Animal Manure Management in the Chesapeake Bay Watershed

New Opportunities to Meet Nutrient Load Reduction Goals

Natural Resource Solutions, LLC

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The Chesapeake Bay Manure Management Project explored opportunities to stimulate new markets for, and accelerate investment in, innovative technologies that create marketable products that will help reduce nutrient loadings from poultry litter and dairy manure in the Chesapeake Bay Watershed. The project was managed by Natural Resource Solutions LLC (NRS) with guidance and support of a Steering Committee composed of agricultural and conservation leaders in the watershed. The report and recommendations were developed by NRS and are commended to bay stakeholders, policy makers, government officials and most importantly to the owners and managers of animal agriculture operations in the watershed for their consideration and use.

The project was funded by a grant from the Keith Campbell Foundation for the Environment. The Steering Committee and NRS are grateful for the Foundation's support as it allowed for our team to undertake a fresh assessment of ways to meet nutrient load reduction goals for the Chesapeake Bay Watershed while simultaneously enhancing the economic viability and long term sustainability of animal agriculture operations in our region

Project Overview

Animal manure is one of a farmer's most valuable resources, providing nutrients and organic material to support crop production and increase yields. In areas however where the amount of available manure exceeds that which is required to support sustainable crop production, soil, water and air quality and habitat can be impaired by excess nutrient and pathogen loadings.

This project explores opportunities in the Chesapeake Bay watershed to harness emerging technologies and markets that can transform excess manure nutrients from animal agriculture operations into value added by-products that enhance net farm income and simultaneously offset costs of containing or treating waste streams that cause environmental problems. A key objective is to identify ways manure can be managed to help meet environmental goals while improving the farmers' bottom lines.

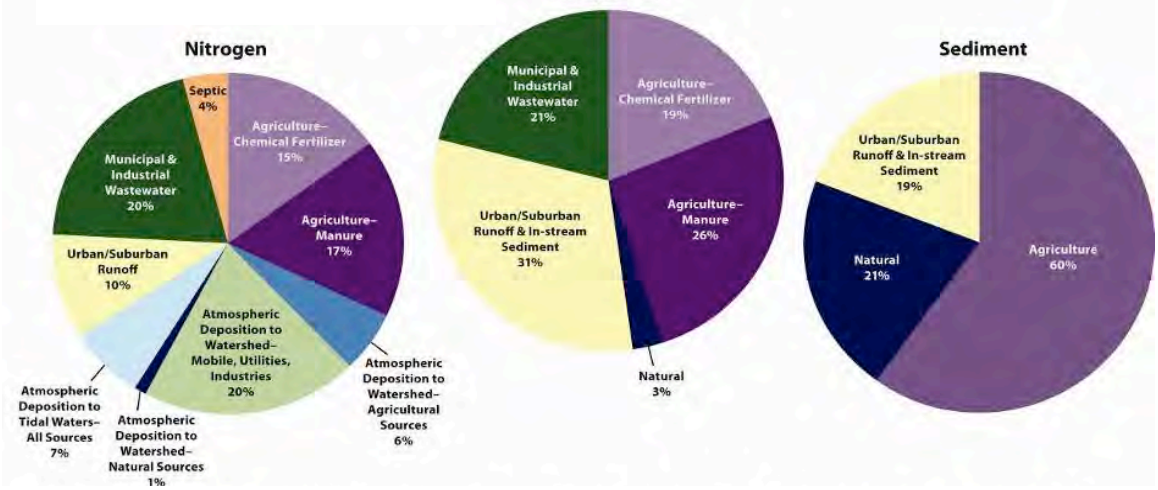
The project involved four distinct components: 1) an examination of current and emerging manure processing technologies that can aid in reducing nutrient loadings from the animal agriculture sector; 2) a review of projects in the watershed that employ new technologies; 3) a scan of innovative national and state programs and incentives that can be employed to help resolve animal agriculture nutrient loading problems; and 4) outreach sessions with farmers, agribusiness representatives, government program managers and ag service providers to garner their perspectives and observations about the opportunities and challenges associated with manure management technologies.

This report and its attendant recommendations were developed by Natural Resource Solutions LLC (NRS) with input and support from a Steering Committee composed of agricultural and conservation leaders in the watershed. The team guided the project and helped identify opportunities to stimulate new markets for, and accelerate investment in, technologies and programs that can reduce nutrient loading from poultry litter and dairy manure.

Introduction

EPA and the states have agreed that agriculture is the largest source of nutrient and sediment pollution in the watershed, collectively representing approximately half of the total pollution entering the bay. According to the EPA Chesapeake Bay Program, seventeen percent of the total nitrogen load and 26 percent of the total phosphorus load entering the Bay comes from animal manure (see Figure 1). While not all farms contribute significant pollutant loads, many are and most going forward will be subject to expanded and strengthened programs and requirements involving nutrient management practices, animal waste storage systems, stream fencing and manure and poultry litter management practices and other measures.

Figure 1



Note: Does not include loads from tidal shoreline erosion or the ocean. Urban/suburban runoff loads due to atmospheric deposition are included under atmospheric deposition loads. Wastewater loads based on measured discharges; other loads are based on an average hydrology year using the Chesapeake Bay Program Airshed Model and Watershed Model Phase 4.3 (CBPO, 2009); Source: EPA Chesapeake Bay Program

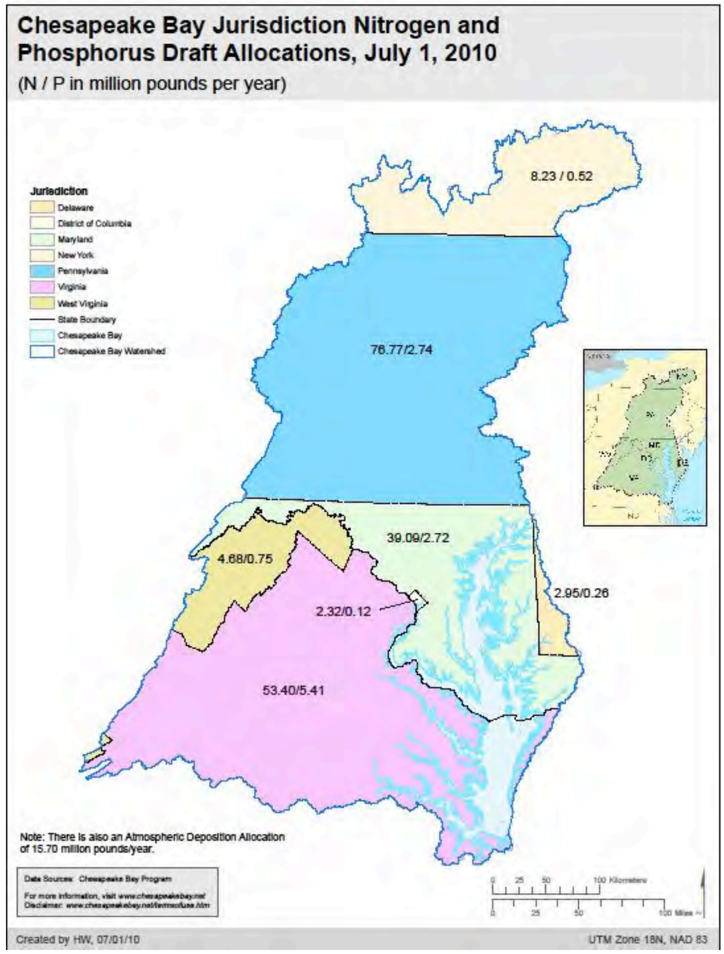
In considering strategies to reduce nutrient loadings from animal agriculture, it is important to recognize their contributions to the region's economy. According to the United States Department of Agriculture's National Agricultural Statistics Service, 2008 cash receipts from the sale of animal agriculture products in the Chesapeake Bay states totaled $10.97 billion. While not all of these receipts were derived from farms actually located in the watershed itself, a significant percentage were, affirming the value of these industries to the regional and state economies. Table 1 below shows the value of production of animal agriculture commodities for a number of counties in the Chesapeake Bay watershed, and their corresponding nationwide rank in production.

Table 1. Production Value by County (2007)

Commodity	County	U.S. Rank	Quantity or Value
Value of livestock, poultry and their products	Lancaster County, PA	10	$922,896,000
	Sussex County, DE	14	$720,873,000
	Rockingham County, VA	29	$514,095,000
Poultry and eggs	Sussex County, DE	1	$706,979,000
	Rockingham County, VA	5	$378,339,000
	Lancaster County, PA	16	$303,043,000
Broilers and other meat-type chickens	Sussex County, DE	1	43,620,576 chickens
	Somerset County, MD	20	12,077,883 chickens
	Worcester County, MD	22	11,688,851 chickens
	Lancaster County, PA	26	10,730,905 chickens
	Wicomico County, MD	31	10,467,370 chickens
Layers 20 weeks old and older	Lancaster County, PA	4	7,086,263 chickens
Turkeys	Rockingham County, VA	4	3,046,414 turkeys
	Augusta County, VA	17	1,509,581 turkeys
Cattle and calves	Lancaster County, PA	20	270,577 cattle
Milk and other dairy products from cows	Lancaster County, PA	10	$387,224,000
Hogs and pigs	Lancaster County, PA	29	$103,331,000
Source: US Census of Agriculture 2007, State Profiles, http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/index.asp			

Over the course of the last decade, a myriad of federal, regional, state and private sector strategies have been developed to reduce animal manure and poultry litter nutrient loadings to the Chesapeake Bay. Among other actions taken, in 2005 the Chesapeake Executive Council formally adopted a comprehensive strategy for managing animal manure and poultry litter in the watershed. In doing so, the Council committed to fully implement current nutrient reduction programs and take further steps to ensure sustainable nutrient reductions into the future, including the development of new markets for use in fertilizer and power generation.

Figure 2



More recently, in response to court action around the failure of the Bay jurisdictions to meet water quality goals set forth in the Chesapeake 2000 Agreement, the U.S. EPA signed a consent order wherein the agency agreed to develop a federal Total Maximum Daily Load (TMDL) for the watershed. The TMDL, which is on track to be finalized by the end of 2010, will for the first time establish the maximum amounts of nitrogen, phosphorous and sediment that each basin the watershed can receive and still meet its water quality standards. The preliminary target loads that have been established by EPA are very aggressive calling for a limit of 187.4 million pounds per year of nitrogen and a 12.5 million pound per year limit for phosphorous (see Figure 2). As agricultural land use activities are responsible for nearly 50 percent of the nutrient loadings in the watershed, the TMDLs that are being developed for the watersheds 92 basins will increase pressure on farmers and ranchers to adopt conservation and management systems that result in significant reductions in nitrogen and phosphorus runoff and leaching. This will be especially true for animal agriculture operations, which make up a significant percent of the total nutrient loading.

Installed Best Management Practice to protect stream. The crossing keeps livestock out of the stream except at the time of crossing. Source: NRCS

A wide variety of implementation measures have been advanced for agriculture in the Chesapeake Bay watershed to control non-point source nutrient and sediment pollution. With regards to managing surplus nutrients from animal manure and poultry litter, the Chesapeake Bay Program has focused on four primary strategies:

1. Reducing surplus animal manure and poultry liter nutrients by adjusting animal diets;

2. Fostering alternative uses for animal manure and poultry litter nutrients by building markets and technologies for manure and litter products that can be used for energy, fertilizers, soil amendments or compost application on land;

3. Developing a comprehensive inventory of manure and nutrient surpluses in the watershed; and

4. Coordinating manure management programs throughout the watershed to address the regional imbalances of manure and poultry litter surpluses.

While much hard work has gone into reducing nutrient loadings from animal agriculture operations, limited progress has been achieved in the watershed and major barriers remain which are impeding the widespread adoption of much needed nutrient reduction practices and technologies. The challenge is to find ways to reduce nutrient and sediment loading while preserving and enhancing the economic viability of animal agriculture operations in the watershed. This report reviews technologies that can be employed to reduce nutrient loadings from animal manure and poultry litter and offers preliminary recommendations for building blocks that can be integrated into a new action plan to expand and accelerate efforts to reduce and mitigate nutrient loadings from the animal agriculture sector.

Nutrient Recovery Technologies

A variety of technologies are used to concentrate or remove nutrients from animal manure. A brief description of the primary technologies that are used today follows.

Anaerobic Digestion

Anaerobic digestion (AD) of animal and poultry manure constitutes the traditional and major current energy recovery process with about 375,000 MWh of electricity generated annually.

While anaerobic digestion does not result in nutrient (N and P) reduction it can be an integral part of an overall energy/nutrient recovery system if combined with additional nutrient capture processes (e.g. separation and composting) because it can generate energy for use and revenue. Anaerobic digesters can also be used for odor control, capturing GHG and more of the nitrogen, energy production via biogas, pathogen control (depending on digestion temperature) and as a pretreatment process allowing the manure to become more pumpable as well as more easily applied to further processing.

Currently AD is not a predominant technology in the Bay (especially in predominant poultry production areas) with only slightly over 20 units in operation primarily on dairy farms, but several more single farm and community AD systems appear to be on the horizon. Purchase agreements with utilities for electrical energy have proven a deterrent to AD implementation in many locations, and community systems face transportation, road and other infrastructure challenges.

Composting

Composting of animal and poultry manure and litter (M/L) represents a significant and growing activity, accelerated by the growth of the organic food production movement, and this will continue as long as the economy supports it and the marketplace is not saturated. Compost provides an opportunity to develop stable, value added products that provide nutrient as well as soil enhancing characteristics. Major advances in quality standards for compost have provided a level of consumer security that did not exist a decade ago, and that has helped develop markets for urban as well as agricultural users.

The advance in organic and/or locally grown food has linked to the value of compost, in the sense that it represents a "non-chemical" way for production to take place. Compost can be produced on-site and that is an attractive way to recycle nutrients. To the extent that compost nutrients are utilized within the watershed, they do not represent a removal function. To the extent that they replace nutrients that would have been brought in from outside the watershed, they impact the mass balance in a positive way. Although highly variable, and process-dependent, ammonia loss from composting operations represents a negative impact in that it can contribute to atmospheric contamination and uncontrolled deposition elsewhere within the watershed.

Composting of M/L is well established in the U.S. with a significant number of sites in the Bay also. A benefit of composting is that it produces a product of established retail as well as wholesale market value that is well accepted for both residential and agricultural (organic and conventional) use. In addition, composting can be appealing because it can be deployed in a simple manner and may require a low capital investment depending on the actual process selected. The distribution chain also provides an opportunity to move the product completely out of the area of production, which is especially valuable for the Bay.

Pelletizing

Pelleting of M/L has been a successful technology for consolidating nutrients. The primary advantages of pelleting are ease of handling and cost of transportation due increased volume density. A liability for pelleted uncomposted M/L is odor. Composting prior to pelleting should be considered in order to compete in a residential retail market. Pelleting offers the advantage of cost effective nutrient removal from the site of M/L production.

Combustion

Direct combustion of litter for electricity generation is increasing and will continue (with addition of co-firing of manures also) as utilities seek/are required to increase renewable energy components in their overall portfolios. This practice results in the generation of mineral residue that can be transported and utilized for recycling in feed or land application. New and emerging technologies to generate bio-oils and other biofuels will continue to add to these opportunities. The benefit to nutrient reduction is that the residue from the process can be more easily transported out of the area than the original raw material. Two barriers for developing manure as a renewable energy biomass for utility use include: a) conditioning the solids for reduced moisture levels and transporting; and, b) realizing an attractive rate the utility is willing to offer the farm producer for his contribution to the grid.

Large-scale energy production using M/L alone has significant issues with transportation, concerns about air quality (emissions) and alternative use pressure. With significant weight and volume reduction, phosphorus rich ash produced by combustion can be transported out of the area efficiently and also used as a land mineral amendment or as source of mineral supplements for animal feeding. Advancements in pyrolysis technology (gasification, torrefaction, etc.) will provide additional opportunities for uses of M/L in energy and co-product production and capture, allowing efficient nutrient reduction to take place.

Separation and Nutrient Recovery

There are many types of technologies available to livestock and poultry producers that enable or will enable separation and recovery of nutrients from manure or litter. For wet waste streams (i.e. dairy and swine) the separation processes are key to moving solids off the farm. For dry wastes such as poultry litter a fractionation process (i.e. screening) has been shown to provide a large percentage of course material having most of the energy, whereas the fines have been shown to contain most of the nutrients. Chemical additions can further enhance the separation process.

State of Technology Today

In order to obtain a fresh assessment of the technology available to address nutrient loadings from animal agriculture operations, a National Technology Scan was conducted starting with a survey of approximately 100 experts in animal manure and waste management arena seeking input on technologies in use in their specific area, the effectiveness of those in nutrient reduction through development of value added products including energy capture. In addition, input was sought on those promising technologies on the horizon but not yet deployed. While nitrogen (N) and phosphorus (P) were the primary nutrients of concern, information on other components was provided in some cases. Each of the states within the Chesapeake Bay Watershed was included in that survey.

The results of the input gathered are summarized below. A more detailed report on the findings is included in Appendix I.

- With few exceptions, land application of M/L in support of the nutrient needs for animal feed and other crop production is the primary method of management. The resulting feed and animal products produced and/or income from sale of M/L to provide crop nutrients for purposes unrelated to animal feed production represent the value added element of that management.

- In many areas in the US, including but not unique to the watershed, long-term land application of M/L prior to the implementation of current nutrient management recommendations and/or requirements has resulted in accumulation of some nutrients (P of most concern in the watershed and eastern US in general, but with others such as Zn and As also) in excess of plant requirements. These conditions dictate that while there is still a need for application of other plant nutrients contained in M/L, P may dictate how much if any M/L can be applied in the future.

- Various types of anaerobic digestion are used to capture energy (as biogas for heat or electricity generation), to reduce odors and to stabilize N, thus reducing emissions. AD does not by itself result in nutrient reduction, but may serve as a unit process in a system, providing value added returns in energy sale or offset (heat) which can help fund a total system. Currently AD is not a predominant technology in the watershed (especially in predominant poultry production areas), but some single farm and community AD systems appear to be on the horizon. Purchase agreements with utilities for electrical energy have proven a deterrent to AD implementation in many locations, and community systems face transportation, road and other infrastructure challenges.

- Composting of M/L is well established in the US with a significant number of sites in the watershed also. A benefit of composting is that it produces a product of established retail as well as wholesale market value that is well accepted for both residential and agricultural (organic and conventional) use. In addition, composting can be appealing because it can be deployed in a simple manner and may require a low capital investment depending on the actual process selected. The distribution chain also provides an opportunity to move the product completely out of the area of production, which is especially valuable for reducing nutrient loads to the bay.

- Pelleting of M/L has been a successful technology for consolidating nutrients. The primary advantages of pelleting are ease of handling and cost of transportation due increased volume density. A liability for pelleted uncomposted M/L is odor. Composting prior to pelleting should be considered in order to compete in a residential retail market. Pelleting offers the advantage of cost effective nutrient removal from the site of M/L production.

- Combustion and or use of thermo-chemical processes of M/L has been accomplished commercially in several locations of the United States. Combustion of M/L alone (poultry litter) or in mixtures with coal to produce electricity is the primary effort, with variations including gasification being evaluated. This effort will continue with pressure on public utilities to include renewable energy in their production portfolios at established percentages. Large-scale energy production using M/L alone has significant issues with transportation, concerns about air quality (emissions) and alternative use pressure. With significant weight and volume reduction, phosphorus rich ash produced by combustion can be transported out of the area efficiently and also used as a land mineral amendment or as source of mineral supplements for animal feeding. Advancements in thermal conversion processes (e.g., pyrolysis, gasification, torrefaction, etc.) can provide additional opportunities for uses of M/L in energy and co-product production and capture, allowing efficient nutrient reduction to take place.

- Although primarily focused on water quality, technologies that capture and remove nutrients from the production area may also be effective in reducing air emissions of N, which has potential water quality impact. This is especially true for poultry litter treatments that retain N for transportation out of nutrient saturated watersheds and thus reduce emissions, both being important to the Bay cleaning effort.

- Work on the use of biological methods for nutrient recovery from M/L has lagged far behind those focused on physical technologies with the exception of a small effort in algae production of biofuels.

- There are numerous possibilities for unit or integrated systems that are being used in municipal wastewater treatment and that could have application to animal waste nutrient removal, capture or stabilization for controlled use.

- AD and composting are biological processes, but those have had limited work targeted toward improved performance through microbiological investigation. There are significant opportunities in this area because of the rich array of research universities and public as well as private institutions. Attention should be given to development of this resource.

The technology scan also verified that the following initiative areas are of great importance in reducing nutrient load in the Bay:

- development of economically viable enterprises based on by- and/or co-products (emphasis on marketing);

- development of "third party service industries" for technology management;

- development of a comprehensive system for technology evaluation (including economic viability) using "third party" oversight and cost sharing by the technology provider and the public.

The three categories for greatest return on converting M/L into value added products include nutrient use (organic and other fertilizers, compost, bio-char, etc.); energy (biogas, bio-oil, electricity, etc); and, water reuse and management (flushing, irrigation, animal watering, etc.).

Projects on the Ground

During the scan on technologies, attention was given to the various kinds of technologies that are in commercial application around the U.S. that are also in place in the Chesapeake Bay watershed. A review of animal manure and poultry litter management projects in the watershed revealed a wide variety of technologies that have been employed to process these value added resources. Most however are immature unit technologies that have not been integrated with other collateral solution sets. For purposes of this review, projects were grouped into two categories: energy recovery projects and composting and pelleting projects. We also summarize the experiences of a dairy operation outside of the watershed that has integrated multiple unit solutions into a highly effective management system that could be replicated in the Bay watershed. A conclusion would be that aside from AD implementation on dairy operations, the rate of adoption of new technologies in the watershed has been less than in other areas of the U.S. A summary of each follows:

Energy Recovery Projects

Anaerobic Digestion

According to the latest information from the EPA/Agstar program, there are 26 functioning anaerobic digestion (AD) units in the Chesapeake Bay Watershed (CB). Fifteen are located in PA (13 located on dairy facilities and 2 on swine operations); ten are located within the CB zone in NY(all on dairy farms); one is on a USDA research facility in MD (dairy waste only); and none currently in DE, VA or WV. Each of those AD units is used to recover energy in the form of methane in the biogas produced by anaerobic digestion. The methane is subsequently burned and the heat is used to produce electricity and/or to heat water or warm interior building space.

Anaerobic digester that processes swine waste and heifer waste at Feerlings Hillside Swine Farm in Overisel, Michigan; Source: FPPC

Effluent from those AD units, containing all of the specific nutrients that are added in the animal manure and/or litter (except the carbon, hydrogen and oxygen collected as biogas, some moisture due to evaporation in the AD unit and trace amounts of sulfur and nitrogen), is land applied for crop fertilizer and soil enhancement with the exception of one in PA and one in NY which separate solids for other value-added organic products (the liquid is land applied as fertilizer). An additional operation in PA is planning to add composting of solids following its AD system. A complete and updated list of the AD units in the CB can be found on the EPA website at: www.epa/gov/agstar/accomplish.html. That site lists each farm, its location and size, as well as its energy production.

Several AD units are reported to be under "planning and development" within the Chesapeake Bay watershed although the number is uncertain and dependent on permitting, power (electricity) sale/purchase agreements with utilities and funding. One example is the CARD/COVE project in Altoona, PA which has been in planning and development for the past six years. It is a digester and wastewater treatment project that will produce biogas from dairy cattle waste (several farms) and other community biosolid waste streams by thermophilic (145F) AD to be used to generate electricity. Separated digestate solids will be dried as a soil amendment, and the wastewater will be treated meet regional standards for discharge. In addition, an AD project that would use poultry litter and a poultry processing byproduct is being considered in MD, but its feasibility has not been adequately evaluated.

These developments should be closely watched as they represent innovative approaches that have not been demonstrated to date in the Chesapeake Bay watershed, and might add substantively to the recovery of energy as a value-added product using AD as a part of a comprehensive waste management program. As noted above, AD by itself does not result in a reduction in nitrogen or phosphorus, which are elements of concern in the water quality of the bay.

Currently there are no poultry AD units in operation in the Chesapeake Bay watershed, primarily due to the fact that the vast majority of poultry waste is combined with litter materials and is in a form that is too dry for normal AD activity. However, there is promising work coming from Mississippi, in a project under development in which substantial management changes are being made in litter-based poultry production to increase manure content. The harvested high-manure content litter is diluted with water to a solids content of about 10 percent and processed through an AD unit. Biogas production is excellent due to the reduced content of high-fiber plant litter materials. The slurry exiting the AD must be, however, further processed to remove the high content of water in order to make transport economically feasible. Additional products from separated solids might include compost and other soil amendments. The poultry industry in the watershed should watch these developments closely for applicability to Chesapeake Bay conditions.

There has been significant interest in the Chesapeake Bay watershed for energy recovery from poultry litter (PLE) for a number of years, and a variety of projects have been initiated with varying success. An excellent and comprehensive report by the Chesapeake Bay Program Office in 2008 titled: ***Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality*** (www.cbp_17018.pdf) provides a detailed analysis of the entire picture. Although somewhat over 2 years old, the report is as relevant today as it was when printed. *It is important to note that there are numerous successful global examples of recovery of energy from combustion of poultry litter and the technology is well established to accomplish that goal while meeting environmental protection standards.*

Thermal treatment of poultry litter results in different products, depending on the temperatures and conditions used, (combustion, gasification and pyrolysis) as the above report documents. Below is a brief differentiation of those processes.

Combustion (high temperatures, up to 3600°F, excess oxygen)
Initially there were several combustion projects in MD, PA and VA but as of this date there are no functioning units on a commercial scale in the watershed. A large-scale combustion facility is under consideration for the Eastern Shore of MD (FibroShore).

Total combustion of poultry litter yields a sterile ash that has numerous possibilities for use. Incorporation of the material based on its mineral composition into chemical fertilizers is an attractive option. In addition, use of the sterile ash as a source of minerals for incorporation into poultry diets offers a way to offset purchase and importation of those minerals from outside the bay.

Co-firing with coal or other existing fuels (combustion) has been done, with technically encouraging results. Transportation and other logistic issues are less attractive. At this time there is no co-firing of litter with coal being done in the Chesapeake Bay watershed.

Gasification (temperatures between 1100-1800F, oxygen limited and no flame)
A number of studies have been conducted with poultry litter in the watershed, and several projects have been proposed. Presently there is one demonstration project on a poultry farm in the bay region of WV, one is operational on a farm-scale level in PA and several are planned in PA as part of a demonstration project. Gasification of poultry litter in a co-firing system with coal has been evaluated elsewhere and as with combustion is technically feasible. Gasification yields a combination of gaseous products that have value as fuels or can be recombined into other biofuels for use elsewhere (transportation, for example). Heat recovery from well-designed gasifiers can result in near elimination of the need for external fuel for operation once the process is initiated. The ash products of gasification have similar value as fertilizer or re-feeding to poultry.

Gasifier that consumes poultry litter and generates electricity at the Marc Marsh Farm in Cheraw, SC; Source: FPPC

Pyrolysis (temperatures between 390-1100F, oxygen free)
Projects have been conducted using poultry litter in VA, and a portable farm-scale unit was in use in VA (VA Tech) on a test-basis (no results available). The products of

pyrolysis include some gaseous compounds and also a mix of biooils, tars and other nonvolatile materials (variable based on composition). These products can be used as biofuels also as noted above. Residual solids from pyrolysis may have too much carbon to be used as a sterile ash or refeeding product.


Mobile pyrolysis unit that converts poultry litter to biochar and heating oil; Source: FPPC

Although there are no projects or tests underway at this time using poultry litter in the watershed, there is also a significant interest in production of biochar (a charcoal-like product produced within the range of temperatures defined as "pyrolysis", and which can be used as charcoal-like fuel as well as a carbon sequestration process) from poultry litter.

Although there is no current activity in the Chesapeake Bay watershed to market the ash that poultry litter energy projects would generate, there is significant opportunity for use of these mineral assets in blended fertilizers, for use in applications that do not allow use of raw poultry litter such as tomato production, or as an easy way to export nutrients out of the watershed. As well, there is sound evidence that those elements can be re-fed to animals to meet dietary mineral needs. These are all being considered in planning in the watershed for poultry litter energy facilities.

Compost and Pelleting Projects

There are currently at least 25 animal and poultry facilities in the Chesapeake Bay watershed and immediately adjacent to it (and therefore possibly gathering litter from the watershed) that compost manure and/or litter. The precise number is uncertain and there are several operations that are planning to initiate composting in each of the states in the watershed.

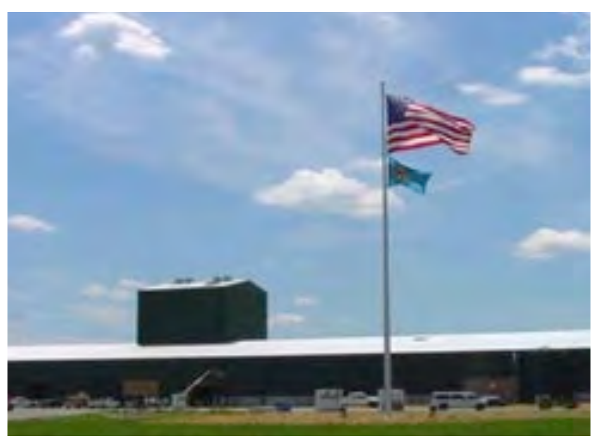
One example is Oregon Dairy Organics, a multi-feedstock (manure and yard-waste) compost facility in Lititz, PA, co-owned with Terra-Gro, and funded by the Chesapeake Bay Funders Network, the W.K.Kellogg Foundation, the National Fish and Wildlife Federation (NFWF), USEPA, the PA Dept. of Environmental Protection, the PA Rural Education Achievement Program, and managed by Environmental Defense Fund. Compost will be marketed within and outside the Chesapeake Bay watershed, thus providing an opportunity to export nutrients as well as offset importation of new nutrients through use of compost within the watershed.

Composting facility at Oregon Dairy; Source: http://blogs.edf.org/oregondairyorganics/

Among those producing compost, the majority market locally, and therefore within the Chesapeake Bay watershed. The only direct impact that this practice has on nutrient reduction is the potential for offsetting of purchasing imported fertilizer nutrients from outside the watershed. There are no data on the extent of offsetting or the quantity of compost exported outside the watershed, and those data are badly needed.

Composting of animal waste of all types results in increased stability of the volatile nutrients, reduction in odors, and a reduction in the mass of material of approximately 50 percent. Emission of nitrogen (ammonia most notably, but possibly other greenhouse gases and particulates) is of concern, especially with the prospect that EPA will increase pressure on reducing ammonia emission in the Chesapeake Bay watershed. Those producing compost should be aware of these considerations.

In 2001, Perdue opened their AgriRecycle, LLC, micronutrient plant in Seaford, DE. This facility has the capacity to produce 80,000 tons of poultry litter pellets annually (with 40-50 percent more potential). Rail transport of pellets out of the watershed for use as crop fertilizer in the Midwest is one of the major end uses, with additional interest in "high-end" applications such as golf courses, etc. This is an existing resource that can substantially impact nutrient reduction in the Chesapeake Bay watershed if operated at an economically viable level.



AgriRecycle, LLC, Seaford, DE

A Case Study from Outside the Chesapeake Bay

The Foster Brother's Farm in Middlebury, VT, is a fifth-generation family dairy farm operated as a corporation currently milking 385 cows producing in excess of 10 million pounds of milk per year with an AD installed in 1982 primarily for odor reduction, and generation of revenue from electricity.

Initially the electrical power produced was sole to their local utility which as regulations evolved led them to supply their own power. Their utility subsequently has embraced generation from AD and developed the Cow Power Program for the utilities customer base.

During the 28 years of operation, they have progressed from separating AD digestate solids (using a progression of separator types, including one that was home-designed and built) for stall bedding, with liquid either used as cropland fertilizer or (small amount) developed as household plant food, to composting digestate solids for local markets, to the current operation (Vermont Natural Ag Products, Inc.) that produces over 28 different compost, soil amendments and landscape materials.

Their operation includes feedstocks from other farms and occasionally byproducts from a local large cheese manufacturing facility (processed in the AD) as well as pre-consumer food residuals for the local Solid Waste District. They have set up a marketing system that includes direct sales, wholesale sales to retailers and landscapers, a distributor network, and partnerships with other suppliers for their extensive customer base as well as an in house scheduling and delivery system. Their marketing effort has expanded their penetration into the Boston, Hartford and greater New York metropolitan areas and covers the New England states, New York State and some in the states of Pennsylvania and New Jersey. This operation is an example of a fully comprehensive approach to recovery of value-added products and energy from manure, and the development of markets to accommodate those products. (www.moodoo.com).


Vermont Natural Ag Products composting facility.

Innovative Government Programs

A third component of the project involved a scan of existing national and state programs that can be employed individually or in combination to help resolve animal agriculture nutrient loading problems. With regard to state programs focused on reducing M/L nutrient loadings, little in the way of "innovative" programs or approaches was found. The vast majority of government M/L programs in place today are well known by natural resource managers and agricultural producers. Most are designed to provide cost share and technical assistance for adopting proven best management practices, developing nutrient management plans and in some states consolidating manure and litter for transport out of impaired watersheds. Examples of existing state programs can be found in Appendix II.

At the federal level the USDA Environmental Quality Incentives Program (EQIP) and a subprogram, the Conservation Innovation Grants Program have been primary tools for directing government support to animal agriculture water quality improvement projects in the Chesapeake Bay watershed. In addition the Chesapeake Bay Watershed Initiative, another EQIP program, is used to address resource concerns involving livestock waste.

Likewise, EPA's Section 319 Program has been employed to fund a variety of on farm water quality programs and projects across the country. Under Section 319, states, territories and tribes receive grant money that supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific non-point source implementation projects. In nearly all cases statewide demand for program resources far exceeds available resources with most operating in an oversubscribed status (see Table 2).

Table 2. EQIP Contract and Funding Data FY 2009

State	Number of Contracts	Financial Assistance Dollars Obligated	Number of Unfunded Applications	Estimated Unfunded Application Dollars
Delaware	138	$5,562,599	706	$10,883,347
Maryland	268	$6,820,190	663	$3,995,410
New York	364	$13,345,998	1,653	$39,158,038
Pennsylvania	342	$12,761,493	3,059	$74,665,929
Virginia	322	$10,418,248	1,048	$15,303,824
West Virginia	209	$5,671,101	1,405	$26,374,691
TOTAL	**1,643**	**$54,579,629**	**8,534**	**$170,381,239**

As noted previously, a major challenge that must be overcome is finding *economically viable* technologies and management practices that can be employed to resolve nutrient loading problems from animal agriculture operations. To date, most government programs in place to address M/L nutrient problems are focused around land management practices for reducing N and P loadings and stand alone unit technology solutions. While many of the technology solutions we investigated pass the "technologically feasible" test they are still in very immature stages of development and have not been proven to be "economically" feasible solutions. For this reason, the need exists to better integrate and harmonize land management and technology solution sets, especially those that can improve economic performance by incorporating value added by- and/or co-products and services such as electricity, mineral ash and fertilizers, compost and animal bedding.

These integrated solution sets offer significant opportunity and should be more fully investigated by Chesapeake Bay watershed managers.

For example, government programs that provide incentives for the development of renewable energy from animal manure and poultry litter can be coupled with nutrient management cost share or grant programs resulting in an integrated system of unit processes that are more likely to be economically viable than stand alone unit components. Renewable electricity standards and feed-in-tariffs create demand for farm based clean energy solutions, the revenues of which can be used to offset BMP and M/L process costs. When combined and harmonized with well designed renewable energy public benefit fund mechanisms; policy measures to ensure energy producers have access to the grid; fair pricing agreements and policy tools to help reduce or manage capital costs such as grants, loans, loan guarantees and tax credits, a more robust and effective solution set emerges.

Unfortunately a comprehensive, centralized and searchable database of national or regional farm focused renewable energy and M/L nutrient management programs does not exist today. The DSIRE web site operating for DOE by NC State www.dsire.org offers a wealth of information on renewable development programs and tools but is not designed to search for agriculture based solution sets. Examples of state M/L programs that may be of interest to Chesapeake Bay program managers and advocates are included in Appendix II.

Key Findings

1. Land application of animal manure and litter (M/L) in support of the nutrient needs for crop production remains the primary method of managing manure in the Chesapeake Bay Watershed. When M/L can be land applied at proper agronomic levels, this is the most cost-effective and technologically feasible method of managing manure.

2. In many areas in the US where there is a concentration of animal agriculture and a shrinking land base, the long-term land application of manure and other fertilizers has resulted in excess nutrients in the soil with phosphorus (P) of most concern (followed by nitrogen) in the Chesapeake Bay Watershed. New requirements for phosphorous will dictate how nutrients will be land applied in the future.

3. If adequate crop-land is not available within the watershed for land applying, farmers face a need to transform the manure, and concentrate the nutrients for transport out of the watershed.

4. A number of technologies can provide nutrient and energy recovery as value added by-products from animal and poultry manure and litter (see Appendix I) but most are still in early and immature stages of development. These solutions usually focus on the feasibility of a unit process and have not been integrated well enough to be "economically" viable. Overcoming the economic hurdle is imperative. Integrated

nutrient and energy technologies must offer complete, comprehensive and economically viable solutions if they are to be commercially viable for either the farming or the investment community.

5. Where there are concentrations of farms with insufficient land base for spreading/land applying nutrients such as on the DelMarVa peninsula and in Shenandoah and Lancaster Counties, the economics of larger centralized treatment and processing systems will be attractive because of logistics and transportation cost factors.

6. At the moment, there is a strong market for the farmer's untreated manure and poultry litter at $15-20/ton. Successful alternatives must upgrade animal waste to higher value by-products for new markets, including liquid fuels, electricity, mineral ash, organic fertilizers, compost and animal bedding.

7. The operation and maintenance skills for new technology and waste treatment systems are critical and are often well beyond the skill set available at the farm. Some farm owners want to be the sole operator of the waste treatment system while others have no desire or the time to be involved; hence there is a growing need within animal agriculture to have a full service provider available as desired if the technology is be deployed appropriately..

8. In order of importance, the advancement of technology solution sets to treat and better manage animal manures and litter for nutrient reduction should include:

- identification and funding of integrated technology solution sets;
- refinement of viable by-products for residential and commercial markets:
- development of third party "service" industries for technology design, installation, monitoring, management and repair;
- creation of an independent, comprehensive system for technology evaluation based on both technical and economic feasibility, with cost of evaluation shared between the provider and the public.

9. The three categories for greatest return on converting M/L into value added products include:

- nutrient use (organic fertilizer, compost, biochar etc);
- energy (biogas, heating oil, electricity, heating/cooling applications); and
- water re-use and management (flushing, irrigation, animal watering needs).

10. In the Chesapeake Bay watershed, all sectors will be required to reduce nutrient and sediment loading to surface waters. Government incentives to offset investments, costs of maintenance of existing and new technology systems and marketing of manure and litter byproducts are needed in order to enable agricultural producers to achieve pollution reduction goals while remaining economically viable in the long-term.

Recommendations

Not surprisingly, there are no "silver bullet" solutions for managing animal manure and litter. However, this analysis and our conversations with producers and bay managers did identify a number of components and collateral programs which, if better integrated, could help solve one of the most significant barriers to meeting the nutrient reduction targets that are being established through the TMDL process- that being the need to find cost effective M/L solutions that are scalable, manageable and appropriate for the wide variety of farming operations and conditions in the watershed.

To expand and accelerate the installation of effective M/L practices and technologies in the Chesapeake Bay watershed, the following actions are recommended as part of a comprehensive plan to reduce nutrient loadings from animal agriculture operations.

1. Authorize and fund and/or strengthen government programs at all levels that can accelerate the deployment of bundled technologies and processes that deliver both nutrient reduction and energy recovery services along with value added end products.

A primary conclusion of this review is that while there are many promising technologies available for M/L processing that can accomplish nutrient reduction and recovery, most while technically feasible, have not proven to be economically feasible. This is most often because these technologies result in new by-products, rely on sub-optimized processes, introduce new financial risk and provide uncertain pathways to markets. Many suppliers and innovators offer unit processes (i.e. processes that accomplish one of the desired outcomes but not all of them) and innovative technologies that masquerade as complete solutions. But to be economically viable each component of the process must fit together and deliver higher value end product/benefit than the cost of its transformation. The emergence of realistic markets for renewable energy, greenhouse gases and organic fertilizers and new policy and regulations will ultimately shape the development and economic viability of these systems.

The following initiatives are recommended to accelerate the deployment of integrated solutions that deliver nutrient reduction and energy recovery services along with value added end products.

Initiative 1- Support Integrated Solution Sets

Recommendations:

- Increase funding for research, development and deployment of integrated unit processes for M/L management that accomplish nutrient reduction objectives;

- Fund training and cost share programs for third party operation and maintenance service providers who support waste treatment and renewable energy generation systems;

- Ammonia levels and emissions need to be quantified with energy recovery systems. This could be accelerated if supported and funded with help from the EPA;

- Broaden the mission of the EPA AgStar program to include collateral water quality improvement outcomes that can be achieved by capturing nutrients from anaerobic digesters, concentrating them or repackaging them for future or alternative use; in essence encourage not only the capture of GHG from the waste stream but technologies that lessen the impact to the environment by nutrient capture.

Initiative 2- Create Demand for M/L Products and Co-Products

Recommendations:

- Explore the use of feed-in-tariffs as a mechanism for providing developers of renewable energy with long-term purchase agreements for the sale of electricity, the revenues of which can offset M/L treatment costs;

- Create and fund market development programs which seek to provide sustainable markets for M/L compost and pellets and the products and by-products of renewable energy technologies including electricity, biogas, fertilizers, ash and heat;

- Establish or expand state purchase requirements for M/L compost or pellets.

Initiative 3- Establish a Public Benefits Fund to Finance Integrated M/L Solution Sets

Recommendations:

- Collect a public-purpose charge from utility customers to support renewable energy development projects associated with M/L management systems;

- Secure payments from utilities as a condition of obtaining an operating permit/license;

- Allow utilities to contract with the state energy conservation corporations/agencies to administer renewable energy programs;

- Provide municipal utilities and electric cooperatives the option of participating in the state program or operating their own "commitment-to-community" programs;

- Provide financial incentives for small-scale and utility-scale projects that generate energy from biomass and M/L resources.

Initiative 4- Ensure Access to Markets and Fair Prices

Recommendations:

- Adopt effective net-metering and power purchase laws that will facilitate the deployment of clean energy technologies and projects;

- Establish interconnection standards and procedures that facilitate the development of distributed renewable energy generation systems;

- Authorize voluntary consumer purchase of renewable electricity programs like the successful and nationally recognized "CowPower" program in Vermont, the first of its kind in the U.S. (www.cvps.com/cowpower) and the "Green Power" program in North Carolina (www.ncgreenpower.org).

Initiative 5- Reduce process costs and help finance M/L technologies

Recommendations:

- Establish and fund grant, low interest loan and loan guarantee programs to support pre-development project work, leverage private capital and support the installation of commercial scale unit processes that can be integrated to deliver nutrient reduction services; renewable energy production; and value added co-products such as compost, feed supplements, minerals, bedding and inorganic building materials;

- Provide financing and tax credits to support renewable energy investments which can help make integrated M/L nutrient reduction systems cost effective;

- Provide self-generation rebates to support existing, new, and emerging distributed energy resources;

- Use existing state manure transport programs to offset transportation costs of moving animal manure and litter to facilities that process M/L into energy or other value added by-products;

- Provide cost sharing for equipment that can separate solids from liquid manure;

- Provide tax incentives such as sales tax exemptions and property tax reductions to help producers offset the capital costs of renewable energy and M/L nutrient reduction technologies and systems;

- Encourage corporate and institutional investments by authorizing long term investor and production tax credits and accelerated depreciation in renewable energy and M/L treatment technologies.

2. Establish a resource center in the watershed dedicated to support pilot scale deployment of animal agriculture nutrient reduction technologies.

It is well known in the agricultural sector that most farmers are more apt to adopt a technology if they can see it operate in a farm environment. In running their business, farmers and their bankers recognize there is risk in making a technology investment particularly if the claims for a payback are uncertain and the regulatory environment is changing.

Our assessment has revealed that there are many nutrient reduction technologies and systems in various stages of development in the watershed. We also found concept stage solutions sets that are being discussed by researchers and early adopters. Many technology providers are offering partial solutions and some of those claims have technical merit but are usually not substantiated in a farm environment or have not qualified with "manure" feedstock. The large majority of solution providers are enthusiastic about their offering and while most can usually demonstrate a unique technical strength, they lack ag experience and usually do not provide a fully integrated solution for the farm – an important attribute for developing an economical solution.

These realities point to the need for **an objective, third party evaluation support system** where new technologies and integrated solutions sets can be "piloted", and data relative to technical and economic feasibility that can be used by producers and lending agencies in making decisions can be centrally gathered.

It is unrealistic to expect that an innovative technology provider will have the capital or be willing to take the financial risk needed to contract with a third party evaluator directly. It is equally unrealistic to think that livestock and poultry producers will independently invest in new technologies that are neither evaluated nor shown to be economically feasible on their own. The Land Grant System, which once would have served in that third party unbiased evaluator role, has been downsized and inadequately funded to the point that in its current configuration cannot be a player in this important mission. The Cooperative Extension Services can help provide technical information and decision making support but ultimately closely managed technology demonstrations on farm are needed to convince farmers and investors alike that technology can be effectively deployed.

The concern for a third party support goes beyond providing technical assistance. Specifically, the operation and maintenance skills for new technology and waste treatment systems are critical and are usually well beyond the skill set available at the farm. Some farm owners want to be the sole operator of the waste treatment system while others have no desire or the time to be involved; hence there is a growing need within animal agriculture to have a full service provider if the technology appropriately deployed is to succeed. The bottom line is that managing the waste treatment system must graduate to a new level or otherwise the investment and reliable production of byproducts to the market place is at risk.

In 2002, Congress chartered and funded Farm Pilot Project Coordination, Inc. to develop farm innovative technology that could meet the growing challenge of managing nutrients in the animal agriculture sector. To date, Farm Pilot has amassed significant experience in the management of 45 pilot projects in eighteen different states. Each pilot project demonstration is conducted at a representative animal feed operation where the waste stream from swine, poultry, beef or dairy animals can be realistically evaluated. The focus of this applied research is the removal or capture of 75% of the (N,P,K) nutrients from the waste stream.

Today, Farm Pilot Project Coordination, Inc. is the only **active** publicly funded organization in the United States that is applying and evaluating competing technologies for the purpose of evaluating capture of nutrients from the waste stream. **We recommend that FPPC be funded at a level of $5 million per year to support pilot scale deployment of animal agriculture nutrient reduction technologies in the Chesapeake Bay watershed.** With this level of support, FPPC could support one pilot project in each of the six watershed states. FPPC should be tasked with operating these projects in a "showcase mode", monitoring and reporting results and training and mentoring operators. FPPC would be expected to collaborate with Land Grant university resources and help them leverage their existing resources and technical expertise. Top priority for project funding should be directed to opportunities to demonstrate integrated technologies and solution sets. Background information on FPPC is provided in the appendix to this report – see description and profile of FPPC in Appendix II – other federal programs.

3. Create a Steering Committee composed of respected and forward thinking farm leaders in the watershed to help accelerate the deployment of animal agriculture nutrient reduction technologies and practices in the watershed.

To achieve success in reducing animal agriculture nutrient loadings to the bay, it is imperative that farmers, related agribusinesses and farm communities be fully engaged in the ongoing decision making processes related to adoption of new technologies for using and processing manure and poultry litter. More importantly, the agricultural community needs to "feel ownership" and play a leading role in designing and implementing these efforts.

Towards this end, we recommend the creation of an animal agriculture leadership team and network, that can serve as a focal point for thought leaders, practitioners and service providers to communicate and share information, explore new solution sets, problem solve and interface with government officials and other stakeholders. Among other responsibilities, the team should serve as an advisory body to the Farm Pilot Project Coordination Program operating in the watershed and help oversee the selection and operation of pilot projects.

The leadership team should be composed of well connected and respected farmers across the watershed and include balanced representation from the dairy, poultry, hog, beef and turkey industries. Additional members representing conservation partners and the service industries that support the animal agriculture sector should be included on the team.

While the initial focus of the group should be on showcasing and demonstrating effective animal agriculture nutrient reduction technologies, opportunities may exist for the leaders to facilitate farmer-to-farmer dialogue around barriers to forward progress, economic analyses, regulatory barriers and enabling policies that can further incentivize forward progress in deploying nutrient reduction technologies and practices.

4. Task an existing or establish a new regional council to enhance interstate communication, coordination and cooperation around animal agriculture nutrient reduction efforts.

Throughout the first phase of its work, the project Steering Committee met with a cross section of federal, regional, state and local agricultural and conservation agency representatives. Collectively these individuals were acutely aware of the nutrient loading challenges and opportunities emanating from the animal agriculture sector. They were also highly motivated and anxious to provide support that will help farmers meet nutrient reduction goals while simultaneously maintaining or enhancing the economic viability of their operations.

We also observed however that many were not well or fully informed about strategies and actions that were underway in other parts of the watershed to reduce nutrient loadings from animal agriculture operations. Agriculture and conservation agency representatives play a critical role in ensuring that the nutrient reduction goals for the watershed are successfully met, and their effectiveness could be enhanced greatly if a non-burdensome system for enhancing intergovernmental communication could be established.

We recommend that the Agriculture and Conservation departments and agencies in the Bay states together with their federal counterparts work to create a mechanism for sharing information, creating centralized and searchable databases and inventories of programs for addressing M/L challenges, monitoring and comparing results, identifying common barriers and exploring ways to collaborate more effectively in planning and delivering services. By doing so there may be opportunities to avoid duplicating efforts across jurisdictions and thereby freeing up additional resources for delivering technical and financial assistance to producers.

Appendix 1

National Technology Scan-Current and On-The-Horizon Technologies/Practices

Process

A survey and cover memo were developed and distributed among approximately 100 individuals throughout the U.S. Distribution was to leaders in animal waste management in various states, members of the former Fund for Rural America funded National Center for Manure and Animal Waste Management (project managed by North Carolina State University), and each of the Chairs or Heads of Animal and/or Poultry Science departments in the U.S. In addition, it was sent to the Steering Committee members of an EPA funded project to provide environmental assessments on livestock production facilities in the states East of the Mississippi River. The responses from the survey were combined with knowledge that the author has gained over about 20 years of experience associated with animal waste management research, technology evaluation in animal waste management, waste-to-energy systems and environmentally sound and sustainable technologies for processing animal manure and litter.

The following is a general description of the most widely and currently used technologies (grouped) and processes in the US (not totally comprehensive) along with some technologies reported to be on the "horizon" that are expected to be available in the near future (assuming that the economic feasibility of each of them supports their deployment).

The discussion below is relevant to the scope of this Project in that it will help focus on those technologies and methods currently used in the Chesapeake Bay watershed and some that may emerge as appropriate in the future. It is important to recognize that as animal production facilities have become larger and more concentrated animal manure/waste management emphasis has expanded from one of strictly local land application for crop nutrient supply, to include disposal, environmental protection and remediation (air, water, soil), by- or co-product development, energy recovery, greenhouse gas emission reduction, human health considerations, property value impact and prospective policies that will impact the future of animal agriculture in the U.S.

Findings

a. **Land Application**

As expected, the responses from throughout the U.S. indicated that the overwhelming and predominant use of animal and poultry manure and litter is to provide, through land application using a wide variety of methods, plant required nutrients for both perennial and annual crops, usually raised to provide feed for those animals and poultry, either as part of the animal or poultry enterprise or in close proximity to same. The plant nutrients of concern are overwhelmingly nitrogen (N) and phosphorus (P), with N historically receiving the most attention, and P interest with increased concerns about its soil buildup and contamination of watersheds (both N and P). Additional concern with N resides with its contribution to air quality and airborne nutrient translocation from wet or dry atmospheric deposition. Of the approximately 1,400,000 tons of animal and poultry manure and litter N and 675,000 tons of P produced in the U.S. annually, the vast majority are held in storage of a variety of types and lengths of time and land applied without further treatment.

Land application has become increasingly regulated by a variety of nutrient management requirements based on quantification of application rate, crop nutrient requirements, site specific requirements (soil type, slope, rainfall, etc.), season, proximity to surface waters, air emission concerns (including odors), and other Federal and State/Local policies/regulations intended to increase use of Best Management Practices (BMP) to assure environmental protection. Those policies and regulations, usually applied to enterprises with or exceeding target numbers of standardized "animal units".

This is especially targeted to production units (poultry, swine and feedlot cattle) which import much if not all of their feed from distances too far removed to practically return the animal waste and litter to support the production of that feed. In areas where these practices have been followed for extended time, the soils proximate to those facilities (due to land application) have often developed concentrations of plant nutrients (especially P and some heavy metals) which preclude additional applications of untreated animal manure and litter based on plant N requirements. The Chesapeake Bay watershed is among those areas in the U.S.

These considerations along with public pressure created by air quality issues (odors), have created the incentives leading to adoption of a variety of technologies and processes to better manage and control the fate of nutrients in manures and litters, as well as to provide for the capture of added value in the form of a variety of products and services. These include recovery of energy and participation in markets based on reductions in emissions of greenhouse gases.

b. **Composting/Pelleting**

The response to the survey confirmed current practices that, in addition to those noted above, include the development of many successful animal manure and litter composting efforts, particularly in areas located around urban areas and in areas experiencing significant growth in organic food production. Composting provides an excellent opportunity to convert biosolids from animal wastes as well as municipal sources into a value added product that has achieved wide consumer acceptance and use. In many applications, the animal waste provides the critical balance between carbon and nitrogen in biomass mixtures to produce high quality compost. Compost retains and enables relocation of a high percentage of the non-volatile elements in the parent feedstocks. There is, however, a concern about air emissions of nitrogen (primarily ammonia) (variable up to 70 percent of input nitrogen) during composting, and more recently concerns about emissions of other volatile organic compounds (VOC's). There are numerous examples of this in the Chesapeake Bay Watershed area, and the mix of agricultural and urban communities is well suited for this to continue.

Efforts in the Chesapeake Bay area have resulted in development of a large commercial poultry litter pelleting operation (Perdue AgriRecycle) that provides, through volume reduction and ease of handling, the ability to transport up to 80-90,000 tons of pelleted litter to areas where they can be used effectively as fertilizer (high value market such as golf courses, etc.) and/or potentially as fuel in combustion systems for energy recovery. In addition, there have been other litter pelleting examples in the region that have had variable degrees of success.

Pelleted litter should be basically the same as the litter in composition excluding the impact of feathers if they are not included in the pellets. Unless there is a sustained release of nutrients from pellets when land applied that is different than that of raw litter, the runoff potential should not change. Of greatest consideration might be a reduced emission of ammonia from pellets compared with raw litter, constituting an air quality impact (positive for pellets) and an increased fertilizer impact from retention of the N on or in the soil. In cases where excessive heat is used in the pelleting process and if wasted feed protein (N) is in high concentration, Mailliard reaction can make N less readily available to release. There are no reported data on this possibility.

While pelleting increases density and reduces volume for transport, there is still a transportation issue for moving the volume of material under consideration. Depending on targeted application sites, there may not be adequate market volume for the material potentially available. (Which will be greater as restrictions on land application due to attention to soil P levels become reality.) Application on farm land, especially land used to produce the grains that are shipped into the watershed as animal feed, poses an opportunity, but handling inconvenience by crop producers due to relatively low nutrient density compared with chemical sources of N and P has been repeatedly cited as a detriment to development of that market.

NC State University conducted testing of pelleted swine waste solids resulting from anaerobic digestion of separated solids (30 percent solid content feedstock, high solids anaerobic digestion system) on DOT roadside plots. The results were acceptable but the cost was unacceptable as was the case in similar work done with poultry litter in Maryland. This further underscores the impact of economics in any voluntary animal manure or litter technology application.

c. Combustion

There have been and continue to be a number of efforts to recover energy from animal manure and litter primarily in the form of space or water heating or electricity from direct combustion or from biogas produced by anaerobic digestion, or heat produced by co-firing with traditional fuels such as coal. Several direct combustion units have been built and operated (Chesapeake Bay watershed region, for example, some employing pelleted litter) and others of significant size and scale are either in operation (Fibrominn, 55MWh, poultry/turkey litter) or are in planning/construction (Fibrowatt in North Carolina and in the Chesapeake Bay area), and several of the major public utilities in the U.S., most notably Duke Energy, are seeking ways to incorporate animal manure solids and litter into large coal gasification electrical generation facilities. (Logistics and therefore cost of supply volume transportation are a major limitation to date). It is noteworthy that the ash resulting from direct combustion of animal waste may be recycled in animal feed or crop fertilizers, reducing the need to recover fossil mineral deposits to provide for those needs (see below reference to work at NC State University).

Tonnage of litter needed to support direct combustion plants such as Fibrominn is significant, and plants would be cited based on available feedstock within a given area governed by transportation logistics and costs. Data on the Fibrominn plant regarding emissions testing and requirements are available in publicly available literature and similar considerations were and are being given for plans in NC and the Chesapeake Bay area. A similar consideration exists for separated or thickened manure solids from swine and dairy (which doesn't have the benefit of bedding and its solids and energy content). Progress Energy did some testing of dairy solids in a coal fired plant in Florida and concluded that co-firing of wet dairy solids was feasible in a slurry coal gasification system at about 5 percent of solids input. That level was beneficial because the availability of solids would possibly be easier to achieve in a shorter distance, and the water in the slurry would offset an equal amount of the water that must be added to the coal in the pulverizing process. In addition, there is evidence (preliminary data) that the N (ammonia/urea) in the waste is actually beneficial to reducing some stack emissions. There is similar interest in NC for use of swine manure solids (wet) but it has not proceeded to implementation. Duke Energy is also interested both in poultry litter and swine/dairy waste in co-firing with coal as part of its stated effort to increase the renewable energy component of its portfolio.

The major problem with these efforts is that if a currently located plant is used, the probability that animal units of enough capacity to provide the tonnages of waste needed being in the "neighborhood" is coincidence only, and there are also many areas where the waste (especially litter) has a local market for land application and current users may not be willing to release the material unless there is a significant purchase fee recovered. Indication of tonnage needed at 5 percent of fuel source is easily determined by knowing the coal capacity of the existing plant to be used. It is unlikely that access to 5 percent of fuel would be a determining economic consideration in the locating of a new power plant unless the local competition for litter was a factor.

NC State University worked with a Canadian firm and developed an on-farm gasification unit to handle mortality (pigs and poultry) that is being produced and marketed in the middle Atlantic area. That unit was also tested to gasify swine waste solids in one of the Smithfield Foods/Premium Standard Farms funded technology evaluations (the project was called "Recycle"). The ash was used in refeeding swine and the bioavailability of P was high. N recovery was not high in the ash, a consideration, (although the emissions from the system were well within EPA emission requirements), but P recovery was very high, as expected.

Arsenic in the form of roxarsone is still fed to poultry (estimates as high as 70 percent of broilers raised nationally). Arsenic in water is a concern, from many sources. Perdue and

Tyson opted several years ago to NOT use arsenicals in poultry production, so to that extent, the Bay area may be somewhat spared, but not totally, as other production concerns may still use it. Arsenic would be expected to remain in combustion ash, but would also be associated with fugitive fine particles of waste associated with any handling process. This has been documented in health cases associated with burning CCA treated wood.

d. **Anaerobic digestion**

At the present time there are approximately 140 operating anaerobic digestion units in the U.S. that process animal manure (including non-littered poultry manure), producing approximately 375,000MWh of electricity annually (and representing over 800,000Mt CO2 equivalent reduction in methane emissions) and a significant number are in planning, construction or development stage, including the "Cove" project in Pennsylvania referenced below. Limitations in ability to secure favorable power purchase agreements that make these units economically viable have been and still are a major detriment, although recent adoption of net metering policies and voluntary consumer purchases of electricity produced by such installations through programs like the successful and nationally recognized "CowPower" program in Vermont and the "Green Power" program in North Carolina, offer models with promise. The adoption of such incentives in the Chesapeake Bay Watershed is uneven and in several of the states does not provide adequate incentives for farmers and producers to invest in this technology. Significant opportunity exists for expansion of anaerobic digestion if programs such as are being developed by several rural electric cooperatives and other some public utilities around the U.S. can be finalized. Additionally, incentives created by successful marketing programs for carbon (under development) will enhance the use of anaerobic digestion, especially in covering those systems using liquid manure handling with lagoons or holding ponds combined with collection and flaring of the methane produced to recover greenhouse gas (GHG) reduction impact value. There are currently scattered applications of this process and more in planning stages (North Carolina, for example, with a legislative funded program involving a public utility for swine lagoon covering and biogas collection but subscription rate is still very low).

Covering of anaerobic waste treatment lagoons have been used for many years for various reasons. Initially most was for odor reduction (semi-permeable and impermeable covers). Starting 20-25 years ago covers were installed to enable collection of biogas. Some swine lagoons were also covered for that purpose, but in most cases the low demand for electricity and/or hot water on a swine finishing facility (unlike the dairy where hot water was a major need), and highly restricted purchase prices for generated electricity (avoidance costs.. and therefore purchase prices of as low as 1-2 cents/kwh or even less) made the effort economically infeasible. Various programs such as net metering options and GHG (carbon mainly) payments, legislative incentives (NC), renewable portfolio requirements for some utilities and voluntary programs such as "NC Green Power" and "VT Cow Power" noted above have helped stimulate interest. However, even with those, with the exception of dairy units, participation has been low, for economic reasons.

Contrary to common misperception, covered lagoons and anaerobic digestion systems themselves do not provide for specific M/L nutrient reductions other than the conversion of carbon that is captured as methane and released as carbon dioxide, resulting in a GHG reduction of a factor of 21times (methane is 21 times more potent as a GHG than carbon dioxide) and would be emitted to the atmosphere from uncontained stored waste without this process. Otherwise, nutrients such as N and P should actually be in slightly higher concentration in the effluent due to removal of the carbon, oxygen and hydrogen in methane and carbon dioxide in biogas. (There will be a slight reduction in sulfur to the extent that hydrogen sulfide is produced and scrubbed out of the gas, and some ammonia may escape in gas also). Thus, anaerobic digestion alone as a nutrient reduction tool is not effective. However, when partnered with other appropriate nutrient capture technologies that might strip nitrogen and phosphorus out of the digestate stream, the value of the products of anaerobic digestion (heat and electrical energy) can help offset the capital investment and result in a value-added system with economic return to the producer.

The Cove Digester Community project in PA (in the watershed) should be touted as a model for the future in that it is a centrally operated unit, third party managed, provides an income stream for producers, and combines energy recovery with energy and nutrient capture and removal (all important features for any successful system). ***In addition, it is revolutionary in that it provides for discharge of treated wastewater. This latter feature is a primary reason why previously evaluated alternatives to liquid manure handling systems using lagoons have been economically infeasible. If this is actually constructed (it has been in an extended planning and development stage covering over 5 years), proves to be effective and is accepted on a wider basis, major progress will be made in the waste management and treatment of many animal waste management systems, but most important to those depending on liquid-based handling.***

e. **Air quality**

As part of the effort to reduce the environmental impact of concentrated animal production systems, a number of technologies have been developed and are in use to reduce air quality concerns. Those include a variety of physical, chemical, thermal and electrostatic techniques for reduction in escape of particulates (dust) that carry odorous compounds. One technique that offers several benefits is the use of biofilters composed of such things as peat moss, compost or wood chips or other fibrous biomass, with or without added nutrient amendments. In some cases, especially successful in Canada, there are systems that treat both wastewater and building exhaust air simultaneously (an especially attractive technology that should be considered in the U.S. and in the Chesapeake Bay watershed).

The Canadian system, developed in Quebec, which is exceptionally effective, does remove air contaminants (including ammonia) from the building ventilation air as well as N and P (adequate to meet water discharge standards), in that separated manure wastewater (carrying N and soluble P) is used to irrigate and maintain the necessary moisture content of the biofilter medium. At the end of the useful life of the filter medium (scaled to be 12-15 years), the resulting peat moss/nutrient biofilter medium material is available for land application as a nutrient enhanced biomass or as a source of compost. The system is most effective in closed building systems where ventilation air is controlled. Open sided and diffuse ventilated systems such as are common in the southern half of the U.S. would require modification for more controlled ventilation patterns. In a unique application of interest, using only clean water, the system is also successfully used in a very large institutional dairy farm unit within the city of Quebec strictly for cleaning ventilation air from a large, closed dairy barn.

Recent action by the Environmental Protection Agency targeting the Chesapeake Bay Watershed also highlights air quality and especially ammonia emissions. It is important that any technology that is implemented to address reduction of nutrients from M/L also include the consideration of reduction of ammonia emission.

f. **Nutrient recovery**

As the attached Appendix shows, there are a many types of technologies available to livestock and poultry producers that enable or will enable separation and recovery of various components or nutrients from manure or litter. Some of them such as alum (and potentially struvite and biochar production in the future) work effectively in rendering P in poultry manure and litter very slowly available to plants when soil applied, thus reducing transport in water runoff and leaching. In addition, there are a very large number of additives (chemical and/or microbial) and amendments that are marketed to target such things as odors, sludge buildup, pathogen reduction, etc. Several of them are used to address a single element in the list of issues that are often attributed to animal manure and litter (viz., air quality, water quality, soil buildup of heavy metals, airborne pathogens, disease vectors, etc.), or in some cases can alter the conditions in the storage or containment system to reduce or eliminate one or more of the issues noted above. Unfortunately many of those products have not been adequately tested to provide reliable performance data.

g. **Economic viability**

The swine industry, among the various animal enterprises, has faced the most intense and visible pressure to modify production practices surrounding manure management as a result (primarily) of air quality concerns (odors and ammonia emission) as well as containment of liquid storage of manure in lagoons. (Arid areas with high-density dairy and beef feedlot operations in the Western U.S. have had regulatory pressures applied to reduce and manage particulate emissions in dust as well.) The use of holding pits and anaerobic treatment lagoons (appropriately constructed according to various Federal or State regulations) have resulted in a variety of efforts in several states to identify technologies that reduce the impact of those production practices on air, water and soil quality as well as human and animal concerns. The result has been a very large industry investment in research and technology evaluation to address those issues.

Unfortunately, despite the identification of numerous processing technologies that are technically viable, none of them, with the exception of covered storage with collection and marketing of biogas as electricity in areas with favorable purchase agreements, and possibly direct combustion of litters, are economically feasible in the current climate. Alteration in tax structure, enhancement of GHG markets through a cap and trade or similar system or other incentives similar to the nutrient trading market in the

Chesapeake Bay watershed are needed to alter the level of voluntary participation, since there is currently no generally viable way to recover the voluntary investment needed to move away from the current systems. Adding regulations without economic incentives will serve only to make current livestock and poultry production systems economically noncompetitive and therefore unsustainable. A combination of efforts will be needed to provide enough scale in the volume of production of appropriate technologies that (through reduced costs) their economic feasibility will be realized.

On the Horizon

A number of technologies, processes and products are on the horizon that could provide for significant improvements in nutrient management from animal manures and litters. The models established at North Carolina State University (Animal and Poultry Waste Management Center), the EPA funded Environmental Technology Verification Centers (ETV Centers) and the Farm Pilot Project Coordination (FPPC) program funded by NRCS offer promise for that to happen, but lack of funding for all except the FPPC has reduced those to ineffective status. The rigor of the economic component of that system needs to be verified (although the FPPC approach is encouraging). There is a major need for a National Center to address these important issues. Whether FPPC will continue to emerge in that role is not certain, although their current efforts provide hope that this may be the case and they have demonstrated exceptional ability in this regard.

Without the comprehensive assessments that will allow economic feasibility to be determined in addition to technical feasibility, and the reasonable pricing that will accompany volume implementation, the situation will not change. Policy mandates for change without a mechanism for recovery or otherwise offsetting of investment cost will not be successful. The evaluation system developed at NC State University (www.cals.ncsu.edu/waste_mgt/) included complete technical as well as extensive economic performance and feasibility. Without the economic component, the process is not complete. Such a system would benefit from the support of agencies active in the Chesapeake Bay area such as National Fish and Wildlife Foundation and others. As noted above, FPPC is involved in this process on a national scale, using NRCS earmarked funds for nutrient reduction focused projects, and AgStar has provided significant impetus to anaerobic digestion system installation. The rigorous technology and economic feasibility components are absolutely essential for providing a basis for initiation of those efforts.

Despite the criteria that were developed by the NC State program, and applied to the 16 or so technologies selected from the 100 applicants (complete reports on each system evaluated in website noted above), after a decade of effort and expenditure of more than $18M, there is not a single one that is operating effectively and economically on a production facility. The majority of those systems tested failed to meet the requirements for designation as Environmentally Superior Technology (only 2 did and one of those was provisional, with neither of those have shown economically feasibility as of this date).

A major difficulty in this area is that potential providers come forth with virtually no data and in many/most cases a complete lack of understanding of animal or poultry production and their economic considerations. As advocated above, it is essential that there be an unbiased third party system and that the provider (as the benefactor of installation of a successful system) share in the cost of the evaluation. The Environmental Technology Verification (ETV) system at EPA and the FPPC program have those components.

The following are examples of technologies and groups of technologies that offer promise for animal and poultry waste management on a commercial scale, subject to the caveat noted above, resulting in value added products or services in addition to environmental benefits.

- **gasification/torrefaction/biochar production** (often in concert with separation technologies for solids) for fuel, carbon sequestration or soil structure, adsorption and chemical/nutrient holding capacity; biochar characteristics relative to ion exchange, adsorption, nanotube function and retention of nutrients are very much in need of verification; there are currently no standards for production of biochar which heighten the need for careful characterization of material properties as well as the processes that produced them.

- **gasification or other high temperature combustion** to recover energy and sterile ash as a feed ingredient for animals (especially important in sparing removal of phosphate from deposits); the watershed is a system, with inputs and outputs; a combination of net removal of excess nutrients from the system and recycling of nutrients already in the labile pool within the system (i.e., nutrients in manure and litter that can be recycled), can avoid need to bring in nutrients of fossil origin (minerals such as P) from the outside, in a simple mass balance exercise similar to atmospheric carbon; (as long as there is continued removal of fossil carbon from the earth, converting it to labile carbon in the environment in excess of the amount that we take out as sequestered carbon, etc., the excess shows up as atmospheric carbon (carbon dioxide)); dietary manipulation to reduce nutrient excretion without reducing animal performance;

- **struvite production to remove and stabilize phosphorus**; the economic feasibility of this is not determined, but struvite is a deposit that spontaneously (in the presence of adequate N, P and Mg, among other things) appears in liquid waste streams, clogging pipes, etc; the P in struvite is very insoluble, and like alum bound P remains only slowly erodable back into "circulation"; offers a way to concentrate and transport nutrients.

- **co-firing with slurry coal gasification electrical generation**; under investigation

- **ammonia stripping to produce ammonium salt fertilizers**; pilot project in North Carolina working to develop stripping technology on economically feasible basis;

- **low-cost covering of lagoons and holding pits to capture biogas for greenhouse gas marketing or energy recovery**; already under evaluation;

- **semi-permeable lagoon and pit covers to capture and break down odors and convert ammonia to dinitrogen gas**; available currently but economics not attractive;

- **innovative, efficient wastewater treatment systems using low labor and energy input for production of discharge quality**; water a system deployed globally and tested with swine flush wastewater at North Carolina State University called IBAC has been used for slaughter house waste commingled with municipal wastewater stream in Quebec, for potato processing wastewater, for a poultry slaughter house in Quebec, for labor workcamp wastewater treatment in Saudi Arabia, and soon Dubai; could be used for dairy wastewater but a separation, chopping or settling basin would need to be used first; used a settling basin at NC State; is **very** labor efficient (www.biodynegroup.com); COVE project offers similar opportunity for water treatment and discharge;

- **advanced pyrolysis of a variety of types to produce and capture biofuels**; a rapidly emerging field;

- **building materials manufactured from manure fibers**; cattle manure solids have a particle distribution almost exactly the same as that for the fibers used in making Masonite or similar types of board; there has been a significant amount of work on this in the past and fiberboard can be made from manure fibers;

- **specifically selected organisms to target manure and litter components for either breakdown, destruction or stabilization**; large number of products introduced with touted benefits for reducing solids in manure storage systems, enhanced conversion of ammonia to dinitrogen gas, reduction of odor causing organics, etc; the vast majority have failed to deliver on advertised benefits when tested under controlled conditions; however, some progress has been made in selecting organisms that offer some benefits; other than the potential for accelerated emission of dinitrogen gas with the destruction of valuable ammonia (fertilizer value), they have no impact on nutrient reductions;

- **use of algae and other simple organisms to convert animal waste into advanced biofuels**; already under investigation;

- **several generic applications such as recovery of heat generated by composting biomass** (already in practice but not widely applied to animal manure and litter in the Chesapeake Bay watershed in ways that transport nutrients out of the watershed. There is little evidence that compost produced and used in the watershed and produced in the watershed offsets imported chemical fertilizer).

Summary

The results of this technology scan can be summarized as follows:

1. The majority of the nutrients in animal and poultry manure and litter (1.4M tons N and 0.7M tons P) are land applied to support crop production in the U.S., according to required nutrient management plans;

2. Most animal and poultry manure and litter is stored or stockpiled for some period of time prior to land application on farmland. Depending on weather, storage conditions, and biological activity, stored manure can affect air quality by generating volatile gases and particulates and the resulting energy content (measured in BTUs) of a unit of stored waste has less value than fresh manure.

3. At a high level look, critical areas or watersheds, like the Chesapeake Bay area, having high concentrations of animals and poultry and where large amounts of nutrients (feed) are imported, waste nutrient excess frequently occurs. Without adequate crop-land base nearby, farmers face the need to process those manures and litters for value added products for export out of the watershed;

4. Many technologies can provide recovery of value added products from animal and poultry manure and litter (see Appendix), but adoption has been slow and driven primarily by individual interests, specific local pressures or regulatory requirements. Today's reality is that a reasonable return on investment is not possible without financial incentives (like those available in EQIP, carbon/nutrient credit programs, etc.) and additional revenue streams provided from byproducts. In fact, many farm owners have been disillusioned with the evolving marketplace or have been conditioned to believe that their manure is a useless "waste" and should be disposed of at the lowest possible cost. This helps reinforce the age old practice that the value of manure is best realized by the farmer by spreading manure/litter on the land he owns or has access to. It is hard to argue that point if manure spreading is cheaper than buying more expensive fertilizer. (Efforts especially those being led by FPPC will enhance application of new technologies and the development of new byproducts, tested at pilot production levels.) Economic feasibility must not only track the fate of nutrients but connect to the marketplace if the process is going to add value. This is a critical element of modeling the economics and making the analysis complete.

5. Anaerobic digestion of (primarily) animal and poultry manure (very little litter to date) constitutes the major current energy recovery process with about 375,000MWh of electricity generated annually (incentivized by several consumer-funded programs within the U.S.). While anaerobic digestion does not result in nutrient (N and P) reduction it can be effective as part of an overall system in that it can generate energy for use and revenue. Suppliers of anaerobic digesters claim benefits for odor control, capture of GHG and more of the nitrogen, energy production via biogas, pathogen control (depending on digestion temperature) and as a pretreatment process allowing the manure to become more pumpable as well as more easily applied to further processing. Some or all of these claims may be critical to the goals of the bay area.

6. Composting of animal and poultry manure and litter represents a significant and growing activity, accelerated by the growth of the organic food production movement, and this will continue as long as the economy supports it and the marketplace is not saturated. Compost provides an opportunity to develop stable, value added products that provide nutrient as well as soil enhancing characteristics. Major advances in quality standards for compost have provided a level of consumer security that did not exist a decade ago, and that has helped develop markets for urban as well as agricultural users. The advance in organic and/or locally grown food has linked to the value of compost, in the sense that it represents a “non-chemical” way for production to take place. Compost can be produced on-site and that is an attractive way to recycle nutrients. To the extent that compost nutrients are utilized within the watershed, they do not represent a removal function. To the extent that they replace nutrients that would have been brought in from outside the watershed, they impact the mass balance in a positive way. Although highly variable, and process-dependent, ammonia loss from composting operations represents a negative impact in that it can contribute to atmospheric contamination and uncontrolled deposition elsewhere within the watershed.

7. Direct combustion of litters for electricity generation is increasing and will continue (with addition of co-firing of manures also) as utilities seek/are required to increase renewable energy components in their overall portfolios. This practice results in the generation of mineral residue that can be transported and utilized for recycling in feed or land application. Direct combustion of litters and manure solids for energy recovery is a contribution to the use of renewable energy regardless where it takes place. New and emerging technologies to generate bio-oils and other biofuels will continue to add to these opportunities. The benefit to nutrient reduction is that the residue from the process can be more easily transported out of the area than the original raw material. The value of the residues for uses such as ash minerals, etc., has been discussed earlier. Two barriers for developing manure as a renewable energy biomass for utility use include: a) conditioning the solids for reduced moisture levels and transporting; and, b) realizing an attractive rate the utility is willing to offer the farm producer for his contribution to the grid.

8. The elements of greatest importance in the advancement of implementation of technologies to treat and better managed animal manures and litter for area nutrient reduction include: development of economically viable enterprises based on by- and/or co-product development with successful marketing; development of third party “service” industries for technology management; ability for end products of animal manure and litter processing to be treated the same as for similar products of municipal and industrial processing (water discharge, for example); development of a comprehensive system for technology evaluation based on both technical and economic feasibility, with cost of evaluation shared between provider and the public. The greatest economic potential for converting animal agriculture waste to value-add products involves 3 pathways for: a) nutrient use (organic fertilizer, compost, biochar etc); b) energy (biogas, heating oil, electricity, heating/cooling applications); and, c) water re-use and management (flushing, irrigation, animal watering needs).

Appendix II

State Programs

The following are resources or examples of innovative nutrient reduction or renewable energy development programs that should be evaluated for possible expansion or use in the Chesapeake Bay watershed. The items contained in this appendix are not an exhaustive list of all programs but rather examples of tools that can be replicated or modified to support the five primary objectives outlined in the programs section of this report. These include ways to support integrated solution sets and create demand for M/L products and co-products; public benefit funds; access to markets and fair prices; and mechanisms to reduce costs and finance M/L projects

1) Support for Integrated Solution Sets
(None found)

2) Create Demand for M/L Products and Co-products;
www.fitcoalition.com
"A Policymaker's Guide to Feed-in Tariff Policy Design",
http://www.nrel.gov/docs/fy10osti/44849.pdf

3) Public Benefit Funds

The following are links to programs and mechanisms states have established to collect funds to support renewable energy or M/L technology development and deployment.

California
Public Benefits Funds for Renewables & Efficiency,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA05R&re=1&ee=1

Colorado
Boulder - Climate Action Plan Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CO37R&re=1&ee=1

Connecticut
Connecticut Clean Energy Fund (CCEF),
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CT03R&re=1&ee=1;

Connecticut Energy Efficiency Fund (CEEF),
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CT12R&re=1&ee=1

Delaware
Delaware Electric Cooperative - Green Energy Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=DE12R&re=1&ee=1;

DEMEC - Green Energy Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=DE11R&re=1&ee=1;

Green Energy Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=DE01R&re=1&ee=1

District of Columbia
Sustainable Energy Trust Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=DC05R&re=1&ee=1

Hawaii
Hawaii Energy Efficiency Program,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=HI14R&re=1&ee=1

Illinois
Energy Efficiency Trust Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IL10R&re=1&ee=1;

Renewable Energy Resources Trust Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IL01R&re=1&ee=1

Maine
Efficiency Maine,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=ME11R&re=1&ee=1;

Renewable Resource Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=ME07R&re=1&ee=1

Massachusetts
Energy Efficiency Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA11R&re=1&ee=1;

Renewable Energy Trust Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA07R&re=1&ee=1

Michigan
Low-Income and Energy Efficiency Fund (LIEEF),
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MI07R&re=1&ee=1

Minnesota
Renewable Development Fund (RDF),
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MN09R&re=1&ee=1

Montana
Universal System Benefits Program,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MT01R&re=1&ee=1

New Hampshire
System Benefits Charge,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NH07R&re=1&ee=1

New Jersey
Societal Benefits Charge,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NJ04R&re=1&ee=1

New Mexico
Efficient Use of Energy Act,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NM09R&re=1&ee=1

New York
System Benefits Charge,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY07R&re=1&ee=1

Ohio
Advanced Energy Fund,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=OH11R&re=1&ee=1

Oregon
Energy Trust of Oregon,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=OR05R&re=1&ee=1

Pennsylvania
Public Benefits Programs,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=PA01R&re=1&ee=1

Rhode Island
Rhode Island Renewable Energy Fund (RIREF),
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=RI04R&re=1&ee=1

Vermont
Clean Energy Development Fund (CEDF),
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=VT06R&re=1&ee=1

Efficiency Vermont,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=VT08R&re=1&ee=1

Wisconsin
Focus on Energy Program,
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=WI15R&re=1&ee=1

4) Access to Markets and Fair Prices

Vermont
Cow Power: Central Vermont Public Service customers who want to support renewable energy and Vermont dairy farms have a new energy choice – CVPS Cow Power. Cow Power customers help support Vermont dairy farms with generators that run on methane from cow manure, renewable generation in the region, or incentives to farmers to get into the business. For every kilowatt-hour requested by customers and provided by a Vermont farm, CVPS will pay the farmer the market price for energy plus the Cow Power charge of 4 cents for the environmental benefits of the generation. If not enough kilowatt-hours are available from participating CVPS farms, CVPS will attempt to acquire and retire Renewable Energy Certificates from other regional renewable generation, issued by the regional system operator, to support renewable generation in a broader sense. If no certificates are available in the regional market for 4 cents per kWh or less, the company will deposit Cow Power payments into the CVPS Renewable Development Fund. This fund, overseen by an independent board, will provide incentives to farmers to stimulate further renewable farm generation in the CVPS service area. CVPS will not profit from the program.
http://www.cvps.com/cowpower/Cow%20Power%20home.html

5) Financing Mechanisms

State-Based Financing Incentives
http://elpc.org/wp-content/uploads/2009/11/ELPC-Community-Wind-Book-09.pdf

Property Tax Incentives

Montana
Property Tax Reduction for New/Expanded Generating Facilities: Property tax reduction for renewable generating facilities of 1 MW or greater; taxed at 50 percent of its taxable value in the first five years after the construction permit is issued. Each year thereafter, the percentage is increased by equal percentages until the full taxable value is attained in the tenth year; http://deq.mt.gov/Energy/renewable/taxincentrenew.mcpx#15-24-1401

Ohio
Energy Conversion Facilities Tax Exemption: tax exemptions for energy conversion, solid waste conversion (i.e., the use of waste to produce energy and the utilization of such energy), and thermal efficiency improvements; rewards corporations for investing in qualified types of energy conservation; http://epa.gov/lmop/publications-tools/funding-guide/state-resources/oh.html#two

Investment Tax Credit Incentives

Montana
Alternative Energy Investment Tax Credit: Commercial and net metering alternative energy investments of $5,000 or more are eligible for up to 35 percent tax credit against individual or corporate tax on income generated by the investment; http://deq.mt.gov/Energy/renewable/taxincentrenew.mcpx#15-32-401

Oregon
Business Energy Tax Credit: 50 percent of the eligible project costs for High Efficiency Combined Heat and Power, Renewable Energy Resource Generation and Renewable Energy Resource Equipment Manufacturing Facilities; http://www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml

Production Tax Credit Incentives

New Mexico
Renewable Energy Production Tax Credit: provides a tax credit against the corporate income tax of one cent per kilowatt-hour for companies that generate electricity from wind or biomass; http://www.emnrd.state.nm.us/ECMD/CleanEnergyTaxIncentives/cleanenergytaxincentives.htm

Sales Tax Exemptions

Idaho
Sales Tax Exemption: Purchasers of machinery and equipment used directly in generating at least 25kW of electricity using fuel cells, low impact hydro, wind, geothermal resources, biomass, cogeneration, sun or landfill gas as the principal source of power may qualify for a rebate of sales or use taxes paid on such purchases; http://legislature.idaho.gov/idstat/Title63/T63CH36SECT63-3622QQ.htm

Vermont
Sales Tax Exemption: 100 percent of sales taxes exempted for purchase of renewable energy systems; http://www.revermont.org/incentives.htm

Wyoming
Renewable Energy Sales Tax Exemption: purchases of equipment used to generate electricity from renewable resources are exempt from the state excise tax; http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=WY04F&re=1&ee=1

6) Miscellaneous State Programs

Alabama

Alabama Certified Animal Waste Vendor Program: certified animal waste vendor (CAWV) is a person certified by the Alabama Department of Agriculture and Industries (ADAI) who removes waste from animal feeding operations (AFO) for land application on another site. This person is certified to be knowledgeable of Alabama Department of Environmental Management (ADEM) regulations and appropriate techniques for managing, handling, transporting, storing, and land-applying animal waste. They are also trained in the Alabama Department of Agriculture & Industries (ADAI) regulations for composting and handling animal mortality. The primary goal is to prevent animal waste from contaminating groundwater and surface water quality. Operators of AFOs or concentrated animal feeding operations (CAFOs) are encouraged to use a registered CAWV to transport animal wastes from the production site to other locations. The CAWV offers a valuable service to AFO and CAFO operators by taking on the responsibility of keeping accurate records of what happens to animal wastes taken off-site. Additionally, they assume responsibility for compliance with ADEM and ADAI regulations and legal liability for any environmental consequences of improper management or application of such wastes. In fact, the ADEM AFO rule states, "Unless responsibility for wastes is properly assumed by a CAWV in writing, to the extent allowed by law, the owner/operator shall remain responsible for the proper disposition of the waste."
http://www.aces.edu/pubs/docs/A/ANR-1176/

Arkansas

The Surplus Poultry Litter Removal Incentives Cost Share Program: This program is intended to provide financial incentives to encourage the removal of excess poultry litter from Arkansas's nutrient surplus areas. The Commission may provide cost share from the Water Development Fund of up to fifteen dollars per ton for the purchase and transportation of surplus litter from any nutrient surplus area to be used or disposed of within Arkansas but outside nutrient surplus areas and outside the excluded watersheds listed herein.
http://www.anrc.arkansas.gov/ANRC%20Title%20XI%20Litter%20Transport%20Cost%20Share%201-04-09.pdf

Poultry Litter Transport from Nutrient Surplus Watersheds in Northwest Arkansas: In October 2003, the Arkansas Soil and Water Conservation Commission (ASWCCC) established the Poultry Litter Transport from Nutrient Surplus Watersheds in Northwest Arkansas (PLT) Project. The purpose of the PLT Project is to remove litter generated from contract Grower operations from the Eucha/Spavinaw and Illinois watersheds in northwest Arkansas and transport it selected areas of Arkansas outside of the ASWCC-defined surplus nutrient watersheds. ASWCC's financial assistance will entail compensation to approved litter Haulers to offset the costs of transporting poultry litter from the approved poultry Growers to the approved Buyers in the selected areas as well as compensation to Growers for the litter that is removed.
http://www.litterlink.com/arkansas.html
http://www.litterlink.coAMLitter-docs/Arkansas%20Project%20Info.pdf

California
Dairy Power Production Program: The purpose of the Dairy Power Production Program (DPPP) was to encourage the development of biologically based anaerobic digestion and gasification ("biogas") electricity generation projects on California dairies. Objectives of the program included developing commercially proven biogas electricity systems that could help California dairies offset the purchase of electricity, and providing environmental benefits by reducing air and ground water pollutants associated with storage and treatment of livestock wastes.
http://www.wurdco.com/index.php?option=com_content&view=article&id=47&Itemid=56

Iowa
Iowa Energy Center Alternative Energy Revolving Loan Program: promotes the development of renewable energy production facilities in the state by providing loan funds equal to 50 percent of the total financed cost of a project (up to $1 million) at 0 percent interest.
http://www.energy.iastate.edu/AERLP/index.htm

Michigan
Michigan Agricultures Environmental Assurance Program (MAEAP) is a voluntary certification program based on a risk based evaluation of all management practices on the farm. Within that program is the MAEAP Livestock System which focuses on environmental issues related to livestock activities, including manure management. The goal of participation is to achieve Livestock System verification. The Livestock*A*Syst program is a series of risk questions and answers about livestock production management practices reflecting components of a CNMP. Producers can work with a non-regulatory MAEAP partner to identify risks and develop a confidential Livestock Improvement Action Plan to reduce those risks. This is a self-governed action plan that has no deadline.

Oklahoma
Oklahoma Litter Market: The Oklahoma Litter Market website serves as a communication link for buyers, sellers and service providers of poultry litter. Marketing poultry litter to more distant nutrient-deficient areas or for further processing offers one solution to the litter surplus problem associated with high production areas. The goal of this site is to provide educational materials, maps, guides, practical information and avenues of contact with producers, buyers, sellers and service providers. Listing your company on the Litter Market website does not imply approval for or participation in any subsidy or incentive programs. Applications for incentives are available from the sponsoring agencies or organizations. Development of this site was funded by a grant from U.S. EPA 319(h), administered by the Oklahoma Conservation Commission as part of the Oklahoma Nonpoint Source Program.
http://www.ok-littermarket.org/

Pennsylvania
Pennsylvania had, until recently, numerous programs that supported innovative developments in the CB. Budgetary restrictions have eliminated or closed some programs

and reduced by half the credits available in the Resource Enhancement and Protection (REAP) Tax Credit Program. REAP, an excellent program that should be considered by other CB states, operates on a tax credit basis that allows up to 75 percent tax credit on some projects and 50 percent on technology adoption, with the tax credit eligible to be sold.

The Pennsylvania Infrastructure Investment Authority (PENNVEST) program is expanding its non-point source program. PENNVEST is Pennsylvania's State Revolving Fund program and uses federal and state infrastructure funds to provide loans and grants for a water pollution abatement projects. In July 2010 PENNVEST expanded its scope to include agricultural runoff, urban stormwater and abandoned mine drainage. PENNVEST recently approved funding of over $4.0 million for five non-point source projects. Four of the five projects were in the Chesapeake Bay watershed, including a $291,000 loan to treat both hog and dairy manure at various farms to remove both nitrogen and phosphorous from the manure that farmers spread on their fields, and a $495,000 grant to construct structures for composting and storing manure to reduce both nitrogen and phosphorous contamination of the Conestoga River from the runoff of barnyard waste.

The Nutrient Trading program (voluntary) operates to enable farmers to who exceed their nutrient outputs to trade them with those who do not, based on certain criteria. The Nutrient Trading program is expanding and will be conducting a nutrient credit auction this fall.

Manure and litter management technologies are eligible BMPs for consideration under the State Chesapeake Bay Implementation Grant special project funding.

In July 2008, Pennsylvania enacted a broad $650 million alternative energy bill designed to provide support for a variety of renewable energy and energy efficiency technologies. Included in this legislation was a provision authorizing the creation of a grant and loan program for alternative energy and clean energy production projects. The program is jointly administered by the Department of Community and Economic Development (DCED) and the Department of Environmental Protection (DEP), under the direction of Commonwealth Finance Authority (CFA). Program guidelines were issued in May 2009. Incentives are available to businesses (including non-profits), economic development organizations, and political subdivisions (e.g., local governments, schools, etc.).

The program will offer support for alternative energy and clean energy projects in the form of loans, grants and loan guarantees (i.e., grants to be used in the event of a financing default). Under this program, alternative energy production projects and clean energy production projects are governed by distinct sets of definitions and rules.

Texas

Composted Manure Incentive Project: A project in the North Bosque and Leon River watersheds that gives incentives for using manure from dairy farms as roadside compost. In September 2000, the TCEQ and the Texas State Soil and Water Conservation Board initiated an innovative project to reduce phosphorus levels in the North Bosque and Leon River watersheds. Storm water runoff containing manure from dairy farms is a significant

source of phosphorus in the two watersheds. To address the problem, the TSSWCB's Dairy Manure Export Support project created incentives in November 2000 for the transport of manure from dairies in the North Bosque and Leon River watersheds to composting facilities, where it is turned from waste into a beneficial product. The composting process reduces the volume of manure by roughly half. The composted manure can then be hauled to other watersheds to be used as a soil amendment.
http://www.tceq.state.tx.us/compliance/monitoring/nps/projects/compost.html
http://www.fhwa.dot.gov/publications/publicroads/04mar/03.cfm

Anaerobic Digester-Phosphorus Removal Project: In 2004, the City of Waco brought an environmental lawsuit against 14 dairy farmers located along Bosque River for polluting (phosphorous-loading) the watershed (higher land that drains water into the river). In a proactive move, the Central Texas Broumley Dairy Farm partnered with several Texas state agencies on a demonstration anaerobic digester-phosphorus removal project that has two objectives: to improve the water quality, water which was being polluted by dairy run-off near the Bosque River; and to generate enough electricity for the farm's operations to sell back to the grid. The project has been a great success, and is expected to begin full operation in 2008.
http://www.seco.cpa.state.tx.us/re_biomass-manure.htm
http://www.window.state.tx.us/specialrpt/energy/renewable/feedlot.php

Vermont
Vermont's Clean Energy Development Fund (CEDF) Grant Program seeks to promote the development and deployment of cost-effective and environmentally sustainable electric power and thermal resources – primarily renewable energy resources and combined heat and power (CHP) systems – for the long-term benefit of Vermont electric customers. There are two grant solicitation periods for 2010. The first round of proposals closed March 12, 2010; a total of $2.5M in grants are to be awarded. The second request for proposal will be issued mid-year.

Funding is available to four categories of projects: pre-project financial assistance, small-scale systems (microturbines, fuel cells, and CHP), large-scale systems, community scale systems and special demonstration projects. Proposed electrical generation projects are required to be grid-connected. Thermal projects, including CHP projects, should maximize the thermal efficiency of the fuel source. There is a maximum award of $75,000 for Pre-Project Financial Assistance, $50,000 for Small-Scale Systems, $250,000 for Large-Scale Systems and Special Demonstration Projects, and $500,000 for Community-Scale Systems. Cost-share is required for all projects. In addition, the Municipal Technical Assistant Grant is available to municipalities, public schools, and state colleges to explore renewable energy projects and feasibility up to $5,000.

The CEDF was established in 2005 and is funded through proceeds due under the terms of two memoranda of understanding between the DPS and Entergy, an investor-owned electric utility operating in Vermont. The CEDF will receive payments of between $4 million to $7 million annually from Entergy through 2012. The CEDF is authorized to allocate funding from the American Recovery and Reinvestment Act (ARRA) of 2009 to

these incentives. If CEDF awards ARRA money through this solicitation, recipients would be obliged to comply with additional reporting and transparency requirements.
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=VT48F&re=1&ee=1

Appendix III

Federal Programs

Rural Energy for America Program (REAP)

REAP, or the Rural Energy for America Program, (formerly known as "Section 9006" in the 2002 Farm Bill, but now renumbered Section 9007 of the 2008 Farm Bill) is part of the Energy Title of the 2008 Farm Bill. It provides grants and loan guarantees to agricultural producers and rural small businesses to help purchase renewable energy systems, make energy efficiency improvements and perform renewable energy feasibility studies. It also funds an energy audit and technical assistance program to serve ag producers and rural small businesses.

Farm Pilot Project Coordination, Inc.

In 2002, Farm Pilot Project Coordination, Inc. (FPPC), a not-for-profit organization, was designated by Congress (Public Law 107-76) to assist in implementing innovative treatment technologies to address the growing animal waste issues emanating from animal feeding operations (AFOs). Farm Pilot is a non-profit organization registered in the state of Florida with 501(c) (3) status. To date FPPC has executed four cooperative agreements with NRCS promoting the research and demonstration of Alternative Manure Technology. FPPC's objective is to foster the conservation, development and wise use of land, water, and energy related resources, while providing AFOs with opportunities for profitable operation. FPPC's specific mandate is to oversee the implementation and administration of a Pilot Project Program to demonstrate economically viable and innovative technology that reduce N,P,K nutrients from the waste stream by 75 percent minimum.

FPPC is uniquely qualified by its broad exposure to different nutrient management technologies deployed at forty-five (45) different farm projects across the country. The Farm Pilot organization is staffed with an experienced multi-discipline team of professionals having a wide range of technical skills and hands-on experience to manage the challenges of an innovative technology project on the farm. In addition FPPC utilizes an Advisory Board composed of senior professionals and recognized experts from USDA, EPA, the financial sector, the livestock industry and farm producers to provide guidance and key insight for agriculture.

Using a combination of technical, project management skills and hands on experience FPPC has acquired critical knowledge about the waste stream from dairy, poultry, feedlot and swine operations and the limitations/advantages of Alternative Manure Technology. In addition, Farm Pilot understands the importance of regional differences in critical watersheds and hotspots where nutrients from animal agriculture must increasingly compete with the shared resources of the watershed. In managing innovative technology on the farm, FPPC has accumulated knowledge and lessons learned from its farm-scale demonstration projects. Some of these are listed below:

In evaluating new innovative forms of nutrient management, FPPC has learned the value of collaborating with all stakeholders and working closely with regulators, technology providers, university researchers, testing laboratories and the farm owner. More than ever, the promise of a solution set is now dependent on economic viability and system performance rather than technical performance of a unit process or a silver bullet technology. Over the last few years much progress has been made, but Alternative Manure Technologies must be objectively measured to better understand how solution sets can be better integrated while process improvements are targeted.

More information about Farm Pilot can be found at their website at www.fppcinc.org