cavanaugh & Associates, P.A., served as Project Technical Manager, with responsibility of permit and construction management for the candidate technologies located on commercial-scale farms.

An advisory panel appointed by the Designee has provided invaluable input and review to this process. Their participation and oversight has contributed significantly to decisions made by the Designee regarding the technology determinations. The panel is made up of individuals with expertise in animal waste management as well as individuals with an interest in the development of Environmentally Superior Technologies. The panel's representation is comprised of academic research scientists, engineers, public health and public law experts, and economists. In addition, individuals representing community interests, environmental interests, North Carolina Department of Environment and Natural Resources, United States Environmental Protection Agency, agribusiness, farm owners and swine contract growers (Frontline Farmers), and the companies (Smithfield Foods and Premium Standard Farms) are on the appointed panel.

The following abbreviations and acronyms are used frequently throughout this report:

- Agreements – Agreements between the Attorney General of North Carolina and Smithfield Foods, Premium Standard Farms, and Frontline Farmers
- EST – Environmentally Superior Technologies
- Designee – C.M. (Mike) Williams, as appointed per the Agreements
- NCDENR – North Carolina Department of Environment and Natural Resources
- PSF – Premium Standard Farms
- Smithfield – Smithfield Foods and Subsidiaries

[1] Development of Environmentally Superior Technologies. 2004. Phase 1 Technology Determination Report, published by NCSU College of Agriculture and Life Sciences, 941 pgs, on file with NCSU Animal and Poultry Waste Management Center (July 26, 2004). Also available at www.cals.ncsu.edu/waste_mgt/

Development of Environmentally Superior Technologies. 2005. Phase 2 Technology Determination Report, published by NCSU College of Agriculture and Life Sciences, 1,428 pgs, on file with NCSU Animal and Poultry Waste Management Center (July 25, 2005). Also available at www.cals.ncsu.edu/waste_mgt/

Summary

Efforts to identify and implement "Environmentally Superior Technologies" (EST) onto swine farms in North Carolina were initiated in 2000 by the Attorney General of North Carolina through agreements with Smithfield Foods (SF) and Premium Standard Farms PSF). A third and related agreement was established with Frontline Farmers in 2002. This report documents the "Technology Determinations" as described in the Agreements: a written determination by the Agreements' Designee that contains findings relative to a technology or combination of technologies as an EST.

Considerations for EST, which were mandated by the Agreements, included technical, operational, and economic criteria. Technical (Environmental) performance standards (previously established by the North Carolina General Assembly) targeted the discharge of animal waste to surface waters and groundwater, emission of ammonia, emission of odor, release of disease-transmitting vectors and airborne pathogens, and nutrient and heavy metal contamination of soil and groundwater. The determination of economic feasibility included consideration of technology costs and the estimated impact that the adoption of EST could have on the competitiveness of the North Carolina pork industry. A cost-benefit analysis was also conducted; this was done to compare the relative advantages of the different candidate technologies but was not included in the determination of economic feasibility.

An advisory panel appointed by the Designee provided input and oversight to this initiative. The panel was composed of academic research scientists, engineers, public health and public law experts, and economists. In addition, individuals representing community interests, environmental interests, North Carolina Department of Environment and Natural Resources, U.S. Environmental Protection Agency (USEPA), agribusiness, farm owners and swine contract growers (Frontline Farmers), and the companies (SF and PSF) were represented.

Candidate technologies studied in North Carolina included a covered in-ground anaerobic digester with biological trickling filters and greenhouse vegetable production system, a sequencing batch reactor system, two belt manure removal systems, several solids separation systems, a constructed wetland system, a reciprocating wetland system, an upflow biological aerated filter system, a gasification system, a fluidized bed combustion system, an insect biomass conversion system, mesophilic and thermophilic anaerobic digesters, a water reuse system, permeable lagoon covers with aerobic blanket system, a nitrification and denitrification soluble phosphorus removal system, a centralized composting system, and a closed loop chemical treatment system. In addition to these systems, technologies not funded directly by this initiative but under development by SF in Utah (bio-diesel fuel from manure project), PSF in Missouri (manure to fertilizer project and several other technologies per a consent agreement between PSF and the state of Missouri and USEPA) are under consideration as candidate EST.

Analyses and review of economic data compiled for all candidate EST showed the projected additional annualized (10 years) costs of retrofitting existing lagoon spray field farms with EST for a complete treatment system (liquid and solids treatment) ranges between approximately $90 to over $400 per 1,000 lbs. steady state live weight per year. This compares to a predicted approximate cost of $85 per 1,000 lbs. steady state live

weight per year for constructing a permitted lagoon spray field system in North Carolina in 2004. The economic analysis also showed that adopting candidate EST may result in annual reductions in the North Carolina inventory of pork. In addition, the study concluded that sources of financial support, including cost share programs to help finance the additional costs may be available in the future, with the most promising opportunities for technologies that generate energy; however, no significant sources of such support are currently available.

Following extensive review of the economic data and associated issues, discussion, debate, and input by the referenced advisory panel (documented herein), economic feasibility was defined by the Designee as follows: *A technology may be economically feasible even though it would impose incremental cost increases on the North Carolina swine industry and potentially result in a reduction in swine herd size in North Carolina. Technologies will be considered candidates for EST Determinations only if the maximum predicted reduction in herd size resulting from implementation would not exceed 12 percent. The Designee will be responsible for determining whether the predicted herd size reduction that would result from the implementation of a technology is sufficiently accurate to consider it a candidate for determination as an EST. The Designee will also be responsible for determining, and limiting his determination and implementation recommendations to a category, or categories of farms, to ensure that an EST Determination would not result in unintended negative impacts and consequences for other farms which are dependent on the EST farms for their ongoing supply of production animals.*

Based on the criteria for the technical and economic standards, review of all available data, and advisory panel inputs, the following Technology Determinations are made at this time:

<u>New farm category</u>*: Designee concludes that the solids separation / nitrification–denitrification / soluble phosphorus removal system ("Super Soils" technology as described in a previously published {July 26, 2004} technology determination report) in combination with any one of the following four solids treatment systems: the high solids anaerobic digester ("ORBIT" technology as described in the July 26, 2004 report); "Super Soil Systems" centralized composting system; gasification for elimination of swine waste solids with recovery of value-added products system; and "BEST" – fluidized bed combustion of solids system (the latter 3 systems as described in a previously published {July 25, 2005} technology determination report) comprise an unconditional Environmentally Superior Technology for new farms which are permitted and constructed for the first time after the date of this report. This determination is limited to the following types of farms: farms using EST on sites that have not been used previously for the production of swine ("Greenfields"); construction of new swine facilities using the EST on farms which previously housed swine, but which are no longer permitted for that purpose; and expansions (for purposes of increasing permitted herd size) of existing swine farms using the EST to treat waste for new construction on such existing swine farms. In the case of expansions, this determination applies only to the waste generated from the expansion.*

Existing farm categories*: Designee concludes that contingent EST, as described in the July 2004 and 2005 technology determination reports, have not at the current time met economic feasibility conditions required for unconditional EST to be implemented onto existing farm categories in North Carolina.*

The scope of the Technology Determinations herein is considered final and inclusive of the candidate technologies described in this report. Any subsequent Technology Determinations, including contingent determinations that have been described in the referenced July 2004 and July 2005 reports, and also including technologies under development by parties to the Agreements that were referenced in those reports, that may be made by the Designee will be based on available data and appropriate outside critical review and inputs resulting from efforts that go beyond those described in this report.

The results reported herein collectively show that this initiative has resulted in a combination of 5 technologies that meet environmental performance standards that have been established by the North Carolina General Assembly. The data also show that with technical modifications and improvements (some of which may only be minor), several of the additional technologies considered in this initiative may meet the environmental performance criteria. However, the technologies studied which have been shown to meet the environmental performance standards and would be required for a complete liquid and solids treatment system currently exceed the threshold cost for economic feasibility as defined herein for existing categories of farms.

Based on these findings the following next steps are recommended:

Continue, as expeditiously as possible, current efforts by targeted technology suppliers and researchers to improve upon their treatment processes to reduce the costs of their respective treatment systems.

Establish a framework or process by which additional technologies may be considered viable Environmentally Superior Technologies. This would include technologies that can be improved upon (technically and / or operationally and / or economically) as a result of information derived from this initiative, as well as technologies that were not part of this funded initiative.

Identify potential institutional incentives, public policies, and markets related to the sale of byproducts (with priority on energy production) that will reward farmers for utilizing technologies identified by this process that are shown to yield improvements and environmental benefits over the current lagoon spray field system. The optimal method of achieving net cost reductions and even positive revenue flows from alternative technologies is to install targeted technologies on a sufficient number of farms to facilitate engineering improvements, value-added product market development, and other cost reduction methods.

1.0 Introduction and Overview

Agreements: Efforts to identify and implement "Environmentally Superior Technologies" (EST) onto swine farms in North Carolina were initiated in July 2000 by the Attorney General of North Carolina by an agreement with Smithfield Foods and its subsidiaries and a similar agreement (in September 2000) with Premium Standard Farms. A third and related agreement was established with Frontline Farmers in 2002.[2]

Performance standards and economic feasibility: Technical environmental performance standards defined in the Agreements and previously established by the North Carolina General Assembly[3] mandate that successful EST address the discharge of animal waste to surface waters and groundwater; emission of ammonia; emission of odor; release of disease-transmitting vectors and airborne pathogens; and nutrient and heavy metal contamination of soil and groundwater. Although not a component of the referenced Session Law 1998-188, House Bill 1480, comprehensive determinations of economic feasibility are mandated by the terms and conditions of the Agreements. Targeted economic variables include projected 10-year annualized costs and returns analysis for each technology; projected revenues from byproduct utilization; consideration of available cost-share monies; and the impact that the adoption of the EST may have on the competitiveness of the North Carolina pork industry as compared to the pork industry in other states.

Advisory panel: The Agreements mandate that an advisory panel provides input and peer review of this overall initiative. The panel is made up of individuals with expertise in animal waste management as well as individuals with an interest in the development of Environmentally Superior Technologies. The panel's representation is comprised of academic research scientists, engineers, public health and public law experts, and economists. In addition, individuals representing community interests, environmental interests, North Carolina Department of Environment and Natural Resources, U.S. Environmental Protection Agency, agribusiness, farm owners and swine contract growers (Frontline Farmers), and the companies (Smithfield Foods and Premium Standard Farms) are on the appointed panel (see Appendix E for names and affiliations of panel members).

Candidate technologies: Beginning in 2000 candidate EST technologies were competitively selected. They included solids separation systems, a covered in-ground anaerobic digester with biological trickling filters and greenhouse vegetable production, mesophilic and thermophilic anaerobic digesters, a sequencing batch reactor, an upflow biological aerated filter system, a gasification system, belt manure removal systems, and wetland systems. In addition to these systems, technologies not funded directly by this initiative but under development by Smithfield Foods in Utah (biodiesel fuel from manure project), Premium Standard Farms in Missouri (manure to fertilizer project and several other technologies per a consent decree between Premium Standard Farms and

[2] See Agreements between Attorney General of North Carolina and SF, PSF, and Frontline Farmers (North Carolina Department of Justice, on file with Ryke Longest, 2000 & 2002). Also available at www.cals.ncsu.edu/waste_mgt/

[3] See General Assembly of North Carolina, Session 1997, Session Law 1998-188, House Bill 1480

the state of Missouri and USEPA), Sustainable North Carolina and Frontline Farmers (closed-loop swine waste management system located in Eastern North Carolina) are considered candidate EST. Table 1 shows the technology names and status of the environmental and economic studies. Technical and economic data procurement for all of the projects located in North Carolina and funded under the initial July 2000 Agreements and has been completed to date.

Detail progress reports describing the EST initiative between the dates of July 25, 2000 and July 25, 2003 have been published.[4] In July 2004 and July 2005 Technology Determination Reports were issued.[5] These reports comprised written determinations relative to a technology's or combination of technologies' candidacy as an EST. The July 2004 report focused on eight of the candidate EST, and two were shown to be capable of meeting the Agreements' technical performance standards and were declared to be contingent EST. Those technologies were: 1) the solids separation/nitrification–denitrification/soluble phosphorus removal system ("Super Soils" technology) and 2) the high solids anaerobic digester system ("ORBIT" technology). The July 2005 report focused on an additional eight funded technology candidates not covered in the July 2004 report and showed that three of those technologies also met the identified technical performance standards and were declared to be contingent EST; those technologies were: 1) "Super Soil Systems" centralized composting system, 2) gasification for elimination of swine waste solids with recovery of value-added products system, and 3) "BEST" – fluidized bed combustion of solids system. It is noted that these latter three technologies as well as the "ORBIT" technology described in the 2004 report are specific for the treatment of swine manure solids only. Each of these technologies must be combined with a system that successfully removes solids and also successfully treats (meets EST technical performance criteria) the liquid components of the waste stream (urine and/or flushed manure slurry).

Some of the candidate technologies studied as part of both the Phase 1 and Phase 2 determinations met many of the technical feasibility performance criteria. For these technologies it is possible that making technology modifications and/or combining treatment unit processes between other candidate EST may enable them to meet all of the EST technical feasibility performance criteria. An Engineering Subcommittee made up of nine of the above referenced panel members carefully studied the possible combination of candidate EST technology treatment unit processes for the purpose of making a

[4] See Development of Environmentally Superior Technologies: One, Two, and Three Year Progress Reports, published by NCSU College of Agriculture and Life Sciences, on file with NCSU Animal and Poultry Waste Management Center (July 25, 2001; 2002; 2003). Also available at www.cals.ncsu.edu/waste_mgt/

[5] See Development of Environmentally Superior Technologies: Phase 1 Technology Determination Report, published by NCSU College of Agriculture and Life Sciences, 941 pgs, on file with NCSU Animal and Poultry Waste Management Center (July 26, 2004). Also available at www.cals.ncsu.edu/waste_mgt/ and,
Development of Environmentally Superior Technologies. 2005. Phase 2 Technology Determination Report, published by NCSU College of Agriculture and Life Sciences, 1428 pgs, on file with NCSU Animal and Poultry Waste Management Center (July 25, 2005). Also available at www.cals.ncsu.edu/waste_mgt/

determination of an EST; their Recommendation Document is contained herein as Appendix C.

Economic feasibility: For the mandated economic analysis, projected costs of retrofitting existing lagoon spray-field systems have been estimated for the candidate technologies and are collectively provided herein and in the referenced July 2005 report (see Appendix B.1 of the July 2005 report). The impacts of adopting EST technologies on the competitiveness of the N.C. pork industry were reported in detail in the July 2005 report (see Appendix B.2 of the July 2005 report). An Economics Subcommittee comprised of 10 appointed members of the above referenced advisory panel reviewed these data and the methods utilized to derive them. Reports from this subcommittee are provided herein as Appendix D.

Phase 3 technology determinations: The report herein provides technical data for two technologies that were not included in the Phase 1 and 2, July 2004 and 2005 reports. Economic costs and returns data are provided for all candidate technologies for which that information was not reported in the July 2004 report. This report, however, summarizes technical (see report summary data that follow this section) and economic feasibility data (see referenced Tables in Section 3.0) for all technologies studied to date that were funded under the initial July 2000 Agreements. EST status for all of these referenced candidate technologies and next step recommendations as determined by the Designee are provided.

2.0 Candidate Environmentally Superior Technology Descriptions

Concise descriptions, schematics, and figures for each of the Phase 3 candidate EST follow. Additional information related to the farm or experimental sites where the technologies were evaluated is provided in Table 2.

"AgriClean" Mesophilic digester and "AgriJet" flush system – Bobby Ray Harris Farm, Belvoir, NC – 11520 head finisher

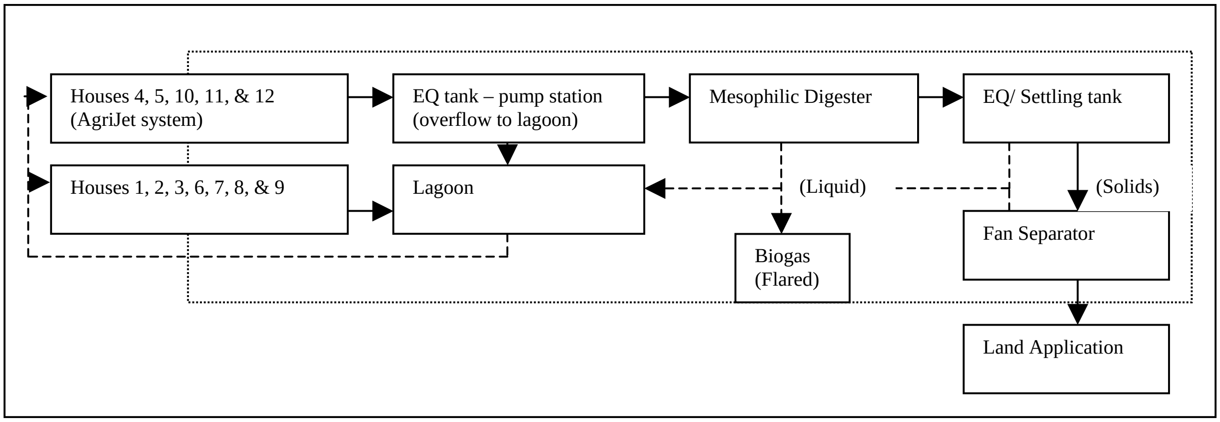
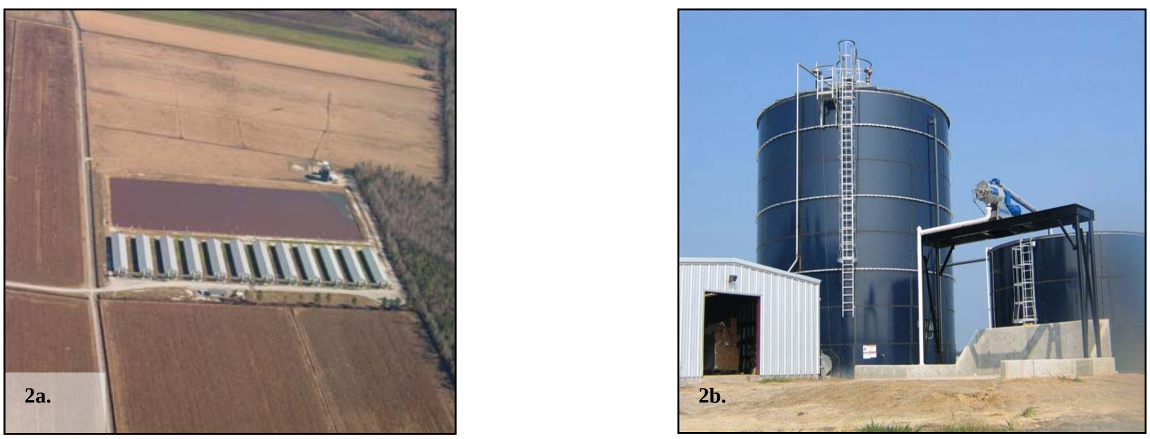


Figure 1. Process flow diagram for AgriClean technology.



Figures 2a and b. Aerial view of BR Harris Farm and image of fixed – film mesophilic digester with settling tank and fan separator.

The AgriClean technology consists of an EQ tank/pump station, a fixed-film mesophilic anaerobic digester, a setting tank and a Fan separator, with the system receiving waste from five of the 12 finishing houses. The five test houses housed a pressure flush style waste removal system (AgriJet system - not funded through the EST candidate process). Approximately 13,000 gallons of wastewater was delivered daily to the 255,000-gallon mesophilic digester, which was mixed and recirculated through a heat exchanger to provide the target digester temperature of 95^{o}F. Both undigested and settled solids were transferred to a settling/EQ tank, which was designed to deliver the solids through a Fan separator for additional solid separation. Biogas produced as a result of the digestion process was to be utilized as a heat source for the mesophilic digester (heat exchanger). All processed liquid was returned to the existing lagoon.

Environmental Technologies – Red Hill Farm, Ayden, NC – 3,700 head finisher

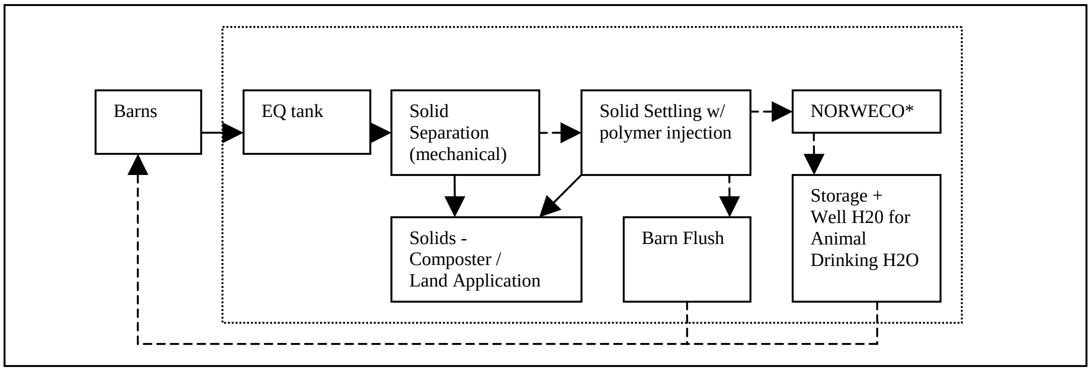


Figure 3. Process flow diagram for Environmental Technologies technology.
* NORWECO - This system provides a tertiary treatment to water that will be used as animal drinking water through filtration and aeration.

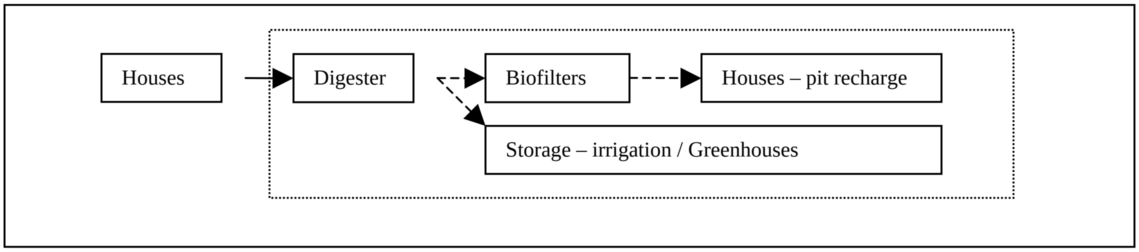
Figures 4 a, b, c and d. Aerial image of Red Hill Farm, solid separation components and NORWECO filtration component of Environmental Technologies technology.

The Environmental Technologies (ET) technology components include an EQ tank, solid separation (mechanical - screen) (4a & b), polymer injection with additional solid separation (settling tank) (4c), and aeration filtration (NORWECO) (4d). Solids separated with the mechanical solid separator were land applied; however, an additional treatment of the solids through mechanical composting was offered as an alternate option. The NORWECO filtration system provides drinking water (with the addition of well water) for the animals housed on the farm.

2.1 Process flow Diagrams and Technical Performance Summaries for all EST Candidates

The following diagrams and summary tables are provided as a concise overview and do not provide all of the details that were considered by the Designee and the Advisory Panel needed to evaluate the candidate technologies. Readers are strongly encouraged to refer to the appendices herein as well as in the referenced July 2004 and July 2005 Technology Determination reports for the details of candidate EST.

Ambient Temperature Anaerobic Digester and Greenhouse for Swine Waste Treatment and Bioresource Recovery at "Barham Farm"



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	1.5 / 1.2	4.2 / 3.6	.64 / .46	3.4 / 3.1		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	4.1	5.2	4.9	2.8	3.7	4.8
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-66.4	58.8	13.8	-21.5	-11.9	2.5
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**TP**	**Cu**	**Zn**	
Anaerobic Digester	28	+3	81	89	87	
Biofilters	21 (29 trickling biofilters[5])	21	11	33	7	

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[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

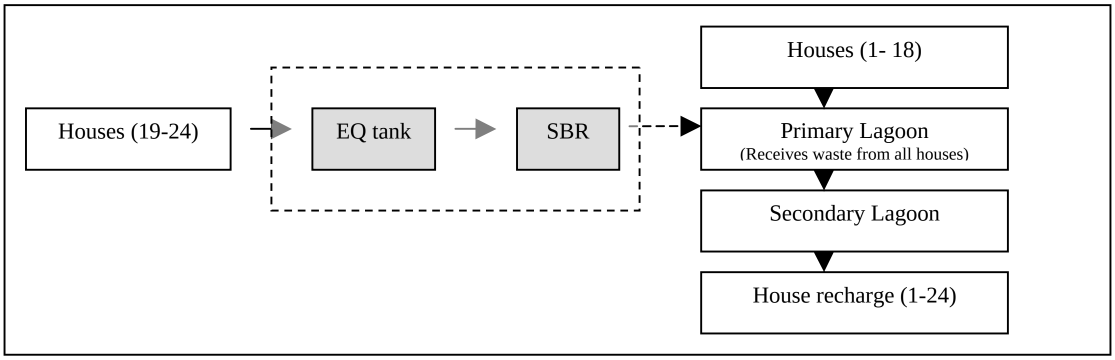
[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

[5] Value reflects nitrification efficiency of biofilters and also represents annual average. Summer season was reported to be approximately 90% nitrification efficiency.

"ANT" Sequencing batch reactor system



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	1.4 / 1.7	3.4 / 4.0	.65 / .79	2.9 / 3.4		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	1.7	1.7	2.8	0.6	1.9	0.9
SBR + Lagoons	3.0	2.9	3.0	0.5	2.0	1.2
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	31.5	-23.5	-95.0	98.0	-4.9	67.2
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
SBR	83.0	96.8	-	-	-	
w/ biosolids separation	90.0	96.8	36.5	76.1	81.4	

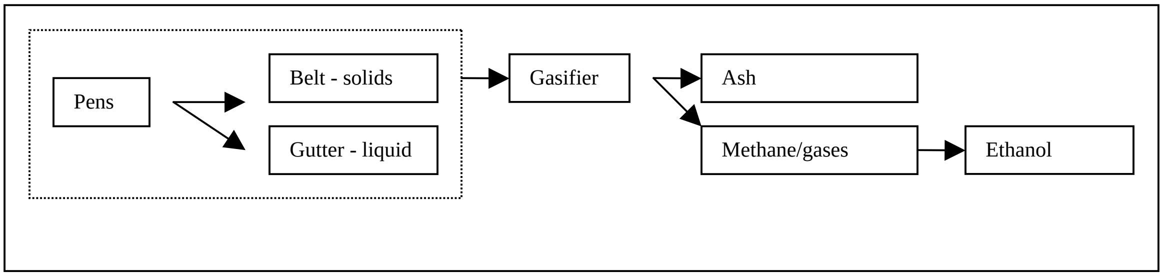
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions). As noted in the full report for this technology (Appendix A.9 from Phase 2 Report, July 2005, pages 33-34) less than 1% of the ammonia emissions are from the "ANT" treatment system.

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

Belt System for Manure Removal (Grinnells)



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	.04 / NA	1.9 / NA	0 / NA	0.9 / NA		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	0.0	0.0	-2.2*	0.2	ND	1.0
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-	-	-59.8	55.3	-59.8	55.3
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
	-	-	-	-	-	

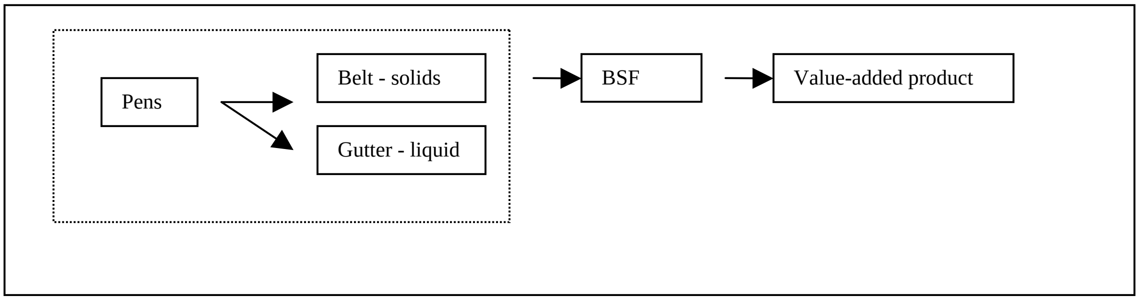
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions). This system did not include a water-holding structure.

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery. This is a solid separation system component.

Belt System for Manure Removal (LWFL)



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	0.07/ NA	1.7 / NA	0 / NA	1.1 / NA		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	-0.6	-0.4	0.4	-0.6	-0.6	-0.4
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-	-	-88.7	21.9	-88.7	21.9
Nutrients[4] **% Reduction**	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
	80.2	-	75.4	76.2	75.8	

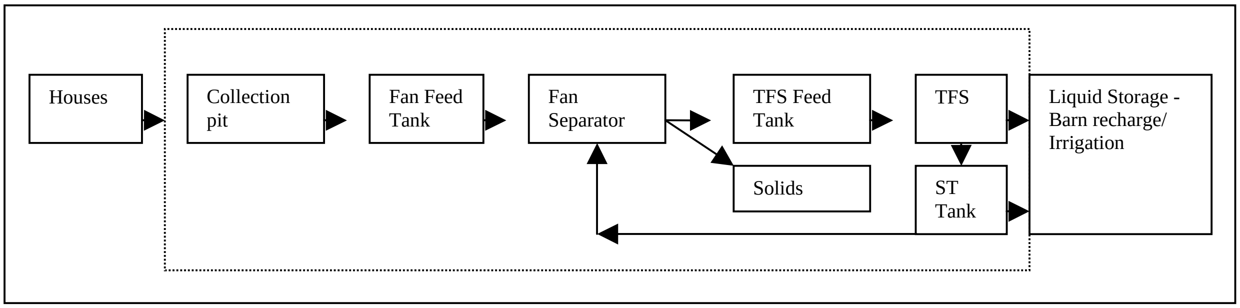
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions). This system did not include a water-holding structure.

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery. This is a solid separation system component.

"BEST" (solids / liquids separation) Biomass Energy Sustainable Technology Site 1 (FAN® + TFS)

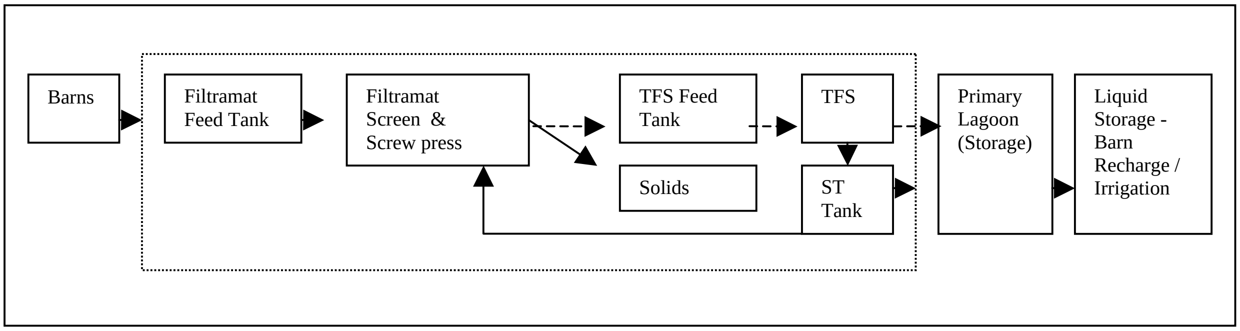


Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	1.0 / 1.2	3.3 / 3.4	0.4 / 0.4	2.6 / 2.8		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	0.2	0.3	0.1	0.0	0.4	0.1
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	71.1	13.6	73.0	97.0	71.8	66.0
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**TP**	**Cu**	**Zn**	
FAN	2	2	15	9	4	
TFS (at FAN site)	15	4	55	50	58	
Mass Recovery FAN + TFS	1.1	-	1.2	3.4	2.9	

[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.
[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)
[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).
[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"BEST" (solids/liquids separation) Biomass Energy Sustainable Technology Site 2 (Filtramat™ + TFS)

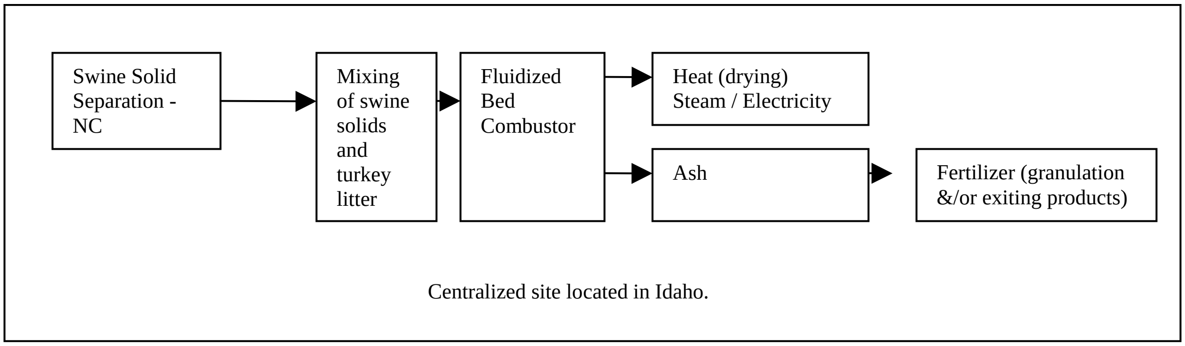


Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	1.0 / 1.0	3.0 / 2.8	0.4 / 0.3	2.5 / 2.1		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	0.4	0.2	0.7	-0.4	0.1	1.9
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	39.6	7.4	-184.0	22.0	-29.2	17.0
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
Filtramat TFS (at Filtramat site)	4 15	3 2	-12 40	15 46	15 56	
Mass Recovery Filtramat + TFS	2.5	-	3.9	11.4	11.9	

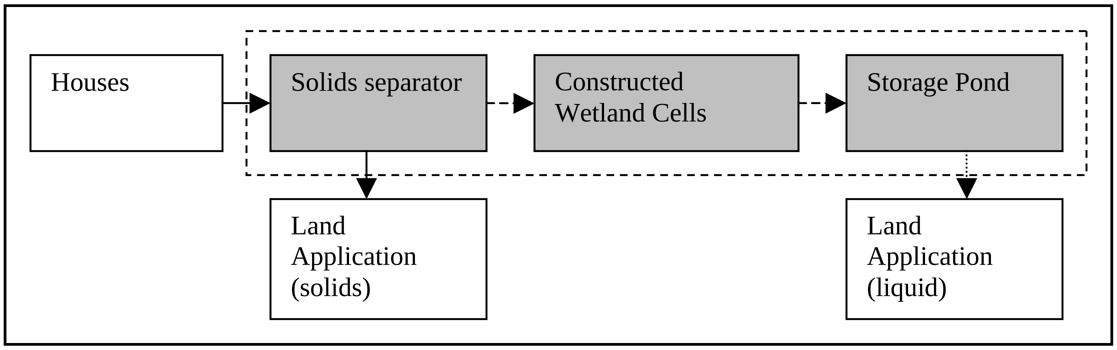
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.
[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)
[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).
[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"BEST" – Fluidized Bed Combustor



Data available in Appendix A.3, Phase 2 Report, July 25, 2004

Constructed wetlands system / solids separation



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	1.4 / 1.5	3.7 / 3.8	.70 / .67	3.0 / 3.1		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	2.4	3.6	1.7	3.1	2.1	2.3
Waste stream only	3.2	4.6	2.5	4.1	2.8	2.9
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-41.8	-156.8	-59.4	-47.4	-50.9	-62.6
Nutrients[4] % Reduction	TKN	NH4-N	P	Cu	Zn	
	57.0	-	87.0	41.0	39.0	

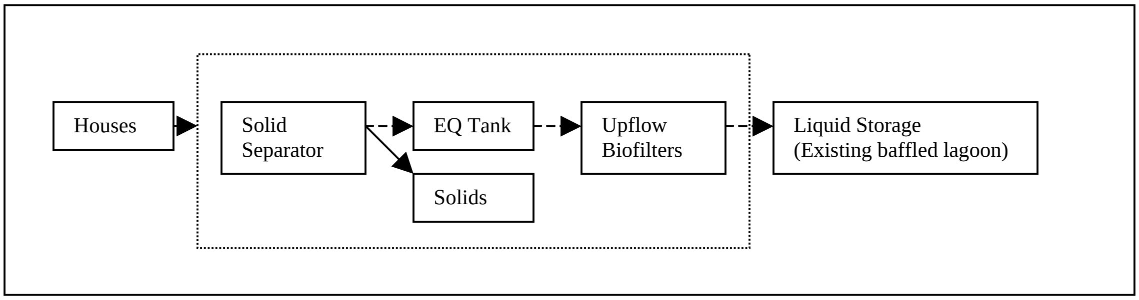
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"Ekokan" Biofiltration Technology



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	1.7 / 1.6	4.4 / 4.2	0.7 / 0.7	3.6 / 3.4		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	1.5	1.3	1.1	0.7	1.8	1.8
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	42.7	71.7	11.4	-2.9	23.5	43.3
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
EKOKAN[5]	31 to 72 (57) -1 to 30 TN (15)	23 to 98 (71)	5 to 50 (32)	19 to 91 (34)	23 to 78 (54)	

[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

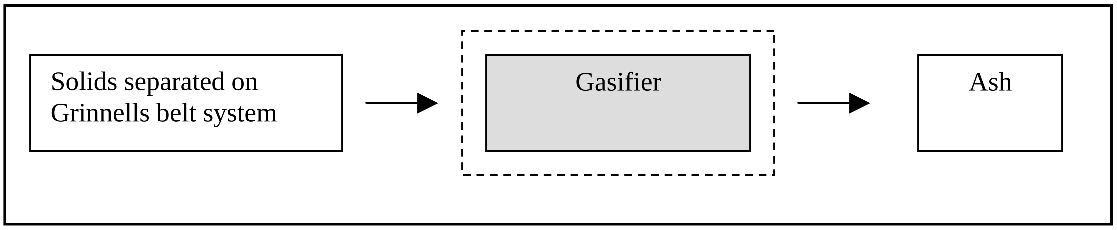
[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

[5] Values reflect reductions from EQ tank (post solids separation) through biofilter treatment of 2nd stage. Range and (mean) reductions for monthly averages (2/25/03 – 6/27/03) for Biofilters series A and B.

Gasification of Solids (Belt System for Manure Removal - Grinnells)



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	NA / 0	NA / .04	NA / 0	NA / 0		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	2.2	1.9	2.7	3.1	-	-
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-	-	-	-	-	-
Nutrients[4] % Reduction	TKN	NH4-N	P	Cu	Zn	
	-	-	-	-	-	

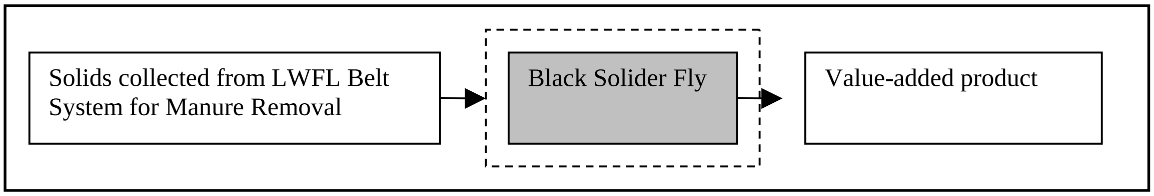
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions). This technology did not include animal housing or a lagoon; calculations for ammonia emissions are available in Appendix A.9a – Addendum, Phase 2 Report, Development of Environmentally Superior Technologies, July 25, 2005.

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery. This is a system component.

Insect Biomass from Solids (Belt System for Manure Removal - LWFL)



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	NA / 0	NA / 1.1	NA / 0	NA /.38		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	-3.7	-2.8	-5.0	-3.2	1.1	-1.0
(Combined w/ belt)	-3.6	-2.5	-4.7	-4.0	-0.2	-1.8
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-	-	-	-	-	-
Nutrients[4] % Reduction	TKN	NH4-N	P	Cu	Zn	
	80.2	-	75.4	76.2	75.8	

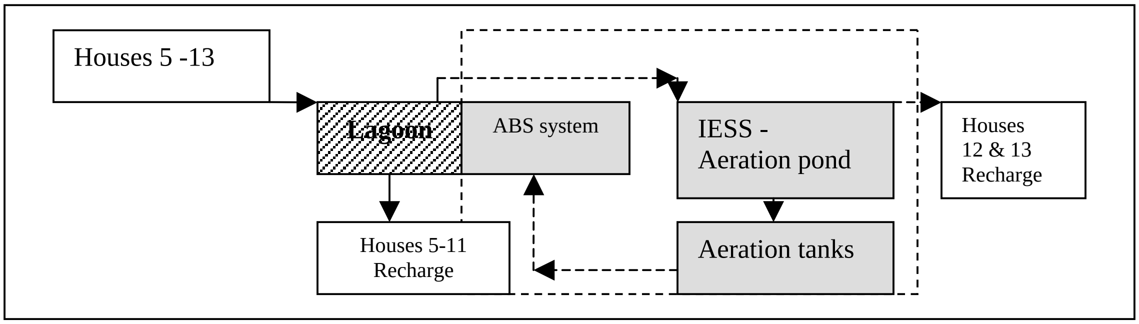
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions). This technology did not include animal housing or a lagoon; calculations for ammonia emissions are available in Appendix A.5, Phase 3 Report, Development of Environmentally Superior Technologies, March 8, 2006.

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"ISSUES" Aerobic blanket



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
(No IESS) (w/ IESS operational)	1.2 / 1.3 1.3 / 1.2	3.8 / 3.7 3.6 / 3.2	.57 / .46 .55 / .45	3.1 / 3.0 2.8 / 2.6		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	1.7	2.3	2.2	0.9	1.8	2.0
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	86.7	47.2	-16.3	-10.1	49.5	8.1
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
	33.0	27.5	49.7	35.0	64.3	

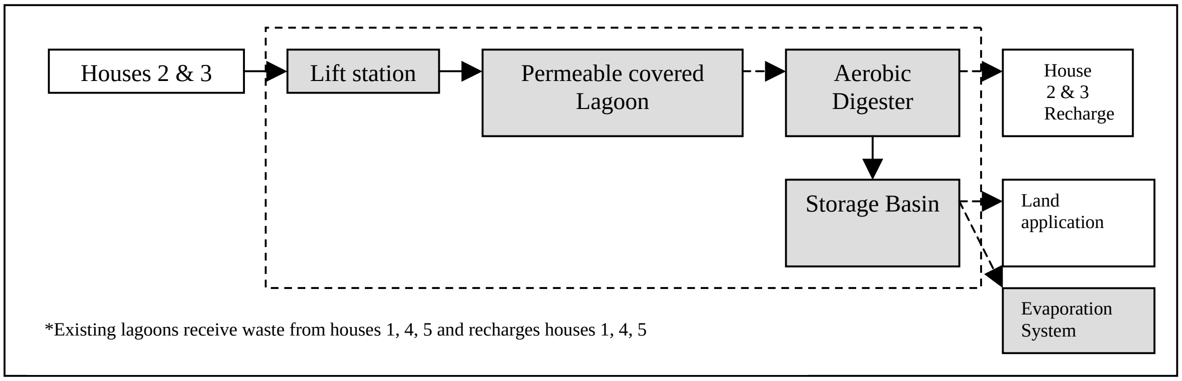
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"ISSUES" Permeable cover



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	1.0 / 1.0	3.4 / 2.9	.45 / .33	2.9 / 2.3		
w/ evaporation system	1.1 / 1.0	3.4 / 3.0	.45 / .37	2.9 / 2.5		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	4.1	4.1	3.3	1.9	3.3	0.5
w/ evaporation system	3.8	5.2	3.4	2.5	4.4	0.8
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-143.8 / -1.4	44.7	0	81.0	-109.9	69.4
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
	51.5	46.3	81.0	86.3	93.7	

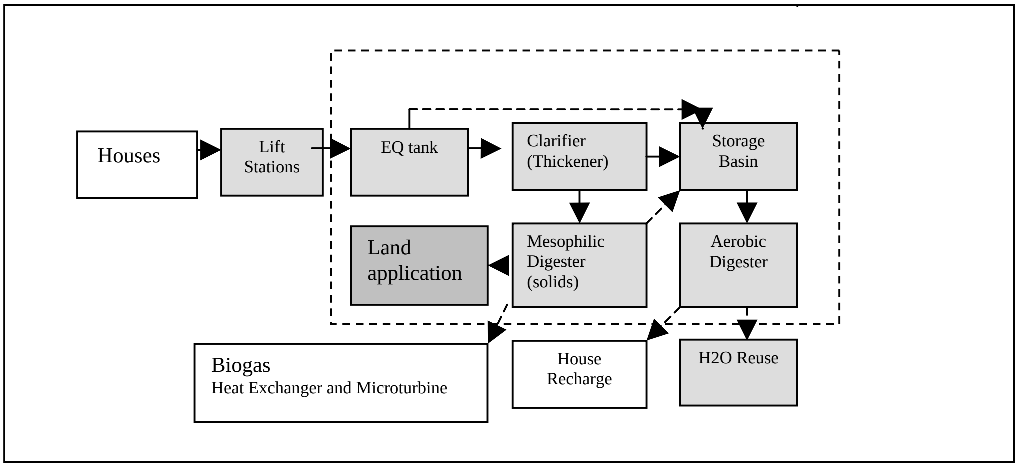
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"ISSUES" Mesophilic digester/microturbine/water reuse system



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
mesophilic digester/ microturbine/ w/ water reuse system	1.1 / 1.5 1.1 / 1.5	3.6 / 4.1 3.5 / 4.0	.47 / .58 . 53 / .55	3.0 / 3.4 3.0 / 3.2		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	3.1	3.1	2.7	0.6	1.4	1.3
w/ water reuse system	6.5	6.5	6.7	3.9	5.9	2.1
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	48.8	22.0	-37.0	86.0	31.1	54.0
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
	70.1	85.5	44.6	49.7	47.8	

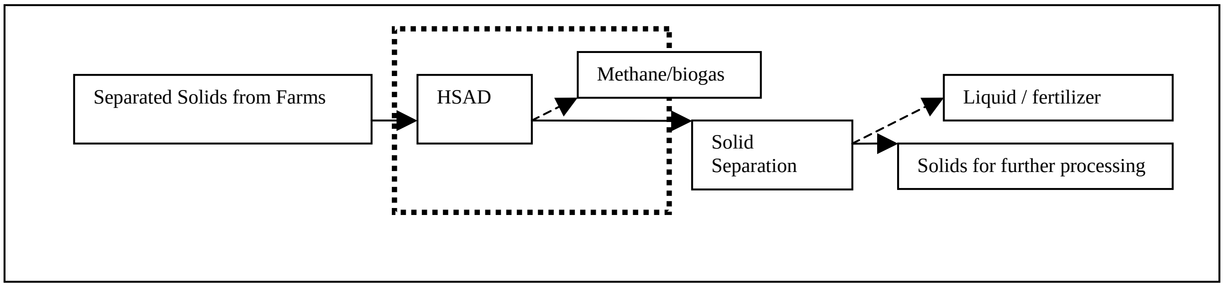
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"ORBIT" High Solids Anaerobic Digester

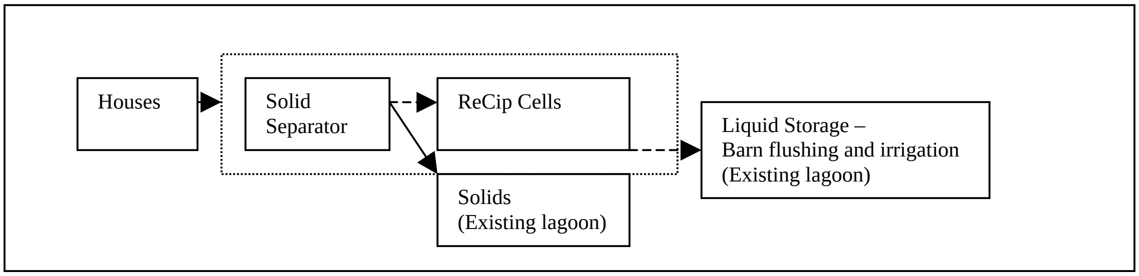


Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	0 / NA	1.4 / NA	0 /NA	0.8 / NA		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	4.4	4.3	3.2	1.0	1.8	2.4
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-	-	-	-	-	-
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
	56	72	26	46	32	

[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.
[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)
[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions). This technology did not include animal housing or a lagoon; calculations for ammonia emissions are available in Appendix A, Phase 2 Report, Development of Environmentally Superior Technologies, July 25, 2005.
[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"ReCip" Solids Separation – Reciprocating Wetland



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	0.8 / 0	2.5 / 1.5	0.3 / 0	2.1 / 0.9		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	1.6	1.7	0.9	0.7	0.8	1.8
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	18.2	-26.4	-9.0	62.0	9.7	20.9
Nutrients[4] % Reduction	TKN	NH4-N	P	Cu	Zn	
	88	-	49	75	85	

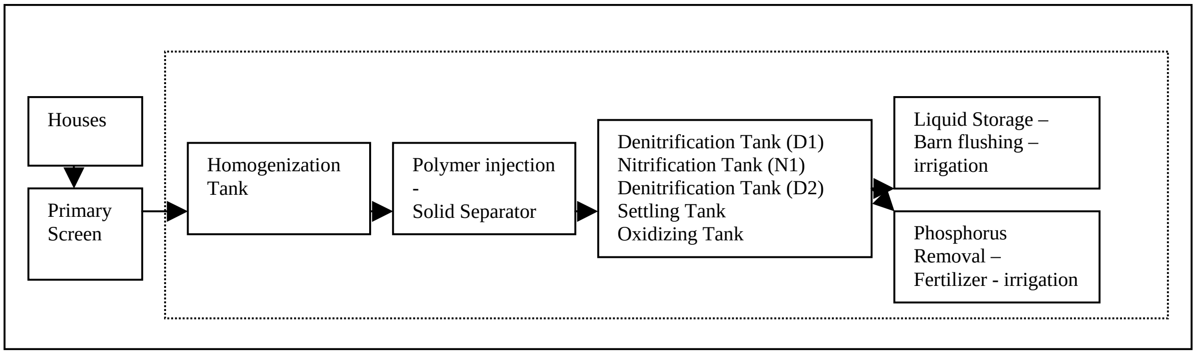
[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions). Calculations for ammonia emissions are available in Appendix A.12 , Appendix A and B, Phase 1 Report, Development of Environmentally Superior Technologies, July 26, 2004.

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

“Super Soils” Solids Separation/Nitrification-Denitrification/Soluble Phosphorus Removal

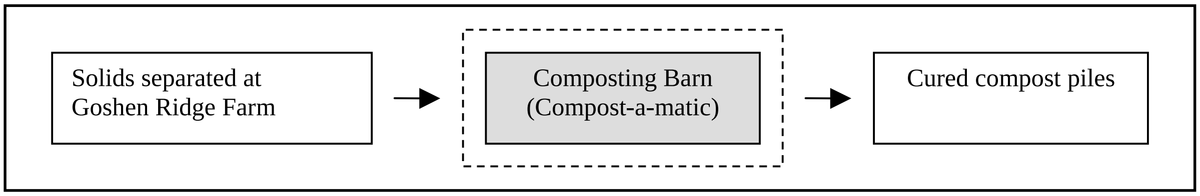


Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	1.2 / 0.8	3.6 / 2.6	0.4 / 0.9	2.9 / 2.0		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	4.4	4.2	4.0	1.4	3.0	3.4
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	94.7	99.0	-111.0	98.0	-1.9	98.5
Nutrients[4] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
	98	99	95	99	99	

[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.
[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)
3 From Table 5, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).
4 From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"Super Soils" solids processing (Composting system)

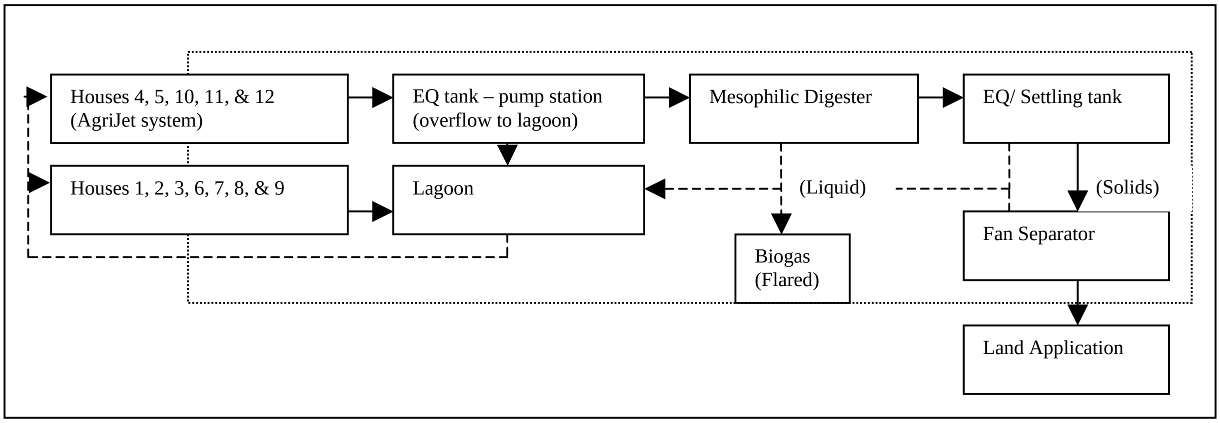


Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	NA / .63	NA[2] / 2.7	NA / .04	NA / 1.9		
Pathogen[3]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	-0.2	1.1	0.3	2.4	2.3	0.7
w/ 30 day curing	3.5	3.9	2.3	3.9	2.6	1.2
NH_3 % Reduction[4]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-	-	-	-	-	-
Nutrients[5] % Reduction	**TKN**	**NH4-N**	**P**	**Cu**	**Zn**	
	96.5 Recovery	-	100.0 Recovery	95.6 Recovery	99.6 Recovery	

[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.
[2] NA = not applicable.
[3] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)
[4] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions). This technology did not include animal housing or a lagoon; calculations for ammonia emissions are available in Appendix A.9, Phase 2 Report, Development of Environmentally Superior Technologies, July 25, 2005.
[5] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

"AgriClean" Mesophilic digester and "AgriJet" flush system

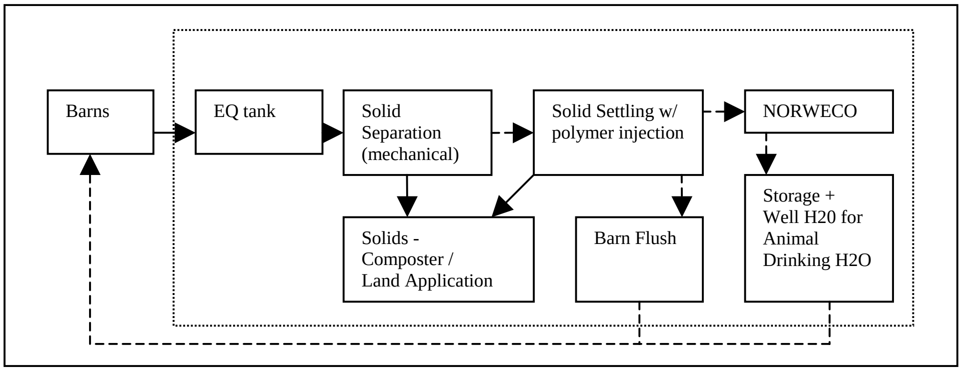


Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
	1.0	3.6	0.5	3.0		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	1.5	1.5	1.5	0.1	1.1	1.7
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	-	3.6	-	-7.5	-	-6.3
Nutrients[4] % Reduction	TKN	NH4-N	NO3-N	P	Cu	Zn
Meso Digester	30	3	-	51	54	56
Storage Tank	0.5	2	4	19	42	47

[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.
[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)
[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).
[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

Environmental Technologies



Report Summary:

Parameter						
Emissions						
Odor [1]	**200 m day**	**200 m night**	**400 m day**	**400 m night**		
+ composter (3rd)	0.7 / 0.7 / 0	3.0 / 3.1 / 0.2	0.2 / 0.2 / 0	2.3 / 2.4 / 0.04		
Pathogen[2]	**Fecal coliforms**	**E. coli**	**Enterococci**	**Cl. perfringens**	**Coliphage**	**Salmonella**
Log_{10} Microbial Reductions	0.3	0.5	0.6	0.3	1.0	0.1
composter	2.1	2.3	2.6	3.0	2.9	0.8
NH_3 % Reduction[3]	**Water holding Structures**		**Barn Emissions**		**Total Emissions @ Technology site**	
	Warm Season	**Cool Season**	**Warm Season**	**Cool Season**	**Warm Season**	**Cool Season**
	46.8	-55.0	-58.0	92.0	30.7	18.5
Nutrients[4] % Reduction	TKN	NH4-N	P	Cu	Zn	
	-	-	99+[5] Recovery	99+ Recovery	99+ Recovery	

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[1] From Table 4, Executive Summary , page 53. Environmentally Superior Technology candidate projects demonstrated performance for odor reduction. Values shown are approximate average odor intensity ratings at 200 and 400 meters from the odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. The first value represents whole farm odor emissions / the second value represents partitioned emissions from the technology treatment components targeted in the experiment.

[2] From Table 5, Executive Summary, page 54. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology)

[3] From Table 6, Executive Summary, page 55. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites (positive values indicate reductions in emissions, negative values indicate enhancement of emissions).

[4] From Table 3, Executive Summary, page 51. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.

[5] As currently operated, the only pathway by which solids, COD, BOD, TP, Cu and Zn are removed from the system is in the form of separated and settled solids, which are exported off-farm to the composting operation. With the exception of the Norweco tertiary treatment system (which represents a small fraction of the overall volume of wastewater treated), none of the unit processes that constitute this system are designed to reduce the above species. Therefore, differences between influent and effluent concentrations in these species for a given unit process (and for the system as a whole) are assumed to represent sampling and/or measurement error. It is expected that some nitrogen will be lost from the system due to ammonia volatilization and that some solids, COD, and BOD will be lost due to microbial activity in this aerobic process, but the majority of these species will be exported off-farm with the separated and settled solids to the composting operation. Measurements were not sensitive enough to determine the magnitude of these nitrogen, solids, COD and BOD losses during treatment. Virtually all phosphorous, copper and zinc will be recovered if the system is operated as planned because these species are not volatile and will only leave the system through the separated and settled solids.

3.0 Determination of Technical Performance and Standards

Process: The 15-step systematic process for the competitive selection, site location determination, permitting, construction, and study of the candidate EST per the terms and conditions of the Agreements was previously described.[1] Experimental site location information for each candidate technology studied is shown in Table 2. Technology descriptions and process flow diagrams are shown in Section 2.0 and elsewhere in this report. Each candidate technology was assessed for technical, operational, and economic feasibility. This section of the report focuses on the technical performance standards.

Technical performance standards: The Agreements specify that a successful EST must meet the following performance standards:

1. "Eliminate the discharge of animal waste to surface waters and groundwater through direct discharge, seepage, or runoff;
2. Substantially eliminate atmospheric emissions of ammonia;
3. Substantially eliminate the emission of odor that is detectable beyond the boundaries of the parcel or tract of land on which the swine farm is located;
4. Substantially eliminate the release of disease-transmitting vectors and airborne pathogens; and
5. Substantially eliminate nutrient and heavy metal contamination of soil and groundwater."

These performance standards were established by the North Carolina General Assembly[2] and used as the basis for technical environmental performance standards in the Agreements. An Engineering Subcommittee comprised of appointed members of the advisory panel referenced in Section 1.0 of this report compiled a recommendation document that served as the basis of further defining and quantifying the five technical performance criteria outlined above.[3] Interpretation and conclusions regarding the Engineering Subcommittee recommendations are discussed in Section 3.0 of the referenced July 26, 2004 report. In brief they are as follows:

Eliminate the discharge of animal waste to surface waters and groundwater through direct discharge, seepage, or runoff.

All wastewater-holding structures must have a mechanism for containing the flow rate of the largest pump in the system for the maximum amount of time that an operator will not be on-site. Technologies should contain less than the volume equivalent of one month of

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[1] See Section 3.0, page 20 "Development of Environmentally Superior Technologies: Phase 1 Technology Determination Report", published by NCSU College of Agriculture and Life Sciences, 941 pgs, on file with NCSU Animal and Poultry Waste Management Center (July 26, 2004). Also available at www.cals.ncsu.edu/waste_mgt/

[2] See General Assembly of North Carolina, Session 1997, Session Law 1998-188, House Bill 1480

[3] See Appendix D, "Development of Environmentally Superior Technologies: Phase 1 Technology Determination Report", published by NCSU College of Agriculture and Life Sciences, 941 pgs, on file with NCSU Animal and Poultry Waste Management Center (July 26, 2004). Also available at www.cals.ncsu.edu/waste_mgt/

flow in concentrated waste prior to complete treatment. Any earthen structures should be designed and constructed to current Natural Resource Conservation Service (NRCS) standards and have a maximum hydraulic conductivity of 1.25 x 10^{-6} cm/sec. Structures other than earthen should be designed and constructed using proper engineering practices to eliminate seepage. Solids storage structures should meet current NRCS design standards. Land application of treated wastewater or solids should be based on realistic crop yield expectations, land application setbacks, buffers, and hydraulic loading rates that at a minimum maintain compliance with current NRCS, local, state, and federal standards and/or requirements.

Substantially eliminate atmospheric emissions of ammonia.

An approximately 80% reduction of ammonia emissions from waste storage/treatment components and land application areas is required as compared to a typical swine farm. The system must also target reduction of ammonia from the barns.

Substantially eliminate the emission of odor that is detectable beyond the boundaries of the parcel or tract of land on which the swine farm is located.

Odor intensity levels, measured using an index scale from 0-8, should not exceed the established metric of 2 (or equivalent) at a property line on which the swine farm is located (see Table 4 and Appendix A.3 of report herein for specific description of index scale).

Substantially eliminate the release of disease-transmitting vectors and airborne pathogens.

Approximately 4 log reductions of pathogens (microorganisms documented to be of human health concern) are required in the treated liquid and solid waste stream, as compared to concentrations of the pathogens in raw manure. All components of the waste management system (technology treatment, fate of farm generated solids, method and location of land application of liquid and/or solids, etc.) are considered factors for pathogen reductions.

Substantially eliminate nutrient and heavy metal contamination of soil and groundwater.

The system should reduce total nitrogen mass by 75% and total phosphorus, copper, and zinc mass by 50% from influent levels for the whole farm. Current N.C. NRCS Nutrient Management Standard 590 must be met, including added considerations of current realistic yield expectations, individual plant-available nitrogen calculations, N.C. Phosphorus Loss Assessment Tool (PLAT) evaluation to determine phosphorus loss and application rates, and metal soil index threshold warnings. Where on-farm resources (i.e., available land) are not sufficient to meet these described standards, reductions may be met by transporting the nutrients off the farm and/or animal diet modification.

Technical data analysis: The data considered for the technical analysis involved the candidate waste treatment systems' performance in terms of: 1) partitioning, conversion or removal of the waste stream solids and organic matter, nutrients (primarily nitrogen and phosphorus), and metals (copper and zinc); and 2) reducing emissions of odor, pathogens, and emissions of ammonia. The methods and results, relevant to the technical environmental performance data, are provided in the project investigator final reports (Appendix A of this report and Appendix A in both the referenced July 2004 and July 2005 reports). Data from these reports relative to the technical feasibility determinations are summarized in Tables 3-6 of this report.

In addition to technical feasibility, operation feasibility was also mandated by the Agreements. Although specific factors for determining operational feasibility are not described in the Agreements, inputs from the project investigators involved with the technical data collection and analysis of the candidate waste treatment systems as well as input from the technology suppliers were considered. Parameters such as: operator hours required per week; system inspection needs; maintenance of "moving parts," required skills; trouble shooting pumps, equipment, and electrical controls, etc. were considered. In addition, NCDENR was consulted regarding operator certification and license requirements. Operational feasibility information for the Phase 2 targeted technologies is provided in Table 7.

4.0 Technology Permittability and Category or Categories of Farms

Permittability: The Agreements specify that any technology or combination of technologies that meet unconditional EST status must be "permittable by the appropriate governmental authority." In North Carolina the Department of Environment and Natural Resources (NCDENR) and its Division of Water Quality, Division of Air Quality, and Division of Waste Management are specifically involved with the permitting and regulatory aspects of the EST projects. NCDENR is represented (with two members) on the Agreements appointed advisory panel (see Appendix E).

Category or Categories of Farms:[1] The Agreements reference, in several sections, EST for identified "category or categories of farms." Further, the Agreements specify, "the categories may be determined based on farm size, geographic location, the geographic concentration of the hog population, the type of farm, and any other factors the Designee deems appropriate."

For the objectives related to the EST determinations, categories of farms are based on the types of North Carolina swine farms and the distribution of weight across these farms. This is based on input and study by the investigators conducting the economic feasibility analysis needed to partition the representative swine farms for the economic modeling of farm sizes to compute cost estimates and industry impact of adoption for all candidate EST technologies. The category distribution used and as described by the economic team investigators (see Appendix B.1) is summarized as follows.

The production process for market hogs is comprised of three primary stages — farrow-to-wean, wean-to-feeder, and feeder-to-finish. Farrow-to-wean farms house sows during their breeding, gestation, farrowing, and nursing stages. Sows nurse newborn pigs until weaning, which typically occurs 18 to 23 days after a litter of pigs is born. The pigs may weigh 10-12 pounds at weaning. The weaned pigs are moved to a nursery facility to begin the second stage of the production process. Pigs will remain in the nursery (also called wean-to-feeder stage) for 7-10 weeks, enabling them to reach a weight of 45-55 pounds. Finally, the pigs are moved to another facility to enter the feeder-to-finish stage. In this stage, pigs will add approximately 200 pounds of bodyweight over a period of 16 weeks. At a live weight of approximately 260 pounds and an age of about six months, the pigs will be marketed for slaughter. Thus, the three primary stages of the hog production process can be combined to form five types of hog farming operations: 1) farrow-to-wean, 2) farrow-to-feeder, 3) farrow-to-finish, 4) wean-to-feeder, and 5) feeder-to-finish. The majority of North Carolina's hog farms concentrate on one stage of production, but some include two (farrow-to-feeder) or three (farrow-to-finish) stages.

Farms with inventories of greater than 250 hogs are required to obtain a permit through the NCDENR. Data recorded in the permit database include the permitted capacity of the farm in number of head of each type of pig (breeding animals, nursery pigs, and feeder to finish pigs) and the associated steady state live weight (SSLW). By partitioning the farm

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[1] Information in this section compiled, in part, from reports submitted by the project investigators conducting the economic feasibility determinations.

size into categories of 0-500 SSLW, 500-1,000 SSLW, 1,000-1,500 SSLW, 1,500-2,000 SSLW, and >2,000 SSLW, and using the five types of hog farming operations described above, 25 possible combinations of farm size and type of operation result. These 25 possible combinations include all permitted hog farms in the state and are used as the basis for "category or categories of farms" as applicable to the Agreements.

In addition to these categories, an additional category of farm, "new farms" relative to the permitting and construction of new swine farms in North Carolina, is also considered by the Designee.

5.0 Determination of Economic Feasibility

The Agreements specify, "In determining whether it is economically feasible to construct and operate a particular alternative technology for a category of farms, the Designee will consider all relevant information including but not limited to the following factors:

1) the projected 10-year annualized cost (including capital, operational and maintenance costs) of each alternative technology expressed as a cost per 1000 pounds of steady state live weight for each category of farm system;
2) the projected 10-year annualized cost (including capital, operational and maintenance costs) per 1000 pounds of steady state live weight for each category of farm system of a lagoon and sprayfield system that is designed, constructed and operated in accordance with current laws, regulations, and standards, including NRCS design, construction and waste utilization standards;
3) projected revenues, including income from waste treatment byproduct utilization, together with any cost savings from the new technology;
4) available cost-share monies or other financial or technical assistance from federal, state or other public sources, including tax incentives or credits; and
5) the impact that the adoption of alternative technologies may have on the competitiveness of the North Carolina pork industry as compared to the pork industry in other states."

Data analysis: Pursuant to factors 1-4, the project investigators conducting this work compiled extensive costs and returns data for each candidate EST. The cost and returns analysis, collectively reported in the July 2005 report as Appendices B.1a. – B.1.i, and herein as Appendices B.1 – B.11, and summarized for all technologies as Table 8a, predicts the estimated costs of retrofitting North Carolina swine farms with candidate EST. The costs are projected as incremental costs, e.g. additional costs to the existing lagoon and spray field system on a farm site. Projected revenues from by-products plus avoided costs in operating the lagoon and spray field system are considered in each case estimate. As mandated by the Agreements, the net costs are reported based on the following metric: $ per 1000 pounds steady state live-weight per year ($ / 1,000 lbs. SSLW / year) over a 10 year economic life. Table 8a is organized to show results for on farm complete systems and separated solids treatment systems ("add on" treatment components). Table 8b shows a sensitivity analysis on solids treatment systems focusing on the impact of solids separation rate and moisture content of solids on the annualized incremental costs metric ($ / 1,000 lbs. SSLW / year). Table 8c is a sensitivity analysis showing the effect in varying assumed interest rates, expected economic life, and overhead rates for the on-farm systems; Table 8d shows the same for the "add-on" treatment components.

Pursuant to factor 5, this cost data was subsequently utilized to predict the impacts of adopting EST technologies on the competitiveness of the NC pork industry, (methodology and analysis data previously reported in detail in the July 2005 report as Appendix B.2) and summarized herein in Table 9. An equilibrium displacement model was used to estimate the economic impacts for different types of producers across farm operational size (farm categories) relative to prices and quantities of animals produced as projected for implementation of the candidate EST. Table 9 is organized to show the predicted percent change in the inventory of North Carolina hogs (reported in quantities of 1,000 lbs. of weight) in the short, intermediate, and long runs for selected incremental costs as determined by the referenced displacement model.

In brief the collective economic data, regarding the above referenced factors 1-5 indicates:

1) the projected additional costs of retrofitting existing lagoon sprayfield farms with candidate EST for a complete treatment system (liquid and solids treatment) ranges between approximately $90 to over $400 per unit cost ($ per 1,000 lbs. steady state live weight per year) (see Table 8a); this compares to approximately $85, utilizing the same costs metric, for the predicted costs of constructing a permitted lagoon spray field system in North Carolina in 2004 (see Appendix B.1, July 2005 report) ; these values, however, can be significantly impacted by assumptions relative to interest rates, expected economic life of the technology, and overhead rates,
2) long term impacts on adopting candidate EST may result in annual reductions in the North Carolina inventory of pork; at present there is considerable uncertainty in the predicted magnitude of this impact, the values range between a low of 8% to the *entire herd inventory* to greater than 50% of *market quantities* of pork (see Table 9),
3) various sources of financial support, including cost share programs, may be available in the future with the most promising opportunities for technologies that generate energy, however, no significant sources of such support are currently available.

In addition to the Agreement mandated factors enumerated above, the Designee expanded the scope of the economic feasibility to also include the following factors:

1) identify and quantify the pathways by which the adoption of new waste management technologies changes pollutant emissions to air and water and affects environmental quality; and,
2) estimate the monetized benefits to North Carolina households of the changes in environmental quality achieved by implementing alternative waste management technologies.

RTI International (RTI) conducted this scope of work (see Appendix C, July 2004 report). The benefits analyses information will be utilized for distinguishing among technologies that qualify as EST such that the maximum benefits are realized for the citizens of North Carolina. However, as noted by RTI in the report, the information was developed using the best available methods and data available but the estimates should not be interpreted as complete or precise monetized estimates of the total benefits of reducing swine-related environmental residuals in the state of North Carolina (see Section 1.2.2, pages 1-11 and 1-12 of the RTI report).

Recommendations for economic feasibility determinations: Quantitatively defining "economic feasibility" relative to requirements for unconditional EST has been one of the more challenging, and controversial, tasks for this initiative. To provide guidance and recommendations on this subject, the Designee appointed a 10 member Economics Subcommittee, made up of all appointed panel members with economics experience. In addition, panel members representing North Carolina Environmental Defense, Smithfield, PSF, and Frontline Farmers were also represented; Richard Whisnant, Associate Professor of Public Law and Government, School of Government, UNC-Chapel Hill, was appointed chair.

After much deliberation most of the 10 subcommittee members were in agreement on many aspects of a recommended methodology for making economic feasibility determinations, summarized as follows:

- Designee should consider economic versus financial points of view regarding feasibility – e.g. in addition to the financial consequences which focus on payments made by farmers, the Agreements require attention to the true economic consequences, including non-monetized commitment of resources.
- The economic models used to determine the costs-returns and predicted impact on the competitiveness of the industry when utilizing the determined EST costs are well reasoned and well justified and thoroughly conducted but include uncertainty and many assumptions (the same conclusions were derived by external ad hoc reviewers).
- In consideration of who makes up the North Carolina pork industry, Designee should consider any and all business entities physically located in North Carolina that generate their income from either the production of live swine or the meat packing of pork.
- It is economically appropriate to implement EST in phases, allowing pilot testing and refinement of the technologies before they are adopted industry wide. New farm categories and company owned farms are appropriate and obvious candidates for this approach.
- The time frame for adoption of EST is important relative to the time value of money and assessing economic feasibility, e.g. additional time for implementation reduces the economic impacts on North Carolina swine herd size.

However, on the issue of threshold for "competitiveness" (Agreements mandated factor 5 discussed above), as well as on the issues of creating an institution to oversee technology transition, and consideration of social costs-benefits (social costs resulting from external effects from ammonia emissions, odors and water pollution), the committee members were divided and unable to reach consensus as reflected in two competing reports that were submitted to the Designee and presented herein as Appendix D. In brief, salient non-consensus components of the two reports can be summarized as follows.

From report (dated December 1, 2005) submitted by Chair Richard Whisnant and 5 additional subcommittee members

- Competitiveness does not mean maintaining the present North Carolina hog inventory size and does not mean avoiding any net increase in waste handling costs. Designee should consider that implementation of EST that has a predicted economic consequence of reducing the North Carolina swine herd by 12% economically feasible. This is, in part, justified based on precedent established by the North Carolina General Assembly upon adoption in 1993 of the so called ".0200 Rules", which were predicted to result in 12% of the State's swine operations not remaining in business.
- Institutional considerations should be studied in consideration of EST implementation planning, e.g. an institution created to oversee technology transition, tradable permits, etc. would ensure that widespread conversion occurs in the most economically feasible manner possible.

From report (dated December 2, 2005) submitted by 4 subcommittee members

- The Agreements did not seek to close farms or otherwise reduce herd size in North Carolina.
- A hog production entity becomes non-competitive when its inability to fund production results in lost market share and an EST is economically feasible if and only if the commercial application of the technology in only North Carolina has no adverse affect, e.g. no net increase in cost or reduction in herd size, on the fiscal competitiveness of North Carolina operations as compared to pork operations in all other states.
- Byproduct revenue from EST must exist to offset any higher operating and capital costs of the EST and the best opportunity for the candidate EST studied is fossil fuel substitutes.

The Designee considers that both reports make several valid arguments and has carefully considered both reports as well as inputs from the full Advisory Panel regarding both reports. Based on those considerations the Designee makes the following economic feasibility determination with the understanding that it is not to be viewed as a fixed standard or cost metric for economic feasibility:

A technology may be economically feasible even though it would impose incremental cost increases on the North Carolina swine industry and potentially result in a reduction in swine herd size in North Carolina. Technologies will be considered candidates for EST Determinations only if the maximum predicted reduction in herd size resulting from implementation would not exceed 12 percent. The Designee will be responsible for determining whether the predicted herd size reduction that would result from the implementation of a technology is sufficiently accurate to consider it a candidate for determination as an EST. The Designee will also be responsible for determining, and limiting his determination and implementation recommendations to a category, or categories of farms, to ensure that an EST Determination would not result in unintended negative impacts and consequences for other farms which are dependent on the EST farms for their ongoing supply of production animals.

The rationale for this economic feasibility determination is based largely on the following factors and concerns.

It is not logical to accept the suggestion that adoption of state specific cost differences, for any commodity, that has any impact at all on raising costs for that commodity is economically infeasible. The December 1, 2005 subcommittee report and its attachments make clear and defensible arguments to support this determination.

There is no compelling advantage at this time to establish a fixed cost metric for economic feasibility. Candidate ESTs for a complete treatment system (liquid and solids) that have been shown to meet the technical performance standards greatly exceed, at the current time, costs that would result in a prediction of 12 percent reduction of herd size in North Carolina. Work is already in progress, and proposed herein, for reducing those costs. Establishment of a fixed cost metric at this time may adversely affect those initiatives. Further, Designee does not believe that at this time, with the available information, it is possible to establish a sufficiently small margin of error around a predicted reduction in herd size. Therefore, the Designee feels that the probability of greatly exceeding the predicted 12 percent herd size reduction at costs associated with that estimate in the referenced economic model is unacceptable at the present time and I am currently not willing to mandate an effect that could potentially be that significant.

It is also noted that the incremental cost metric predicting a 12 percent reduction in herd size may be low when farrow to feeder and farrow to wean pig costs are considered along with market hog costs (this is based on information submitted by the authors of the "Majority" subcommittee report subsequent to December 1, 2005).

The estimates of economic impact on the North Carolina pork industry do not take into account the potential positive effects that investment in environmentally superior waste technology will have on the part of the North Carolina pork industry devoted to producing and servicing the waste technology itself.

Designee considers that these collective uncertainties and factors associated with the predicted impacts on the industry are substantial. All these factors suggest that a specific fixed cost metric for "economic feasibility" would be very premature at this time.

And finally, Designee feels that the subcommittee reports made valuable arguments regarding institutional and political approaches to addressing the economic feasibility issues. Relative to those arguments and next steps recommended herein, I have serious concerns that adoption of a fixed economic cost metric at this time will adversely influence future public policy related to byproduct valuation (especially energy) for candidate EST.

6.0 Environmentally Superior Technology Determinations

Technology Determinations: Based on responsibilities as described in the Agreements, review of project investigator reported performance and economic data, economic models, and Advisory Panel inputs, the following technology determinations are made at this time:

New farm category

Designee concludes that the solids separation / nitrification–denitrification / soluble phosphorus removal system ("Super Soils" technology as described in the July 26, 2004 report[1]) in combination with any one of the following four solids treatment systems: the high solids anaerobic digester ("ORBIT" technology as described in the July 26, 2004 report); "Super Soil Systems" centralized composting system; gasification for elimination of swine waste solids with recovery of value-added products system; and "BEST" – fluidized bed combustion of solids system (the latter 3 systems as described in the July 25, 2005 report[2]) comprise an unconditional Environmentally Superior Technology for new farms which are permitted and constructed for the first time after the date of this report. This determination is limited to the following types of farms: farms using EST on sites that have not been used previously for the production of swine ("Greenfields"); construction of new swine facilities using the EST on farms which previously housed swine, but which are no longer permitted for that purpose; and expansions (for purposes of increasing permitted herd size) of existing swine farms using the EST to treat waste for new construction on such existing swine farms. In the case of expansions, this determination applies only to the waste generated from the expansion.

It is recognized by the Designee that, as shown through this series of studies including the comprehensive economic analyses, any combinations of these technologies comprise significant costs and producers are encouraged to carefully take into account the available economic data when considering implementation of these technologies. It is also noted that the data show that any of the referenced technology combinations produce wastewater and solids that will need to be managed in accordance with applicable state and federal regulations. However, given the transparency of this data, and the recommendations contained within the December 1, 2005 Economics Subcommittee report (see Appendix D, page 12-13) regarding the advantages of phased implementation beginning on new farms, Designee concurs with the Economics Subcommittee findings on this matter and considers this determination well justified. Further, each of these technologies have been documented to meet environmental performance standards established by the Agreements and the North Carolina General Assembly (per the

[1] See Development of Environmentally Superior Technologies: Phase 1 Technology Determination Report, published by NCSU College of Agriculture and Life Sciences, 941 pgs, on file with NCSU Animal and Poultry Waste Management Center (July 26, 2004). Also available at www.cals.ncsu.edu/waste_mgt/

[2] See Development of Environmentally Superior Technologies. 2005. Phase 2 Technology Determination Report, published by NCSU College of Agriculture and Life Sciences, 1428 pgs, on file with NCSU Animal and Poultry Waste Management Center (July 25, 2005). Also available at www.cals.ncsu.edu/waste_mgt/

Innovative Technologies clause of the moratorium legislation[3]) and their non-mandated implementation (e.g. onto new or expanding farms) should be encouraged for reasons described herein.

Existing farm categories

Designee concludes that contingent EST, as described in the above referenced July 2004 and 2005 reports, have not at the current time met economic feasibility conditions required for unconditional EST to be implemented onto existing farm categories in North Carolina.

Scope of Technology Determinations

The scope of the technology determinations herein is considered final and inclusive of the candidate technologies described in Table 1 of this report and all categories of farms as described in Section 4.0 of the above referenced July 26, 2004 Phase 1 report. Any subsequent technology determinations, including contingent determinations that have been described in the referenced July 2004 and July 2005 reports, and also including technologies under development by parties to the Agreements that were referenced in those reports, that may be made by Designee will be based on available data and appropriate outside critical review and inputs resulting from efforts that go beyond those described in this report.

It has been noted herein as well as in the previously issued Technology Determination reports that several of the candidate technologies studied under this initiative have significant potential. Recommendations regarding those technologies are discussed in Section 7.0 of this report.

[3] See General Assembly of North Carolina, Session 1997, Session Law 1998-188, House Bill 1480

7.0 Recommended Next Steps

The findings provided herein, and in the previously issued (July 2004 and 2005 Phase 1 and 2 Technology Determination Reports) represent a comprehensive and unprecedented effort to develop and determine the costs and effects of implementing innovative waste treatment technology onto swine farms in North Carolina. Collectively, the results show:

- A combination of 5 technologies meet technical performance standards that have been established by the North Carolina General Assembly and parties to the Agreements that define Environmentally Superior Technology,

- With technical modifications and improvements (some of which may need to only be minor), several of the additional technologies considered in this initiative may meet the technical performance criteria,

- The technologies studied which have been shown to meet the technical performance standards and would be required for a complete liquid and solids treatment system significantly exceed the threshold cost metric for determination of economic feasibility as recommended by an appointed Economics Subcommittee (see “Majority Report”, Appendix D).

Based on these findings and the Technology Determination described in Section 6.0 of this report, the recommended next steps are proposed:

- Continue, as expeditiously as possible, current efforts by targeted technology suppliers and researchers to improve upon their treatment processes to reduce the costs of their respective treatment systems.

- Establish a framework or process by which additional technologies may be considered viable Environmentally Superior Technologies. This would include technologies that can be improved upon (technically and / or operationally and / or economically) as a result of information derived from this initiative, as well as technologies that were not part of this funded initiative.

- Identify potential institutional incentives, public policies, and markets related to the sale of byproducts (with priority on energy production) that will reward farmers for utilizing technologies identified by this process that are shown to yield improvements and environmental benefits over the current lagoon spray field system. The optimal method of achieving net cost reductions and even positive revenue flows from alternative technologies is to install targeted technologies on a sufficient number of farms to facilitate engineering improvements, value-added product market development, and other cost reduction methods.

ACKNOWLEDGEMENTS

Acknowledgement and sincere appreciation are expressed to the following: Advisory Panel members; all project principal investigators, co-investigators, and collaborators; farm property owners and operators; technology suppliers; construction and permit on site project technical managers; Animal and Poultry Waste Management Center staff; North Carolina Department of Environment and Natural Resources; North Carolina Department of Justice; North Carolina State University administration; and, finally the companies that entered into the Agreements (Smithfield, PSF, and Frontline Farmers).

Without the resources, inputs, and support of these individuals, agencies, and organizations, the findings noted in this report would not have been possible.

Appreciation is also expressed to the NCSU College of Agriculture and Life Sciences Communication Services for assistance with format and web copy compilation of this report.

C.M. Williams, Agreements' Designee
March 8, 2006

Table 1. Environmentally Superior Technology candidate projects status (December 2005).

Technology	**Environmental Performance Data Procurement**	**Economic Feasibility Determination**
Ambient Temperature Anaerobic Digester and Greenhouse for Swine Waste Treatment and Bioresource Recovery at “Barham Farm”	Complete	Complete
“ANT” Sequencing batch reactor system	Complete	Complete
Belt System for Manure Removal (Grinnells)	Complete	Complete
Belt System for Manure Removal (LWFL)	Complete	Complete
“BEST” Biomass Energy Sustainable Technology	Complete	Complete
Constructed wetlands system / solids separation	Complete	Complete
“Ekokan” Biofiltration Technology	Complete	Complete
Gasification of Solids (Belt System for Manure Removal - Grinnells)	Complete	Complete
Insect Biomass from Solids (Belt System for Manure Removal - LWFL)	Complete	Complete
“ISSUES” Aerobic blanket	Complete	Complete
“ISSUES” Mesophilic digester / microturbine / water reuse system	Complete	Complete
“ISSUES” Permeable cover	Complete	Complete
“ORBIT” High Solids Anaerobic Digester	Complete	Complete
“ReCip” Solids Separation – Reciprocating Wetland	Complete	Complete
“Super Soils” Solids Separation / Nitrification-Denitrification / Soluble Phosphorus Removal	Complete	Complete
“Super Soils” solids processing (Composting system)	Complete	Complete
“AgriClean” Mesophilic digester and “AgriJet” flush system	Complete (Cool season only)	Complete
“Environmental Technologies” - Sustainable NC and Frontline Farmers project – NCAG Environmental Enhancement Funding	Complete	Complete

Table 2. Environmentally Superior Technology candidate projects experimental site location information.[1]

Technology	Farm type and approximate animal inventory	Houses ventilation type	Houses waste discharge type and approximate waste stream flow
Conventional Technology[2] (Stokes)	Finishing / 5,000 head / 4 houses	Natural	Flush, 14,000 gal/d
Conventional Technology (Moore Bros.)	Finishing / 7,000 head / 8 houses	Tunnel	Pit recharge, 70,000 gal/d
Ambient Temperature Anaerobic Digester and Greenhouse for Swine Waste Treatment and Bioresource Recovery at "Barham Farm"	Farrow-to-wean / 4,000 sows / 6 houses	Tunnel	Pit recharge 37,000 gal/d
"ANT" Sequencing batch reactor system	Finishing / 13,000 head (4200 test) 24 houses (6 test)	Natural	Flush 26,000 – 39,000 gal/d
BELT (Grinnells lab, NCSU campus – research unit)	Feeder (25 to 55 kg) 80-100 head each in 5 separate experiments Single room	Mechanical	Belt .6 lbs dry matter (49%) solids/pig/d + .3 gal urine/pig/d
BELT (LWRFL[3]site – research unit)	Finishing / 15 head 4 separate experiments Single room	Mechanical	Belt 2 lbs dry matter (33%) solids/pig/d + 1 gal pig urine/d
"BEST"[4] (solids / liquids separation) Biomass Energy Sustainable Technology Fluidized Bed Component	Finishing Site 1 (Corbett 1) 3,000 head / 5 houses Site 2 (Corbett 3 & 4) 4,000 head / 4 houses Centralized site (Idaho)	Natural (both sites)	Flush (both sites) Site 1 – 30,000 gal/d Site 2 – 36,000 gal/d
Constructed wetlands / solids separation	Finishing / 3,500 head / 4 houses	Tunnel	Pit recharge 40,000 gal/d
"Ekokan" Biofiltration Technology	Finishing / 4,000 head / 5 houses	Tunnel	Pit recharge 6 pits at 20,000 gal/pit/d
Gasification of Solids (Belt System – NCSU Grinnells)	Centralized site (Received solids from belt system)	N/A	30 kg @ 50% DM/ batch (66 lbs./ batch)
Insect Biomass from Solids (Belt System – LWFL)	Centralized site (Received solids from BELT (LWFL – research unit)	N/A	170 kg/45,000 larvae total; (45,000 larvae consumed 6.26 Kg/day)
"ISSUES"- Aerobic blanket	Finishing / 6,500 head / 9 houses	Tunnel	Flush 43,000 – 50,000 gal/d
"ISSUES" – Permeable cover	Finishing / 6,100 head (2400 test) / 5 houses (2 test)	Natural	Flush 32,000 gal/d
"ISSUES" – Mesophilic digester/ microturbine/ water reuse system	Finishing / 9,800 head / 8 houses	Natural	Flush 77,000 gal/d
"ORBIT" High Solids Anaerobic Digester	Solids processing facility, no animals on site	Not applicable	Not applicable
"ReCip" Solids Separation – Reciprocating Wetland	Finishing / 2,000 head / 2 houses	Natural	Flush 20,000 gal/d
"Super Soils" Solids Separation / Nitrification-Denitrification / Soluble Phosphorus Removal	Finishing / 4,000 head / 6 houses	Natural, with fan-ventilated pits	Pit recharge 10,000 gal/d
"Super Soils" solids processing – (Compost System)	Centralized site (Received solids from 4,300 head finisher)	N/A	3 – 3.3 m^3/day solids processed (800 gal/d 17% DM)
"AgriClean" Mesophilic digester and "AgriJet" flush system	Finishing / 11,500 head (4800 test) 12 houses (5 test)	Tunnel	Pit Recharge (flush – AgriJet) 31,000 gal/d
"Environmental Technologies" - Sustainable NC and Frontline Farmers project	Finishing / 3,700 head / 3 houses	Natural	Flush 13,500 – 16,000 gal/d

[1] Approximate values derived primarily from Project Investigator Final Reports. Full reports contain more precise and detailed information and are available at http://www.cals.ncsu.edu/waste_mgt/ or upon request from the NCSU Animal and Poultry Waste Management Center, on file with C.M. Williams.

[2] Conventional Technology = Permitted lagoon sprayfield waste treatment system

[3] LWRFL = NCSU Lake Wheeler Road Field Laboratory.

[4] Project was comprised of two solids/liquid separation systems; a screw-press separator (FAN® Separator) followed by tangential flow gravity-settling tanks (TFS System) located on Farm Site 1; and a screen and hydraulic press separator (Filtramat™) followed by the TFS System located on Farm Site 2. Fluidized bed located in Idaho.

Table 3. Environmentally Superior Technology candidate projects demonstrated performance for solids, organic matter and nutrients. Values shown are percent reductions and/or recovery.[1]

Technology	TAN[2]	TKN[3]	Solids[4]	COD[5]	BOD[6]	TP[7]	Cu	Zn
Ambient Temperature Anaerobic Digester and Greenhouse for Swine Waste Treatment and Bioresource Recovery at "Barham Farm"[8] — AnD	+3	28	76 total 88 volatile	93	NR[10]	81	89	87
Biofilter	21	21 (29 trickling biofilters[9])	+5 total +15 volatile	+14		11	33	7
"ANT" Sequencing batch reactor system	96.8	83.0	60.0 (SS as COD)	63.7	-	-	-	-
(w/ biosolids separation)	96.8	90.0	89.7 (SS as COD)	84.0	-	36.5	76.1	81.4
BELT (Grinnells lab, NCSU campus – research unit)	-	-	-	-	-	-	-	-
BELT (LWRFL[11]site – research unit)	-	-	-	-	-	-	-	-
"BEST"[12] — FAN	2	2	11,16, 20 (Total, susp., vol.)	10	-1	15	9	4
Filtramat	3	4	6, 10, -4	10	8	-12	15	15
TFS (at FAN site)	4	15	32, 47, 47 (Total, susp., vol.)	48	5	55	50	58
TFS (at Filtramat site)	2	15	26, 35, 44	35	11	40	46	56
Constructed wetlands / solids separation	-	57.0	97.0 (SS)	-	-	87.0	41.0	39.0

[1] Values derived primarily from Project Investigator Final Reports. Full reports are available at http://www.cals.ncsu.edu/waste_mgt/ or upon request from the NCSU Animal and Poultry Waste Management Center, on file with C.M. Williams. Some values reflect concentration reductions / recoveries due to nature of waste stream.
[2] TAN = Total Ammonia Nitrogen
[3] TKN = Total Kjeldahl Nitrogen
[4] Solids = Type reported, e.g. suspended, total, volatile noted within each table cell
[5] COD = Chemical Oxygen Demand
[6] BOD = Biochemical Oxygen Demand (5-d)
[7] TP = Total Phosphorus
[8] Values reflect reductions from house effluent (pre digester) through digester unless otherwise noted.
[9] Value reflects nitrification efficiency of biofilters and also represents annual average. Summer season was reported to be approximately 90% nitrification efficiency.
[10] NR = not reported
[11] LWRFL = NCSU Lake Wheeler Road Field Laboratory.
[12] Values reflect reductions from FAN® or Filtramat™ influents (pre-separation) through TFS effluents. Note: project was comprised of two solids/liquid separation systems; a screw-press separator (FAN® Separator) followed by tangential flow gravity-settling tanks (TFS System) located on Farm Site 1; and a screen and hydraulic press separator (Filtramat™) followed by the TFS System located on Farm Site 2. The separated solids for each of the 2 systems (FAN and Filtramat) averaged approximately 30% dry matter. For explanation of the reported negative nutrient recovery values related to the total systems (FAN or Filtramat combined with the TFS System) see page 10 of the Project Investigator Final Report.

Technology (Table 3 continued)	TAN	TKN	Solids	COD	BOD	TP	Cu	Zn
"EKOKAN"[13]	23 to 98[14] (71)	31 to 72[15]TKN (57) -1 to 30[15] TN (15)	-18 to 59[15] suspended (27) -2 to 14 total (4.5)	-18 to 40[15] (18)	0 to 73[15] (48)	5 to 50[16] (32)	19 to 91[17] (34)	23 to 78[18] (54)
Gasification of Solids (Belt system – Grinnells)	-	-	92.5	-	-	-	-	-
Insect Biomass from Solids (Belt System – LWFL)	-	80.2	56.0	-	-	75.4	76.2	75.8
"ISSUES"- Aerobic blanket	27.5	33.0	40.0	-	-	49.7	35.0	64.3
"ISSUES" – mesophilic digester/ microturbine/ water reuse system[19]	85.5	70.1	60.5	-	-	44.6	49.7	47.8
"ISSUES" – Permeable cover	46.3	51.5	81.3	-	-	81.0	86.3	93.7
"ORBIT"[20]	72	56	29 total	NR	NR	26	46	32
"RECIP"[21]	NR	88	48 total 94 suspended	83	NR	49	75	85
"SUPER SOILS"[22]	99	98	98 suspended 99 volatile	97	100	95	99	99
"Super Soils" Compost System	-	96.5 Recovery	-	-	-	100.0 Recovery	95.6 Recovery	99.6 Recovery
"AgriClean" Mesophilic digester and "AgriJet" flush system — MD	3	30	-	-	-	51	56	54
"AgriClean" Mesophilic digester and "AgriJet" flush system — Settling Tank	0.5	2	-	-	-	19	47	42
"Environmental Technologies" - Sustainable NC and Frontline Farmers project	-	-	-	-	-	99+[23] Recovery	99+[23] Recovery	99+[23] Recovery

[13] Values reflect reductions from EQ tank (post solids separation) through biofilter treatment of 2nd stage. Range and (mean) reductions for monthly averages (2/25/03 – 6/27/03) for Biofilters series A and B.
[14] Based on values in Table 1, page 18 of Project Investigator Final report.
[15] Based on values in Table A-4, page 31 of Project Investigator Final Report.
[16]Based on values in Table A-11, page 35 of Project Investigator Final Report.
[17] Based on values in Table A-17, page 36 of Project Investigator Final Report.
[18] Based on values in Table A-18, page 37 of Project Investigator Final Report.
[19] Values reflect reductions noted for primary technology only; water reuse not included
[20] Values reflect reductions from digester feedstock and post digestion.
[21] Values reflect reduction from Cell 1 influent (post solids separation) through Cell 2.
[22] Values reflect reduction from house effluent (pre solids separation) through P removal unit.
[23] Virtually all P, Cu, and Zn are recovered if the system is operated as planned because these species are not volatile and will only leave the system through the separated and settled solids.

Table 4. Environmentally Superior Technology candidate projects demonstrated odor reduction performance. Values shown are approximate average odor intensity ratings at 200 and 400 meters from odor source during the day and night where 0=none at all; 1=very weak, 2=weak; 3=moderately weak; 4=moderate; 5=moderately strong; 6=strong; 7=very strong; and 8=maximal. First value represents whole farm odor emissions; second value represents partitioned emissions from the technology treatment components targeted in the experiment.[1]

Technology	**Day values 200m**	**Night values 200m**	**Day values 400m**	**Night values 400m**
Conventional Technology (Stokes)	1.4 / 1.7	4.0 / 4.2	.57 / 0.5	3.2 / 3.3
Conventional Technology (Moore Bros.)	1.5 / 1.2	4.2 / 3.6	.64 / .46	3.4 / 3.1
Ambient Temperature Anaerobic Digester and Greenhouse for Swine Waste Treatment and Bioresource Recovery at Barham Farm	1.3 / 1.0	3.9 / 2.4	0.5 / 0.3	3.2 / 2.0
"ANT" Sequencing batch reactor system	1.4 / 1.7	3.4 / 4.0	.65 / .79	2.9 / 3.4
BELT (Grinnells lab, NCSU campus)	.04 / NA	1.9 / NA	0 / NA	0.9 / NA
BELT (LWRFLsite)	0.07 / NA	1.7 / NA	0 / NA	1.1 / NA
"BEST" (solids / liquids separation) Biomass Energy Sustainable Technology Site 1 (FAN® + TFS)	1.0 / 1.2	3.3 / 3.4	0..4 / 0.4	2.6 / 2.8
"BEST" (solids / liquids separation) Biomass Energy Sustainable Technology Site 2 (Filtramat™ + TFS)	1.0 / 1.0	3.0 / 2.8	0.4 / 0.3	2.5 / 2.1
Constructed wetlands / Solids separation	1.4 / 1.5	3.7 / 3.8	.70 / .67	3.0 / 3.1
"Ekokan" Biofiltration Technology	1.7 / 1.6	4.4 / 4.2	0.7 / 0.7	3.6 / 3.4
Gasification of Solids (Belt System – Grinnells)	NA / 0	NA / .04	NA / 0	NA / 0
Insect Biomass from Solids	NA / 0	NA / 1.1	NA / 0	NA /.38
"ISSUES"- Aerobic blanket (No IESS) (w/ IESS operational)	1.2 / 1.3 1.3 / 1.2	3.8 / 3.7 3.6 / 3.2	.57 / .46 .55 / .45	3.1 / 3.0 2.8 / 2.6
"ISSUES" – Permeable cover w/ Evaporation system	1.0 / 1.0 1.1 / 1.0	3.4 / 2.9 3.4 / 3.0	.45 / .33 .45 / .37	2.9 / 2.3 2.9 / 2.5
"ISSUES" – mesophilic digester/ microturbine/ w/ water reuse system	1.1 / 1.5 1.1 / 1.5	3.6 / 4.1 3.5 / 4.0	.47 / .58 .53 / .55	3.0 / 3.4 3.0 / 3.2
"ORBIT" High Solids Anaerobic Digester	0 / NA	1.4 / NA	0 /NA	0.8 / NA
"ReCip" Solids Separation – Reciprocating Wetland	0.8 / 0	2.5 / 1.5	0.3 / 0	2.1 / 0.9
"Super Soils" Solids Separation / Nitrification-Denitrification / Soluble Phosphorus Removal	1.2 / 0.8	3.6 / 2.6	0.4 / 0.9	2.9 / 2.0
"Super Soils" Compost System	NA / .63	NA / 2.7	NA / .04	NA / 1.9
"AgriClean" Mesophilic digester and "AgriJet" flush system	1.0 / 0.8	3.6 / 3.3	0.5 / 0.2	3.0 / 2.6
"Environmental Technologies" - Sustainable NC and Frontline Farmers project / Composter	0.7 / 0.7 / 0	3.0 / 3.1 / 0.2	0.2 / 0.2 / 0	2.3 / 2.4 / 0.04

[1] Values derived from Project Investigator data reports.

Table 5. Environmentally Superior Technology candidate projects demonstrated performance for reductions in pathogenic microorganisms. Values shown are approximate Log_{10} reductions in liquid or solid waste (based on waste stream focus of technology).[1]

Technology	Fecal Coliforms	E. coli	Enterococci	Cl. perfringens	Coliphage	Salmonella
Conventional Technology (Stokes)	1.7	1.8	1.6	0.8	1.5	1.9
Conventional Technology (Moore Bros.)	1.4	1.3	1.0	0.6	1.2	0.4
Ambient Temperature Anaerobic Digester and Greenhouse for Swine Waste Treatment and Bioresource Recovery at Barham Farm	4.1	5.2	4.9	2.8	3.7	4.8
"ANT" Sequencing batch reactor system SBR + Lagoons	1.7 3.0	1.7 2.9	2.8 3.0	0.6 0.5	1.9 2.0	0.9 1.2
BELT (Grinnells lab, NCSU campus)	0.0	0.0	-2.2*	0.2	ND	1.0
BELT (LWRFLsite)	-0.6	-0.4	0.4	-0.6	-0.6	-0.4
BEST (Corbett #1): Solids separation - tangential flow separator combined with a fan separation system	0.2	0.3	0.1	0.0	0.4	0.1
BEST (Corbett #3/4): Solids separation - tangential flow separator combined with a screen and screw press system	0.4	0.2	0.7	-0.4	0.1	1.9
Constructed wetlands / Solid separation Liquid waste stream (only)	2.4 3.2	3.6 4.6	1.7 2.5	3.1 4.1	2.1 2.8	2.3 2.9
"Ekokan" Biofiltration Technology	1.5	1.3	1.1	0.7	1.8	1.8
Gasification of Solids / Belt System	2.2	1.9	2.7	3.1	-	-
Insect Biomass from Solids (Combined w/ belt)	-3.7 -3.6	-2.8 -2.5	-5.0 -4.7	-3.2 -4.0	1.1 -0.2	-1.0 -1.8
"ISSUES"- Aerobic blanket	1.7	2.3	2.2	0.9	1.8	2.0
"ISSUES" – Permeable cover w/ evaporation system	4.1 3.8	4.1 5.2	3.3 3.4	1.9 2.5	3.3 4.4	0.5 0.8
"ISSUES" – mesophilic digester/ microturbine w/ water reuse system	3.1 6.5	3.1 6.5	2.7 6.7	0.6 3.9	1.4 5.9	1.3 2.1
"ORBIT" High Solids Anaerobic Digester	4.4	4.3	3.2	1.0	1.8	2.4
"ReCip" Solids Separation – Reciprocating Wetland	1.6	1.7	0.9	0.7	0.8	1.8
"Super Soils" Solids Separation / Nitrification-Denitrification / Soluble Phosphorus Removal	4.4	4.2	4.0	1.4	3.0	3.4
"Super Soils" Compost System 30 day + curing	-0.2 3.5	1.1 3.9	0.3 2.3	2.4 3.9	2.3 2.6	0.7 1.2
"AgriClean" Mesophilic digester and "AgriJet" flush system	1.5	1.5	1.5	0.1	1.1	1.7
"Environmental Technologies" - Sustainable NC and Frontline Farmers project Composter	0.3 2.1	0.5 2.3	0.6 2.6	0.3 3.0	1.0 2.9	0.1 0.8

[1] Values derived from Project Investigator Final Report.

Table 6. Environmentally Superior Technology performance for ammonia reduction. Values shown are % reductions as compared to ammonia emissions from comparable conventional technology sites[1] (positive values indicate reductions in emissions, negative values indicate enhancement of emissions). (Table derived from project investigators report, see Appendix A. 9). Note: Some of these values represent combined whole farm site emissions that are outside of the candidate EST unit process. For determination of EST for ammonia emissions, partitioned data regarding performance of the unit process was considered when possible.

Technology	% Reduction in Emissions from Water Holding Structures[2]		% Reduction in Barn Emissions		Total % Emission Reduction at Technology site[3 4]	
	--- Season ---					
	Warm	Cool	Warm	Cool	Warm	Cool
Ambient Temperature Anaerobic Digester and Greenhouse for Swine Waste Treatment and Bioresource Recovery at "Barham Farm"	-66.4	58.8	13.8	-21.5	-11.9	2.5
"ANT" Sequencing batch reactor system	31.5	-23.5	-95.0	98.0	-4.9	67.2
BELT (Grinnells lab, NCSU campus – research unit)[5]	-	-	-59.8	55.3	-59.8	55.3
BELT – NCSU LWRFL research unit[5]	-	-	-88.7	21.9	-88.7	21.9
BEST (Corbett #1): Solids separation - tangential flow separator combined with a fan separation system	71.1	13.6	73.0	97.0	71.8	66.0
BEST (Corbett #3/4): Solids separation - tangential flow separator combined with a screen and screw press system	39.6	7.4	-184.0	22.0	-29.2	17.0
Constructed wetlands / Solids separation	-41.8	-156.8	-59.4	-47.4	-50.9	-62.6
"Ekokan" Biofiltration Technology	71.7	42.7	-2.9	11.4	43.3	23.5
Gasification of Solids[5]	-	-	-	-	-	-
Insect Biomass from Solids[5]	-	-	-	-	-	-
"ISSUES"- Aerobic blanket	86.7	47.2	-16.3	-10.1	49.5	8.1
"ISSUES" – Permeable cover / evaporation system[6]	-143.8 / -1.4	44.7	0	81.0	-109.9	69.4
"ISSUES" – mesophilic digester/ microturbine	48.8	22.0	-37.0	86.0	31.1	54.0
"ORBIT" High Solids Anaerobic Digester[5]	-	-	-	-	-	-
"ReCip" Solids Separation – Reciprocating Wetland	18.2	-26.4	-40.0	62.0	0.0	20.9
"Super Soils" Solids Separation / Nitrification-Denitrification / Soluble Phosphorus Removal	94.7	99.0	-111.0	98.0	-1.9	98.5
Super Soils Composting[5]	-	-	-	-	-	-

[1]Conventional technology sites included a primary anaerobic lagoon and either tunnel (Moore Brothers farm) or naturally (Stokes farm) ventilated houses.
[2]Percent reductions in water holding structures are based against average lagoon ammonia emissions measured at both conventional farm sites for the respective season. Percent reductions in barn emissions are based against the conventional technology using the corresponding housing ventilation technique.
[3]Percent emission reduction figures are calculated using a precise algorithm that is documented in the respective reports for each technology. The summary numbers provided in this table should not be averaged or combined in any fashion across components of the technologies or across season.
[4]Unless otherwise noted, percent reduction in emissions from water holding structures means emissions from all measured structures at a technology were combined together for a single season to arrive at the single percetn reduction figure.
[5] This technology had no accompanying water holding structures or animal barns. This was due to the configuration and location of the technology.
[6] Right hand box represents the warm season evaluation of Harrell's with the irrigation system. The total emissions were not calculated for this evaluation as no barn measurements were taken at this time

Table 6 (continued)						
Technology	**% Reduction in Emissions from Water Holding Structures[2]**		**% Reduction in Barn Emissions**		**Total % Emission Reduction at Technology site[3 4]**	
	--- Season ---					
	Warm	**Cool**	**Warm**	**Cool**	**Warm**	**Cool**
"AgriClean" Mesophilic digester and "AgriJet" flush system	-	3.6	-	-7.5	-	-6.3
"Environmental Technologies" – Sustainable NC and Frontline Farmers project	-55.0	46.8	-58.0	92.0	30.7	18.5

Table 7. Environmentally Superior Technology candidate project operational feasibility information.

Technology	Operator hours/week	Operator skills	Operator certification / license requirements
Conventional (Stokes)	10	Record keeping, irrigation equipment operation and maintenance. All aspects of planting, harvesting crops receiving lagoon effluent.	Licensed "Operator in Charge" per NCDENR requirements.
Conventional (Moore Bros.)	10	Record keeping, irrigation equipment operation and maintenance. All aspects of planting, harvesting crops receiving lagoon effluent.	Licensed "Operator in Charge" per NCDENR requirements.
Ambient Temperature Anaerobic Digester and Greenhouse for Swine Waste Treatment and Bioresource Recovery at "Barham Farm"	2.5 hours/week (for anaerobic digester, engine, generator, and nitrification biofilters only)	Trouble-shooting pumps, blower, and piping.	TBD[1]
"ANT" sequencing batch reactor system	< 20	HS education or higher with mechanical and electrical skills – working knowledge of physical and chemical lab tests – computer knowledge – capable of troubleshooting pumps and pipes	TBD – on-site training for 1 month
BELT (Grinnells lab)			TBD
BELT (LWR site)	1.0 (belt system to remove solids and liquid from barn only)	Trouble-shoot mechanical systems (motors and drive unit)	TBD
"BEST" Site 1 (FAN® + TFS)	14	Trouble-shooting pumps, equipment and electrical controls	TBD
"BEST" Site 2 (Filtramat™ + TFS)	16	Trouble-shooting pumps, equipment and electrical controls	TBD
Constructed wetlands / Solids separation	7	HS education and mechanical skills	None.
"EKOKAN"	20	Trouble-shooting pumps, equipment, electrical controls and computer controls. Knowledge of system operation and principles of nitrificaton treatment in order to make changes in operation if needed.	TBD
Gasification of Solids / Belt System	15 (farm) 40(centralized)	Record keeping, knowledge of gasification process, mechanical skills / more specialized for centralized facility	TBD
"ISSUES"- Aerobic blanket	5	HS education and mechanical skills– capable of troubleshooting pumps, pipes, and nozzles.	None.
"ISSUES" – Permeable cover	5	HS education and mechanical skills–capable of troubleshooting pumps, and pipes	None.
"ISSUES" – mesophilic digester/ microturbine/ water reuse system	30 - 40	HS education or higher with mechanical and electrical skills – computer knowledge – capable of trouble-shooting pumps and pipes	TBD (microturbine)
ORBIT	40	Mixes feedstocks, feeds digesters, performs lab tests, keeps records, operates forklift, maintains equipment, repairs equipment	TBD
"RECIP"	0.75 (ReCip Cells w/o solid separation only)	Trouble-shoot pumps and electrical controls	TBD
SUPER SOILS	20	Simple trouble-shooting, identification and reporting of problems, automation controls	TBD
"Super Soils" Compost System	13.3	HS education and mechanical skills	None. Operator receives 1-week training by company
"AgriClean" Mesophilic digester and "AgriJet" flush system	5	HS education and mechanical skills– capable of troubleshooting pumps, pipes, and nozzles.	
"Environmental Technologies" - Sustainable NC and Frontline Farmers project / Composter	20 - 30	HS education or higher with mechanical and electrical skills – computer knowledge – capable of trouble-shooting pumps and pipes	

[1] TBD = To be determined. Information provided by NCDENR indicated that currently the Water Pollution Control System Operators Certification Commission (WPCSOCC) is taking no action on classifying any of these systems until final determinations have been made. After determinations are made, it has been discussed that specific classifications will be made for each type of system using training materials developed by the technology providers and approved by the Division. The classifications will be specific to the technology and the certified operator must follow the training developed for the specific technology. All technology providers are required by their permit to develop and submit a comprehensive operator training program for approval if the system is to remain operational. The WPCSOCC rules allow for this type of classification based on treatment processes that are sufficiently different from the conventional treatment process (15A NCAC 8G .0308).

Table 8a. Predicted Annualized Incremental Costs[1] (Task 1) of the EST Candidate Technologies

Technology	Annualized Cost[1] ($ / 1,000 lbs. SSLW / year)
Baseline (lagoon and sprayfield)	$86.81
On-Farm Complete Systems	**Annualized Incremental Cost[1] ($ /1,000 lbs. SSLW / year)**
AgriClean	Insufficient data
ANT Sequencing Batch Reactor (SBR)	$221.43
Barham Farm	$89.17
Belt System	$89.39
BEST (FAN + TFS)	$114.56
BEST (Filtramat + TFS)	$146.50
Constructed Wetlands	$168.05
EKOKAN	$342.26
Environmental Technologies (Sustainable NC-Frontline Farmers)	$136.70
ISSUES Aerobic Blanket System (ABS)	$95.02
ISSUES Permeable Cover System (PCS)	$114.52
ISSUES RENEW	$125.93
Re-Cip	$143.21
Super Soils	$399.71
Separated Solids Treatment Systems (Add-On Technologies)[2, 3] (assumes 0.43 dry tons of solids collected / 1,000 lbs. SSLW / year)	**Annualized Incremental Cost[1] ($ / 1,000 lbs. SSLW / year)**
BEST Idaho (centralized fluidized bed combustion facility)	$255.68
Gasifier (RE-Cycle)	$76.33
High Solids Anaerobic Digester (ORBIT)	$373.22
Insect Biomass from Solids (black soldier fly)	Insufficient data
Super Soils Composting Facility	$83.27

[1] Annualized costs as shown in this table are calculated for a 4,320-head finishing farm using a pit-recharge system of manure removal and nitrogen-based land application to forages.

[2] The annualized incremental costs for the solids treatment technologies include the avoided cost of on-farm land application of solids. That is, ($ / 1,000 lbs. SSLW / yr.) = ($ / dry ton technology cost - $ / dry ton avoided land application cost) * (dry tons of solids / 1,000 lbs. SSLW / yr.). By accounting for avoided land application costs, the incremental annualized costs for the solids treatment systems can be added directly to the incremental annualized costs for complete on-farm systems (which include the cost of land applying solids).

[3] See separate technology reports for additional analysis of break even prices for product sales.

Table 8b. Sensitivity Analysis on Solids Treatment Systems: The Impact of Solids Separation Rate on Annualized Incremental Costs ($ / 1,000 lbs. SSLW / year)

Technology	Moisture Content of Solids[1]	$ / Dry Ton[2] Treated/Processed	Low Separation Rate[3]	Medium Separation Rate[4]	High Separation Rate[5]
			(0.15 dry tons of solids / 1,000 lbs. SSLW / yr.)	(0.43 dry tons of solids / 1,000 lbs. SSLW / yr.)	(1.14 dry tons of solids / 1,000 lbs. SSLW / yr.)
	(%)	($ / dry ton)	$ / 1,000 lbs. SSLW / yr.		
BEST Idaho	70%	$597.38	$89.31	**$255.68**	$680.42
Gasifier	50%	$178.35	$26.75	**$76.33**	$203.14
ORBIT HSAD	70%	$872.15	$130.82	**$373.28**	$993.38
Super Soils composting facility	83%	$194.56	$29.18	**$83.27**	$221.60

Note: These costs are based on demonstrated performance and cost data (usually from pilot-scale or prototype systems). Solids treatment technology providers have proposed steps to reduce the costs of these systems in future generations of their technologies. All of these solids treatment technologies also have an associated proposed by-product revenue stream. If product revenue exceeds breakeven prices for solids treatment, the incremental cost of solids treatment could become negative; that is, a net revenue. See the Task 1 Final Reports for these technologies for detailed breakeven analyses, a discussion of potential revenue streams, and the costs and returns of proposed next-generation solids treatment systems

Note: The numbers in bold face (medium separation rate) represent the numbers that are reported in the Task 1 summary table for solids treatment technologies.

[1] Moisture content of separated solids has a significant effect on the cost per dry ton of solids treatment systems. The costs reported in this table assume the moisture content that is listed in this column. Changing this assumption changes the predicted costs reported in this table.

[2] The costs in this column reflect the per-dry-ton technology cost minus the avoided per-dry-ton cost of on-farm land application of solids.

[3] Low separation rate corresponds to performance data collected from the BEST FAN + TFS separator as operated at Corbett Farm #1. Among the EST separators, the EKOKAN separator had the lowest modeled separation rate at 90 dry lbs. of solids (0.045 dry tons) / 1,000 lbs. SSLW / yr.

[4] Medium separation rate corresponds to performance data collected from the Environmental Technologies, Inc. separator as operated at Chuck Stokes Farm.

[5] High separation rate corresponds to performance data collected from the Super Soils separator as operated at Goshen Ridge Farm. Among the EST separators, the belt system had the highest modeled separation rate at 2,990 dry lbs. of solids (1.495 dry tons) / 1,000 lbs. SSLW / yr.

Table 8c. Effect of Changes in Assumed Interest Rate, Expected Economic Life, and Overhead Rate on Predicted Annualized Direct Construction and Overhead Costs for the EST Candidate Technologies: On-Farm Systems

Technology	**6% Interest Rate, 15-Year Life, 20% Overhead Rate**	**8% Interest Rate, 10-Year Life, 43.1% Overhead Rate**	**10% Interest Rate, 7-Year Life, 43.1% Overhead Rate**
		$ / 1,000 lbs. SSLW / yr.[1]	
Baseline (lagoon and sprayfield)	$30.09 (-41.6%)	$51.52	$70.79 (+37.4%)
AgriClean	Insufficient data	Insufficient data	Insufficient data
ANT Sequencing Batch Reactor (SBR)	$106.25 (-31.8%)	$155.71	$198.42 (+27.4%)
Barham Farm	$30.66 (-41.4%)	$52.34	$71.49 (+36.6%)
Belt System	$38.90 (-31.4%)	$56.71	$71.04 (+25.3%)
BEST (FAN + TFS)	$53.51 (-36.5%)	$84.29	$111.92 (+32.8%)
BEST (Filtramat + TFS)	$69.90 (-35.3%)	$108.12	$141.69 (+31.0%)
Constructed Wetlands	$85.31 (-42.1%)	$147.25	$202.96 (+37.8%)
EKOKAN	$114.14 (-37.7%)	$183.31	$245.70 (+34.0%)
Environmental Technologies Closed-Loop System	$50.04 (-36.3%)	$78.58	$103.73 (+32.0%)
ISSUES Aerobic Blanket System (ABS)	$44.19 (-40.3%)	$74.00	$100.67 (+36.0%)
ISSUES Permeable Cover System (PCS)	$53.16 (-39.5%)	$87.86	$118.83 (+35.2%)
ISSUES RENEW	$62.95 (-34.4%)	$95.95	$124.88 (30.2%)
Re-Cip	$65.42 (-42.5%)	$113.71	$158.36 (+39.3%)
Super Soils	$157.80 (-40.2%)	$263.78	$362.47 (+37.4%)

Note: The numbers in parenthesis represent the percent change from the standard assumptions used in the individual technology reports and cited in Appendix A of the Combined Appendices Report (8% interest rate, 10-year economic life, 43.1% overhead rate).

[1] Annual construction and overhead costs as shown in this table are calculated for a standardized 4,320-head finishing farm using a pit-recharge system of manure removal. These cost estimates include only direct construction and overhead costs. They exclude operating costs, change in land application costs, and returns. Expected economic life is the minimum of the technical useful life of the device (e.g. lagoon, pump, et cetera), the period for which the pig farm remains in production, the period until the device is rendered obsolete (by changes in regulations or technology or prices or other factors), or any other period that ends with the technology no longer being used to produce pigs. Note that this sensitivity analysis is not intended to propose alternative costs and returns estimates. It is solely intended to illustrate the sensitivity of the predicted results to changes in parameter values.

Table 8d. Effect of Changes in Assumed Interest Rate, Expected Economic Life, and Overhead Rate on Predicted Annualized Direct Construction and Overhead Costs for the EST Candidate Technologies: Separated Solids Treatment (Add-On) Systems

Technology	6% Interest Rate, 15-Year Life, 20% Overhead Rate	8% Interest Rate, 10-Year Life, 43.1% Overhead Rate	10% Interest Rate, 7-Year Life, 43.1% Overhead Rate
		$ / 1,000 lbs. SSLW / yr.[1,2]	
BEST Idaho (centralized fluidized bed combustion facility)	$63.60 (-42.1%)	$109.86	$151.41 (+37.8%)
Gasifier (RE-Cycle)	$6.83 (-42.1%)	$11.79	$16.25 (+37.9%)
High Solids Anaerobic Digester (ORBIT)	$155.83 (-42.1%)	$269.13	$370.94 (+37.8%)
Insect Biomass from Solids (black soldier fly)	Insufficient data	Insufficient data	Insufficient data
Super Soils Composting Facility	$41.59 (-32.3%)	$61.42	$78.17 (+27.3%)

Note: The numbers in parenthesis represent the percent change from the standard assumptions used in the individual technology reports and cited in Appendix A of the Combined Appendices Report (8% interest rate, 10-year economic life, 43.1% overhead rate).

[1] Annual construction and overhead costs as shown in this table are calculated for a 4,320-head finishing farm using a pit-recharge system of manure removal. These cost estimates include only direct construction and overhead costs. They exclude operating costs, change in land application costs, and returns. Expected economic life is the minimum of: the technical useful life of the device (e.g. lagoon, pump, et cetera), the period for which the pig farm remains in production, the period until the device is rendered obsolete (by changes in regulations or technology or prices or other factors), or any other period that ends with the technology no longer being used to produce pigs. Note that this sensitivity analysis is not intended to propose alternative costs and returns estimates. It is solely intended to illustrate the sensitivity of the predicted results to changes in parameter values.

[2] The annual cost estimates reported in this table were calculated using a solids collection rate of 0.43 dry tons of solids collected per 1,000 pounds of SSLW per year. This is referred to as 'medium separation rate' in the table "Sensitivity Analysis on Solids Treatment Systems: The Impact of Solids Separation Rate on Annualized Incremental Costs." Please refer to this table for additional analyses of the solids treatment systems.

Table 9. Percent Change[1] in Predicted North Carolina Market Quantities (1,000 lbs. of weight marketed) in the Short, Intermediate, and Long Runs for Selected Incremental Costs

Incremental Cost[2]	Predicted Short Run Reduction	Predicted Intermediate Run Reduction	Predicted Long Run Reduction	Predicted Annual Cost Incurred by Remaining Producers[3]
$ /1,000 pounds SSLW / year	% reduction in North Carolina market quantities (1,000 pounds of weight marketed per year)			$ / year
$440.89	15.5%	49.1%	62.7%	$384,662,000
$396.80	14.0%	44.2%	56.4%	$366,763,000
$352.71	12.4%	39.3%	50.2%	$345,338,000
$308.62	10.9%	34.4%	43.9%	$319,953,000
$264.53	9.3%	29.5%	37.6%	$290,743,000
$220.45	7.8%	24.6%	31.3%	$256,475,000
$176.36	6.2%	19.7%	25.1%	$215,841,000
$132.27	4.7%	14.7%	18.8%	$170,141,000
$88.18	3.1%	9.8%	12.5%	$118,936,000
$44.09	1.6%	4.9%	6.3%	$62,224,000

1. Percent reductions are calculated using the Task 2 software model (Swine Waste Management Simulator). Incremental costs are calculated using the actual predicted (Task 1) cost distribution for the Super Soils technology on representative farms, assuming implementation by all North Carolina farms (see Table SS.94 in the Task 1 Super Soils Final Report). Refer to Tables VI.66-VI.78 in the Final Task 2 Report (Wohlgenant) for a detailed breakdown of percent reductions across type/size combinations for the Super Soils technology. The numbers in Tables VI.68-VI.78 will correspond to the numbers in row 1 ($440.89) of the above table. If assuming a different technology (and thus a different cost function/distribution of costs across types/sizes) or implementation by company-owned farms only, the predicted percent reductions will differ from those reported in the above table.
2. Incremental costs in this column represent the annualized cost of constructing and operating the Super Soils technology on a 5,280-head finishing farm using a pit-recharge system for manure removal and N-based land application to forages.
3. The annual cost ($ / year) incurred by remaining North Carolina producers is calculated as the summed products of incremental costs ($ / 1,000 pounds SSLW / year) and remaining inventories (1,000 pounds SSLW) across 21 type/size combinations. These calculations can be replicated using the Task 2 software model (Swine Waste Management Simulator).