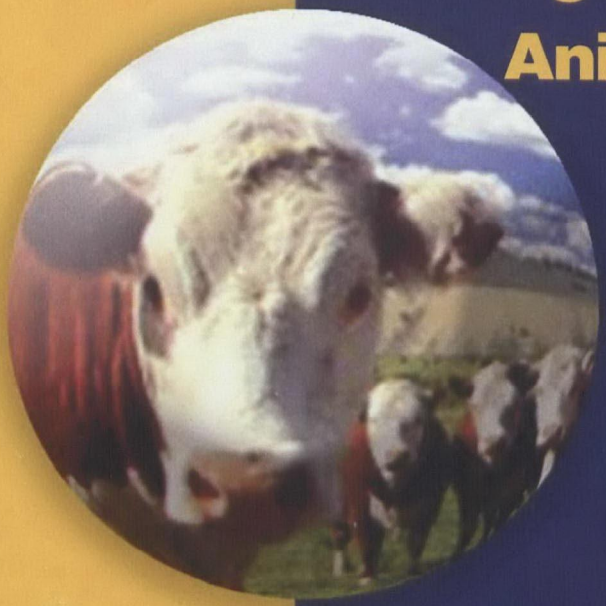
Regional Science Workshop: Animal Feeding Operations (AFOs)



December 6-9, 2004
College Park, MD

Science and Technical Support Needs

ORD REGION

RESEARCH AND DEVELOPMENT

Regional Science Workshop:
Animal Feeding Operations (AFOs)
Science and Technical Support Needs

College Park, MD
December 6–9, 2004

Summary Report

Table of Contents

Regional Science Workshop: Animal Feeding Operations (AFOs) Science and Technical Support Needs

Executive Summary

The U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD) Regional Science Workshop on Animal Feeding Operations (AFOs) Science and Technical Support Needs was held in College Park, Maryland, December 6–9, 2004. The workshop sessions were structured around the top 10 priority research questions identified by the EPA Regions prior to the workshop. The goals of the workshop were to bring together a broad group of scientists from ORD and other research institutions to explore the available tools for addressing the priority research questions and identifying unmet research and technical support needs required to answer these questions.

Question 1: What are the most significant air pollutants, their sources, and their emission rates from AFO operations? What metrics, methods, and models should we use in the future to quantify and monitor these emissions to better understand their relationship to atmospheric deposition and the formation of ground-level ozone and fine particulate matter?

Data presented at the workshop indicated that emissions from some AFO barns exceed Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reporting requirements for ammonia and hydrogen sulfide. Significant particulate matter measurements have been recorded downwind of individual AFOs. Questions, however, remain on the overall significance of AFOs contribution to regional and statewide air quality issues.

The most commonly measured pollutants include ammonia, particulate matter, and hydrogen sulfide. Published research is available on barn emissions, emissions from covered and uncovered lagoons, and the release of hydrogen sulfide and ammonia from basins. Information is lacking on emissions from land application.

Because emissions from AFOs vary throughout the day and the year, real-time measurements are needed to provide information about the dynamics of emissions. Few specific methods were proposed for quantifying and monitoring emissions; however, there was recognition of the large body of data available and the importance of sharing and disseminating data.

The definition of emissions factors to quantify and model various types of AFOs may be necessary for regulatory purposes; however, there was interest in the mass balance approach recommended in a National Academy of Sciences report, *Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs,* as a model that could potentially provide a more accurate, flexible, and multimedia approach to determining emissions from all portions of AFOs that impact air, water, and land.

Question 2: What are the meteorological and other variables that affect the emissions, transport, and deposition of AFO-related pollutants?

The modeling of ammonia emissions, transport, and deposition was the focus because of the amount of work in this area and because AFOs are dominant sources of national ammonia emissions. Variables affecting emissions include mixing, transport, deposition (both wet and dry), and hotspots, which are areas of high ammonia emissions. The knowledge base for modeling of the emissions, transport, and deposition of AFO-related pollutants has increased significantly, but many opportunities exist for interagency research and collaboration.

Question 3: What methodologies can be used to distinguish the sources of contamination in ground or surface waters (i.e., specific animal species, septic tanks, and fertilizers)?

Several studies have traced sources of nitrogen and investigated nitrogen transformations in agricultural, urban, and forested watersheds using stable isotope analysis. The most commonly applied method measures $\delta^{18}O$ and $\delta^{15}N$ of nitrate to assess nitrate contamination in groundwater. A number of other isotope systems can be analyzed to provide information on groundwater and surface water systems. Recent work on newer isotopes, for example isotopes of lithium or strontium, either alone or as part of a multi-isotope approach, has allowed different sources of animal wastes to be distinguished from one another.

EPA's *Microbial Source Tracking Guide Document*, which will be released in spring 2005, details the multiple methods, both phenotypic and molecular, available for microbial source tracking and provides decision trees to assist users in determining the most useful method based on specific circumstances. Detection of indicator organisms commonly is used as a screening tool for contamination, but presence or absence of an indicator cannot provide source identification. Microbial source tracking methods also are used in clinical settings and food safety applications, and increased sharing of information among different fields would be helpful.

Question 4: What specific analytic methods should be used in an environmental setting for the veterinary pharmaceuticals and microorganisms most likely to be found in the environment and linked to adverse human health effects?

Both the presentations and discussions highlighted the lack of consensus for specific analytical methods for the detection of veterinary pharmaceuticals, such as antibiotics and hormones, and pathogenic microorganisms associated with AFOs. The diversity of media, such as liquid waste, manure, water, soils, and sediments, provides an analytical challenge. Sample preservation and time before analysis are issues for both pathogen and pharmaceutical detection methods. An additional challenge in environmental sampling is getting enough material for detection. For pharmaceuticals, solid phase extraction can provide concentration factors of 1,000 to 2,000. Few initial concentration methods can efficiently concentrate all classes of pathogens.

For veterinary pharmaceuticals, the variety of compounds with various degradation byproducts provides a challenge for detection of such compounds in environmental settings. Currently, no indicator compounds are available to examine the fate and transport of these compounds from AFOs. Mass spectrometry usually is paired with gas chromatography (GC/MS) for detection analysis of volatiles such as priority pollutants, insecticides, and other hydrocarbons. Liquid

chromatography with mass spectrometry (LC/MS) is a method for nonvolatile compounds, such as hormones, steroids, herbicides, fungicides, and organometallics. Immunoassays are another method for detecting compounds and include variations such as enzyme-linked immunosorbent assays and radioimmunoassays.

Multiple analytical methods exist for the detection of microorganisms in environmental settings. If the concern is a particular pathogen, specific sampling and detection methods must be selected for that microorganism. For general contamination from animal or human waste, the traditional approach is to assess the sanitary quality of water using bacterial indicators for the detection of fecal contamination; however, there are questions about the relationship between the detection of an indicator organism and adverse public health effects. Some researchers advocate the use of a suite of indicators appropriate for different classes of pathogens.

Question 5: How can we determine the fate, transport, and environmental impacts of pharmaceuticals and pathogens? Are there technologies to mitigate exposures?

Determination of the fate and transport of pharmaceuticals and pathogens can make use of the source tracking methods mentioned earlier as well as modeling and risk assessment methods. Development of monitoring programs for both pharmaceuticals and pathogens needs to be considered. Understanding of the ecological impacts also is needed. Information regarding the health effects such as acute and chronic toxicity of various pharmaceuticals on wildlife, insects, and aquatic invertebrates is lacking. Additional environmental information needed includes half-lives in soil and water, partition coefficients, and bioaccumulation data.

Little is known about the degradation processes of most pharmaceutical compounds in soil and water. The processes to remove pharmaceutical compounds from the environment include sorption to particles, bacterial degradation, reverse osmosis, bank filtration, natural attenuation, nanofiltration, and photolysis. European studies with human pharmaceuticals have shown that the elimination of pharmaceutical compounds from wastewater depends primarily upon sludge retention time. More research is needed in this area.

For farm families and workers, the basic steps for infection controls, such as hand washing and management of clothing, can mitigate personal and family exposure. Prior to land application, waste management and treatment options can reduce the microbial load of manure, but only one or two orders of magnitude reduction can be achieved with presently used systems. Systems designed purposefully to achieve high levels of pathogen reduction are feasible but expensive.

Question 6: What is the strength of the evidence that demonstrates linkages between exposures to AFO contaminants and incidence of disease, especially infectious diseases caused by pathogenic organisms originating from AFO wastes?

From a public health perspective, the focus of concern is pathogenic diseases and antibiotic resistance. Domestic animals are reservoirs for the major foodborne and waterborne disease-causing microorganisms. There are well documented cases where a clear link was demonstrated between animal waste and resulting disease in exposed people. Aside from such examples in which it is clear that agricultural runoff has entered water supplies, the information often is circumstantial. Antibiotic resistance is an area of concern because the same types of antibiotics

are used in both animal and human populations. Additional research is needed to understand the impact AFOs have on the spread of antimicrobial resistant microorganisms.

Quantitative microbial risk assessment can deduce the risks from AFOs, but such assessments are complicated because of the large numbers of different organisms and the presence of organisms from sources other than AFOs. Better surveillance is needed to detect outbreaks followed by more complete investigations into the sources of contamination responsible for the outbreaks. In addition, epidemiologic studies should be conducted to assess if the most exposed people have a high level of disease burden that can be attributed to their contact with animals and animal waste.

Question 7: What tools are available to farmers, watershed authorities, consultants, and other stakeholders that can help them identify specific conditions and geographical locations where animal feeding operations would present a higher risk to water quality?

Some tools that were produced for the CAFO Rule include the *Producers' Compliance Guide for CAFOs*, the *NPDES Permit Writers' Guidance Manual and Example NPDES Permit for Concentrated Animal Feeding Operations,* technical training, and checklists and updates on the national databases for permit and compliance tracking. Land application of manure from AFOs was the focus for many of the risk management presentations and discussions. Limiting application of manure on saturated soil, when a significant rainfall is forecast, and in the winter or on frozen ground have been the mechanisms used to minimize the risk of runoff and discharge from AFOs.

New and better tools are needed that incorporate climate data in calculating the storage capacity required to meet land application standards and avoid overflows. In addition to storage issues, research is needed to assess and minimize the risk of liquid manure or wastewater discharge via subsurface drains in areas with tile drainage. Tools that target where compliance assistance and permitting of CAFOs would provide the greatest environmental benefit are needed along with research that allows for easy assessment of farm management and environmental quality. The goal should be to reduce the probability of risk and allow flexibility in the system to meet this goal.

Question 8: What are the most effective strategies and practices for minimizing the movement of pollutants from animal confinement areas, manure storage areas, and land applications of manure into surface and ground water and limiting emissions into the atmosphere?

Methods for minimizing movement of pollutants from individual farms can be divided into production, treatment, and land application areas. Because of the site-specific nature of AFOs, determination of a national manure management strategy or practice is not feasible. In addition, it may be necessary to step back from a specific farm-scale approach to a total watershed approach requiring broad manure management solutions.

There are multiple pollutants of interest including solids, phosphorus, nitrogen, pharmaceuticals, and microorganisms. Manure management through production modifications and pollution prevention has not received much attention, but it can be effective, and more focus could be given to this area. Research has been done on the treatment and land application aspects of

manure management. Integrated treatment systems combine two to four management practices and can obtain stepwise improvement in pollutant reduction. A problem is that many of the technologies for addressing one pollutant may not help in treatment of the other pollutants of interest. In addition, minimizing pollutants in water may increase loadings in air or vice versa. Research is needed to examine manure management within the complete environmental system. ORD has made recommendations for treatment options in the CAFO regulations that include facultative anaerobic lagoon storage, windrow composting, and anaerobic digestion.

The major variables in land application of manure are the nutrient content, the application equipment, and the application method. Existing research supports the importance of the timing of manure application, with respect to seasonal and rainfall parameters, and the location of manure application, particularly with regard to setback from a water course. Soil type and the existence of tile drains will impact decisions on the use of surface application or incorporation methods.

Question 9: What are the best alternative uses of manure, other than land application?

Alternative uses of manure can be separated into three areas: (1) conversion to value-added product; (2) conversion and use as an energy source; and (3) innovative and emerging technologies. A report on the EPA Web site entitled *Alternative Technologies: Uses for Manure* [http://www.epa.gov/npdes/pubs/cafo_report.pdf] provides details on this subject. Alternatives are successful when there is a guaranteed market for the product and the system is based on a strong business plan and not a government subsidy. Many alternative uses have been proposed for manure; however, the vast amount of the waste is, and will continue to be, applied to land. Therefore, efforts may need to focus on the production of "designer" manure that has reduced volume, moisture, odor, and pathogens as well as increased nutrient content.

The overall environmental impact of alternative uses needs to be assessed, as alternative uses are not necessarily environmentally superior. Attaching a value to the environmental benefits that result from various alternative uses would assist the public and regulatory agencies in deciding how much to spend to achieve environmental benefits.

Question 10: What environmental assessment methodologies/approaches are available to evaluate farming operations and practices to determine impacts and to determine the contributions of these practices toward causing, or effectiveness in preventing, adverse environmental consequences?

Environmental assessment programs that focus on individual farms and practices are available through the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service, EPA, USDA Cooperative State Research, Education and Extension Service, state partnerships, and industry. With voluntary programs, methodologies are needed to ensure that suggested practices are being implemented in a timely fashion, with regular operation and maintenance activities. No studies have examined a single farm operation and measured water quality changes over time based on management practices. Basic survey data on the management practices of different types of farms in different regions also are lacking. Research on water quality impacts from a single farm often is difficult and time consuming, particularly when attempting to document the effects of specific conservation practices. Targeting research at a watershed level may better meet overall environmental goals.

A gap exists between the on-farm assessment models used by individuals and educational institutions and the regulatory state and federal processes used to develop regulations. At the federal level, models were used to determine the environmental quality that would result from a variety of regulatory scenarios for CAFOs. National water quality was examined through analysis of improvements in water quality and suitability of water for recreational activities. Reduced incidences of fish kills, improved commercial shellfishing, and a reduction in nitrogen contamination of private wells were other expected changes analyzed. The National Water Pollution Control Assessment Model (NWPCAM) allowed for estimates to be made in the changes in loadings under different regulatory scenarios and to assess the public's willingness to pay for reduction of pollutants and increased water quality.

Other needs

Some common themes were repeated throughout the presentations and panel discussions. Participants recognized the challenge of providing research data to EPA regional staff more quickly and in a usable format. Regional differences of AFO issues are apparent and as such should be considered in addressing AFOs research needs and control methods. In addition, a challenge exists to address individual AFOs as complete systems and not to separate water, air, or environmental effects into different compartments. Finally, participants highlighted that collaboration among various agencies is needed and should continue and increase.

Post workshop discussion

The workshop concluded with a smaller group discussion during which interested attendees discussed suggestions regarding how to carry forward the momentum developed from the workshop. A proposal was developed to established an interagency workgroup to address the identified unmet needs.

Regional Science Workshop:
Animal Feeding Operations (AFOs)
Science and Technical Support Needs

College Park, MD
December 6–9, 2004

Meeting Summary

OVERVIEW

The U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD) Regional Science Workshop on Animal Feeding Operations (AFOs) Science and Technical Support Needs was held at The Inn and Conference Center, University of Maryland, College Park, Maryland, December 6–9, 2004. The goals of the workshop were to (1) bring the available technical tools to EPA staff to address their highest priority science needs associated with AFOs; (2) identify unmet basic and applied research, technical support, training, and other science needs associated with the regional priorities and develop a plan to address these needs; and (3) capture the most relevant information from the numerous other workshops that have been held on these questions and provide the information to EPA staff. An interactive poster session was held the day prior to the presentations and panel discussions. The posters remained up for the majority of the workshop and allowed for one-on-one interaction with investigators on the tools available to meet the technical needs associated with the priority needs.

OPENING COMMENTS

Jon Scholl, EPA, Office of the Administrator

Dr. Ronald Landy, EPA, Region 3, welcomed participants to the workshop and introduced Mr. Jon Scholl, Counselor to EPA's Administrator for Agricultural Policy. Mr. Scholl said he was excited about the workshop agenda and looked forward to participating. He noted that the conference would provide an opportunity to share ideas and information important to decisions and changes taking place in the agricultural industry. A collaborative approach among EPA, other government agencies, and the agricultural industry is crucial to meeting the challenge of providing information and flexible options needed to make good environmental decisions. In traveling around the country and meeting with farmers, he has been pleased with farmers' recognition of their environmental responsibilities. The agricultural industry wants to be part of the solution and involved in designing options and changes that will work. Mr. Scholl emphasized the need for a good science foundation for making decisions. The agenda for the workshop provides opportunities to share information and interact with others to obtain answers to questions and to determine unmet needs. The questions addressed have major consequences for the agricultural industry, the consumers served, and the environment. He emphasized that it is important to have good facts and sound science to "get AFOs right."

SESSION I—AIR EMISSION CHARACTERIZATION AND MANAGEMENT

Question 1: What are the most significant air pollutants (e.g., dusts, volatile organic compounds, and ammonia), their sources (including housing, storage ponds, lagoons, litter piles, and land application fields), and their emission rates from AFO operations? What metrics, methods, and models should we use in the future to quantify and monitor these emissions to better understand their relationship to atmospheric deposition and the formation of ground-level ozone and fine particulate matter ($PM_{2.5}$)?

Air Pollution From Animal Feeding Operations: Regional Research Needs

Kerry Drake, EPA, Region 9

Mr. Drake stated that the biggest unknowns facing his region are the emissions that come from animals and how to control them. He provided an overview of air quality issues facing the region and information on what is known about the pollutants and their sources. In addition, he examined the regulatory drivers of the process and identified some of the solutions and research needs.

The San Joaquin Valley of Central California is home to more dairy cows than anywhere else in the United States. Dairy operations are estimated to contribute 16 percent of volatile organic compounds and 59 percent of the ammonia emissions in this region. These numbers are based on emission factors calculation and not actual measurements.

State Implementation Plans (SIPs) are one of the main regulatory drivers for assessing air emissions. Eight-hour ozone and $PM_{2.5}$ SIPs are due to EPA in 2007. States are committed to decreases, but there are questions about the accuracy of states' estimates. It will be a challenge to determine if control methods on dairy facilities have contributed to any decreases. In addition, state regulations are a factor in California. The state will begin permitting new and modified facilities, including dairies and other AFOs. Both industry and regulatory agencies need to know which control methods and technologies are effective.

Current research in this area uses flux chambers, whole animal chamber studies, LIDAR, and other methods. Research needs include: (1) methods to estimate emissions (including all portions of AFOs); (2) atmospheric chemistry and modeling (e.g., ammonia and what happens if ammonia is controlled before SO_x and NO_x); and (3) the technology and practices to reduce emissions.

Animal Feeding Operations: Air Quality Issues From a National Perspective

William Schrock, EPA, Office of Air and Radiation (OAR)

Mr. Schrock noted that the public has raised concerns and brought lawsuits about air emissions from AFOs. The Clean Air Act (CAA) applicability for AFOs is confusing. The pollutants of concern are the criteria pollutants, such as particulate matter and volatile organic compounds. There presently is a petition to classify hydrogen sulfide as a hazardous air pollutant (HAP), which could impact animal agriculture. For emissions standards, EPA still needs to settle CAA requirements, such as source definition, fugitive and nonfugitive issues, and emission estimation. Unfortunately, the SIPs schedule is driving decisions on these aspects before the scientific information is available.

Mr. Schrock's office hopes to find an agriculturally appropriate approach for resolving ambient air quality issues, providing a catalyst for best management practice (BMP) implementation, and maintaining consistency with the Managing Manure Guidance for Concentrated Animal Feeding Operations (CAFOs). Issues that confound these goals include the fact that monitoring by farm is not feasible, and BMPs vary across the country. EPA is exploring how to approach air monitoring and control methods for AFOs, trying to maximize the flexibility of the solutions and the U.S. Department of Agriculture's (USDA) involvement.

Until now, EPA's focus been on emissions, but the National Academy of Sciences (NAS) report suggests a process-based model. Moving to a process-based model will take considerable effort and probably will not happen on California's (or other states') schedule for SIPs. EPA recently compiled a list of research projects on agricultural issues related to air that includes information on funding, project descriptions, and principal investigator contacts. USDA also compiled a list. The lists will be combined and examined for gaps or double funding to help focus limited research dollars in the most efficient way.

Comments and Questions

Ms. Bonita Johnson, EPA, Region 4, asked for clarification on why monitoring by farm is not feasible. She also asked about the alternatives. Mr. Schrock replied that monitoring stations presently installed on farms are research based and costly. He was unable to identify any alternatives.

A participant asked about hydrogen sulfide becoming a HAP. Should this happen, would EPA develop a maximum contaminant level and require industry controls? The participant inquired if a performance standard might be a better approach. Mr. Schrock responded that if hydrogen sulfide were listed as a HAP, the Agency would need to modify the source list and determine the major sources. If animal agriculture was determined to be a known source, then maximum standards would need to be developed. He agreed that work practice standards could provide some flexibility, if hydrogen sulfide were listed.

State-of-the-Science in Air Emissions
Albert Heber, Purdue University

Dr. Heber focused his presentation on barn emissions, though there are other sources of AFO air emissions, such as outdoor manure storage, manure treatment facilities, the land application of manure, and dead animals. Tools to estimate barn emissions are available. Dr Heber noted there are more air quality laboratories and equipment than ever before making replication possible; however, he estimated that 80 percent of the research in this area is not in published form.

Dr. Heber summarized his laboratory's work from the 1990s to the present, focusing on the mobile laboratory approach. Initially, he and his colleagues measured gases, such as ammonia and hydrogen sulfide. Then, they added real-time particulate matter monitoring using tapered element oscillating microbalance (TEOM) samplers. Improvements have been made in the system over the years, and Dr. Heber offered to provide information on sampler setup to interested individuals. The systems are online, and most aspects of the samplers are monitored electronically and can be calibrated remotely. All mobile laboratories and sites use similar monitoring plans, but there are site-specific differences.

These studies have contributed information on the emission rates from swine finishing facilities and hen layer barns. Emissions come from the animals themselves and from the manure that usually is stored in the facilities underneath the animals. Dr. Heber took background measurements from outside the barn and factored them into the emissions calculation. Swine finishing facilities that use lagoon water for flushing have high hydrogen sulfide emissions from the barns and the lagoons. Based on his measurements, large farms (> 109,000 animals) would emit enough hydrogen sulfide that they would exceed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reporting requirements. In addition, ammonia emissions from the barns are large enough for CERCLA reporting. Dr. Heber's results show that there are not large amounts of hydrogen sulfide emissions in high-rise layer barns. These barns, however, have large ammonia and particulate matter emissions. Many of the AFOs are large enough to challenge CAA requirements.

Dr. Heber found that emissions varied in different seasons. Real-time measurements provide information about the dynamics of emissions that may be missed by other sampling schemes. For example, in swine facilities, hydrogen sulfide emissions were high in the summer as a result of increased anaerobic microbial activity. For layer barns, there was a decrease in ammonia emissions in the summer, when barn ventilation increased. There was no seasonal variation in concentration of PM_{10} from winter to summer, but because ventilation increases in the summer, there was an overall increase in emissions of PM_{10} from layer barns. Animal activity patterns and events, such as barn flushing, also influenced air emissions. This information can be important for regulatory flexibility and abatement techniques.

Dr. Heber's group also used their samplers to assess emission abatement and control techniques, including manure additives, soybean oil sprinkling, windbreak walls, biocurtains, and biofiltration. Many manure additives have been found to be ineffective. Soybean oil use is effective for reduction of PM_{10} emissions, but practical issues, such as the slipperiness of the barn floors, must be addressed for this abatement method. Dr. Heber's group found no reduction of barn PM_{10} emissions at a site after the installation of a biocurtain. A study on the efficiency of biofiltration found that biofiltration removes pollutants but requires maintenance and disposal. With this method, there are some questions about ammonia possibly becoming a groundwater problem if no liner is used. The top abatement methods include diet manipulation, storage covers, biofiltration, and soybean oil sprinkling. Farm-specific emission models are needed, and data are becoming available to develop and validate emissions models.

Comments

Mr. Drake clarified that there are two parts of the CAA that could affect AFOs. Fugitive versus nonfugitive is a permitting issue. An enclosed barn counts toward permitting thresholds. In SIPs for 8-hour ozone or fine particulate matter, there is a need to examine all sources that may contribute to these pollutants or their precursors; this would apply to total farm emissions without distinguishing between fugitive and nonfugitive.

Question 2: What are the meteorological and other variables that affect the emissions, transport, and deposition of AFO-related pollutants?

Regional Air Quality Modeling Issues Related to Animal Feeding Operations
Thomas Pierce, National Oceanic and Atmospheric Administration (NOAA), Atmospheric Science Modeling Division

Mr. Pierce discussed the importance of monitoring and modeling ammonia because animal feeding operations are dominant sources of national emissions. Ammonia forms a significant part of $PM_{2.5}$ aerosols, and it strongly influences control strategies of NO_x and SO_x. Ammonia contributes to watershed nutrient loading and N deposition to streams, lakes, estuaries, and oceans.

Previous models of farm emissions were very simplistic. There is a need to move toward a process-oriented model. The knowledge base for modeling has increased significantly; for example, before data became available for modelers, a steady state of emissions for the entire year would be assumed. Inverse modeling allows for incorporation and changes in models based on actual data collected. Mr. Pierce gave an example in which this process reduced the estimated ammonia emission factor for beef cattle operations. Inverse modeling now is being applied to the 2001 annual Community Multiscale Air Quality simulations to test the monthly ammonia emission estimates.

Modeling of dry deposition of ammonia is a challenging and largely uncertain area in ammonia modeling. Data from Europe exist, but their applicability is questionable. Dry deposition is a process that should be incorporated into models because ammonia can be both deposited and emitted.

Regional air quality monitoring is a sophisticated process that requires significant computer time. Models can be used to balance the ammonia budget to show the transport of ammonia. Mr. Pierce gave an example of work done in Sampson County, North Carolina. This research showed the surprising conclusion that ammonia moves rapidly away from the surface. Regional models can be useful tools in examining the emissions from AFOs. Ammonia is both regional and local, and airsheds are substantial. The problems come from mixing, transport, deposition (both wet and dry), and hotspots. Hotspots, such as CAFOs, mean that regional grid models may not work. These hotspots have been studied sufficiently to characterize the bias introduced by ignoring or misrepresenting them.

Emissions, Transport, and Deposition of AFO-Related Pollutants
Michael F. Davis, EPA, Region 7

Mr. Davis noted that the study of emissions, transport, and deposition of AFO-related pollutants provides an opportunity for interagency atmospheric research and collaboration. The National Monitoring Strategy requires an assessment of monitoring, examining the redeployment of air monitoring assets, and is driven by the revised CFR Part 58. NCore is a three-tiered approach, with a small number of research-based, real-time monitoring sites; a larger number of multipollutant sites; and a base of single pollutant sites that are intended to fill in the gaps.

The number and location of monitoring sites will affect the ability to depict pollutant spatial gradients, and Mr. Davis provided examples from the Interagency Monitoring of Protected Visual Environments' network. Nitrogenous compounds vary by species, and there are strong local and regional trends. Ammonium nitrate is a wintertime species. Dry deposition data exist, but there are questions regarding the spatial representativeness of the concentration gradient when some values are so high, and the gradient is depicted by so few monitoring sites. Wet deposition shows a unique pattern also, with a higher concentration of ammonium ion east of the agricultural area of the central United States. A clear influence of the ammonia emissions from the central United States has been shown by aerosol and atmospheric scientists.

Continuous monitoring is needed. When EPA obtains midnight to midnight values, some of the variation is missed because of the averaging effect. The most significant questions from Region 7 are: What type of ammonia (e.g., gaseous, wet deposition, dry deposition, ammonium nitrate, ammonium sulfate) is the most important species? What frequency and spatial scale cause concern? Opportunities for collaboration exist, and Mr. Davis suggested making contact with staff at EPA's Office of Air Quality Planning and Standards or local EPA Regional offices, NASA's AERONET program, USDA, NOAA, and universities.

Panel Discussion for Questions 1 & 2—Have the Needs Been Met, and Are There Remaining Technical Needs?

James Liebman, EPA, Region 9; William Schrock, EPA, Office of Air and Radiation; Michael Davis, EPA, Region 7; Albert Heber, Purdue University; Thomas Pierce, NOAA; and Cary Secrest, EPA, Office of Enforcement and Compliance Assistance (OECA)

Emissions Sources Other Than Barns

A participant inquired about emissions from storage systems or land application. Dr. Heber noted a study on hydrogen sulfide and ammonia that was published in the *Journal of Environmental Quality* last year. He noted that data are available on covered versus uncovered lagoons and on the release of hydrogen sulfide and ammonia from basins, but data are lacking on emissions from land application.

Seasonal Fluctuations

A participant asked about the reasons behind the seasonal fluctuation in ammonia emissions. Dr. Heber explained that most barns have an increase in ammonia emissions during the summer because the increased temperature leads to increased decomposition, and, at the same time, the increased air flow leads to stripping and volatilization. Lagoons have a wide variation in emissions because temperature affects outdoor storage. Ammonia and methane emissions decrease in the winter, but in the spring, there is a burst of emissions followed by high emission levels that decrease throughout the summer. Mr. Pierce commented that Dr. Heber's data on barn emissions have not been incorporated into emissions models yet.

Data Availability and Sharing

Dr. Ron Landy asked the researchers what it would take to make needed data available to modelers and regulators in the near future. He asked the modelers and regulators to identify what information they need most need in the next 2 years.

Mr. Cary Secrest, EPA, OECA, noted that data should be presented together in one publication. He referenced a northern European study by Takai with 2 years of data collection that was published in a journal. As data collection is ongoing, periodic reporting may be needed. Dr. Heber noted that the data set increases daily. There are tools to assist with data analysis, but there is a need for students to mine and analyze data to develop emission factors. For the six-state emission study with which he is involved, all the results will be published in one issue of a journal. Mr. Schrock stated that most emissions information has been posted on the EPA Web Site. A conference will be held every other year to get information out to regional staff.

Dr. Jamie Liebman, EPA, Region 9, asked Mr. Schrock about the list being compiled to link studies from EPA and USDA and noted that research at the state level might not be included in this list. Mr. Schrock responded that the list is in the early stages of development. Dr. Liebman asked if there is someone to whom he could send information now. Dr. Beth Sauerhaft (sauerhaft.beth@epa.gov) was willing to receive synopses of AFO air emissions research for inclusion in the EPA and USDA combined list.

Research Needs

Mr. Drake stated that the most pressing research need is to know if animal contributions to air emissions are significant because, if the answer is yes, then AFOs must be addressed in the SIPs. If EPA ultimately decides that emissions from AFOs need to be controlled, how can this be done in a cost effective manner? Dr. Liebman reiterated the need for environmental and economic analysis of the control and treatment options addressing whole-farm control for volatile organic compounds, particulate matter, nitrogen, and phosphorus. Mr. Drake emphasized that mitigation and abatement must be economically feasible because of the CAA and the political climate.

Dr. Heber recognized that more data are needed on treatment and management options. Work is being done and researchers are trying to make the data available, but they need additional resources.

National Academy of Sciences Report

Dr. Liebman stated that emission factors are necessary from various types of AFOs for regulatory purposes; however, the mass balance approach recommended by the NAS report could provide a more accurate, flexible, and multimedia approach to determining emissions from all portions of AFOs that impact air, water, and land. These two tracks are not united, but he hopes that the message will emerge from this workshop that this is an area that should be addressed.

Dr. Wayne Robarge, North Carolina State University, was on the NAS Panel that wrote the report. He commented that EPA had posed a number of questions and asked NAS to evaluate them. At the time of the study, regulations were being considered for individual farms using fixed numbers. The process-based model recommended by NAS addressed the problems with the scenarios proposed at the time. Dr. Robarge noted that emissions inventories are fine for characterizing populations.

Modeling and Data Collection Interaction

Dr. Robarge asked for more guidance from modelers regarding the data needed. The modelers need to be more specific with researchers; it appears that the modelers view segments of data, which is in contrast to the funding of long-term monitoring. Mr. Pierce agreed that it is important for researchers and modelers to work together. Modelers start with a broad framework and then address specific episodes.

State Needs

Mr. Terry Black, Pennsylvania Department of Environmental Protection, asked how the EPA AFO consent agreement will provide information that is helpful to state agencies in developing their SIPs. He asked whether emissions factors or data to develop process-based models will be included in the document. Dr. Heber replied that for the consent agreement study conducted by his group, the study design will provide emission factor data. In addition, they are collecting other data, such as feed content, manure analysis, temperature, and humidity, that will be helpful for process-based models. Mr. Schrock noted that the agreement includes emissions-estimating methodology, but he was not sure of its form. Mr. Drake did not know if the consent agreement information will be usable by states in developing SIPs because of timing. Data from the study will be forthcoming, and EPA will try to make them available to the states.

LUNCHTIME PRESENTATION

Clean Air Act Enforcement Settlement With Buckeye Egg Farm: How Ambient Measurements Helped EPA Forge an Agreement for Reducing Emissions of Particulate Matter and Ammonia From This Large-Scale Poultry Operation
Cary Secrest, EPA, OECA, and Albert Heber, Purdue University

The goal of this joint talk was to present the Buckeye Case as an example of how public health concerns were considered in an enforcement case to obtain a consent agreement that incorporated research on economically controlling emissions from large-scale poultry farms. Mr. Secrest provided background information on the case. A Notice of Violation of the CAA was based on Buckeye's laying hen numbers (2.5 million hens in 16 buildings) and emission factors. It alleged that the facilities were major sources of pollution (250 tons/year of particulate matter) and failed to comply with CAA requirements.

Testing of particulate matter emissions and ambient air monitoring of the nearby community were performed. Data indicated elevated residential area concentrations of ammonia and PM_{10} that were determined to be a public health risk based on Iowa Study Group health standards. Ambient data supported EPA's effort to include ammonia reduction in the consent decree, even though ammonia is not a regulated air pollutant. A consent decree was signed that involved experimental controls and emissions testing by Dr. Heber's research group at Purdue University.

Dr. Heber provided information on the monitoring at the barns, including measuring baseline particulate and ammonia emissions from high-rise barns and comparing emissions from a new belt-battery barn. Barn measurements also were used to evaluate the effectiveness of a

particulate impaction curtain on particulate matter emissions and a feed additive on ammonia emissions.

The belt battery barn has 42 belts and each removes manure from two rows of cages. The belt moves one-seventh the length of the barn per day so there is a change in ammonia emissions along the length of the building. Two different ammonia monitors (a photoacoustic infrared method and a chemilumenscence monitor) allowed examination of both high and low concentrations of ammonia. There was an increase in ammonia from the north end of the barn to the south end of the barn that resulted from the accumulation of manure on the belt. This study showed the importance of taking measurements at different locations in a barn. The carbon dioxide concentration was constant along the length of the building indicating similar ventilation and number of birds throughout the barn. PM_{10} emissions also were monitored, and measured values fluctuated based on the activity of the birds.

Under the consent decree, Dr. Heber must report all of the daily averages within 60 days. Based on the data collected from the belt-battery barn, there is a calculated maximum daily mean of 572 lb/day of ammonia, which exceeds the CERCLA reporting requirement. Ammonia emissions from the high-rise barns were higher with a calculated maximum daily mean of 1,131 lb/day. This was more than the belt barn, so removing the manure seemed to be a benefit. The calculated emission factor for ammonia in the high-rise buildings was similar to those in other published data.

Emissions control utilizing a particulate impaction curtain was measured in two high-rise barns. The curtain provided a 39 percent reduction of PM_{10}. Dr. Heber's group conducted a bench scale test on a manure additive marketed to reduce ammonia emissions. The results indicated that the additive did not work. The producer now is testing a feed additive for ammonia emission reduction, and Dr. Heber's group will collect barn data to examine its effects.

Questions and Comments

A participant asked if Dr. Heber planned to test the manure quality after the feed additive was used. She was concerned about possible water quality effects resulting from nutrient changes in the manure. Dr. Heber stated that manure is sampled every month, and pH and moisture content are monitored. He agreed that perhaps other aspects should be examined, but they are not funded to do so. The participant noted that any changes in the nitrogen content of the manure would be important to know for nutrient management practices.

Dr. Charles Purdy, USDA Agricultural Research Service (ARS), asked about curtain and maintenance costs. Regarding maintenance, Mr. Secrest noted that vibrators on the curtains are supposed to shake down the dust, so there should be little maintenance costs. Dr. Heber stated that the current technique is to turn the fans off and beat the curtain with a broom. Mr. Secrest indicated that the cost for the curtain is approximately $20,000 per building. Dr. Heber said that he has funding to write an Extension-type bulletin for this technology and it will include cost information.

Dr. Robarge commented about the amount of data and time needed for analysis. He asked if there is problem with underestimating the time and resources needed for data reduction. Dr. Heber said that his group is improving turnaround time and now report the data in less than 60

days. The cost and man-hours to establish such a sampling scheme also are considerations. Mr. Secrest stated that the larger issue is the enormous amount of data from multiple projects that must be combined and disseminated.

Dr. Frank Humenik, North Carolina State University, was curious about the effect on air and manure quality from the relative infrequency of running the belt. Dr. Heber answered that the goal was to reduce the moisture content of the manure below 25 percent during the 7 days the manure remained on the belt in the barn to decrease the ammonia emissions.

SESSION II—CONTAMINANT SOURCE TRACKING

Question 3: What methodologies can be used to distinguish the source(s) of nitrogen and other contamination (e.g., pathogens) in ground or surface waters (i.e., specific animal species, septic tanks, and fertilizers)?

Region 4 Perspective on Nitrogen Source Identification

Lee Thomas, EPA, Region 4

Mr. Thomas noted that there are many potential sources of nitrogen in rural areas: excess fertilization of crops, overapplication of animal waste, septic waste, and naturally occurring nitrogen. The need for source identification is important to enforcement actions. The Safe Drinking Water Act addresses impacts to public and private wells. If the source of contamination can be determined, EPA can require the source owners to supply the impacted source with bottled water and work towards a long-term solution. Region 4 makes use of isotope analysis for source tracking. Fifty years of study has shown that elevated ^{15}N levels in groundwater could be attributed to hog waste contamination.

Mr. Thomas presented examples from a 1999 program for sampling nitrate in private wells near AFOs. In the first example, up to 21 mg/L of nitrate was measured in a private drinking water well on a 2,900-animal hog farm. The effluent from the waste lagoons, estimated at 1.4 million gallons a year, was applied to a spray field. Elevated ^{15}N data in the wells made the case for contamination by animal waste, so deeper wells were drilled outside a confining zone from the spray field. In another case, the private wells near a hog farm had nitrate levels up to 16 mg/L. In this case, the ^{15}N of the nitrate was lower than expected if the source of contamination had been hog waste. It was found that, in addition to the hog waste, turkey litter and commercial fertilizer also were being applied to the nearby field. The case was resolved by connecting the private homes to a public water supply line. The last example Mr. Thomas presented had confounding sources for elevated nitrate levels in a private well. Both a poultry land application field and farm supply store with a fertilizer department were located near the well and could have affected the water supply. Multiple sources of possible contamination illustrate the complexity of these issues and the need for source tracking.

Mr. Thomas re-emphasized the need for nitrogen source identification in rural areas. ^{15}N can be used for hog waste but a method is needed for poultry farms. It is important to ensure that local information is included in source identification.

Contaminant Source Tracking: A National Perspective
Paul Shriner, EPA, Office of Water

Mr. Shriner presented background information showing that nutrients and pathogens are important stressors for U.S. water systems. Manure is considered to account for 28 percent of the nitrogen and greater than 75 percent of the phosphorus load in U.S. waters. Pathogens are the biggest stressor in rivers and streams based on fecal coliforms as an indicator of enteric bacterial populations. Mr. Shriner acknowledged, however, that the relationship between fecal coliforms and other organisms is not strong, and fecal coliforms do not indicate the source of contamination.

Waterborne routes of contamination often are hard to pinpoint. More than half of the outbreaks of contamination follow heavy rainfalls. Few outbreaks have been linked directly to farm animals, perhaps because there is no method to show the link or the information shows to the contrary. Recent developments in source tracking include improved fingerprinting and detection methods in both pathogen source tracking and isotope labeling. Cost is an issue for many of these techniques. In addition, there is improved modeling of contaminant transport and bacterial release and survivability. Quantitative information is needed on the variety of water contamination sources from both agricultural and urban settings.

The CAFO program provides some guidance on practices for prevention of contamination. A multibarrier approach can prevent pathogens from entering the facility, propagating within the facility, and being discharged from the facility by land application or worker export. Sound nutrient management plans significantly control runoff, and a proactive approach is warranted.

A participant asked about a pathogen management standard mentioned on one of Mr. Shriner's slides. Mr. Shriner clarified that it is a Natural Resources Conservation Service (NRCS) reference. He did not know the date of that standard, but stated that it is still being referenced in current literature.

Tracing Sources of Agricultural N Using Isotopic Techniques
Carol Kendall, U.S. Geological Survey, Menlo Park

Dr. Kendall noted that various environmental sources have distinctive isotope ratios, and environmental processes can leave isotopic fingerprints that provide a better understanding of systems. Isotope values are reported as delta (δ) values. The standards chosen for various isotopes, such as air for nitrogen isotopes, means that it is possible to have negative δ values if the sample has a smaller ratio of isotopes than the standard.

A common use of isotopes in agricultural settings is tracing the source of nitrate found in water. Methods can utilize stable isotopes for both nitrogen (N) and oxygen (O). There are two stable isotopes of nitrogen ^{15}N and ^{14}N and isotope values are reported as $\delta^{15}N$. The three stable isotopes of oxygen are ^{18}O, ^{17}O, and ^{16}O and $\delta^{18}O$ and $\delta^{17}O$ can be analyzed. Analysis of the oxygen isotopes is not as common, but work by Dr. Bill Showers has shown the utility of $\delta^{17}O$ for assessing atmospherically derived nitrate.

A challenge in the use of isotopes for examination of agricultural sources of nitrogen is isotopic fractionation. Isotopic fractionation is the result of changes in the isotopic composition of

materials because of biological processes that either can make it difficult to identify sources or allow for greater distinction. For example, if denitrification is an active process in a system, isotope analysis cannot easily distinguish between a manure source and a fertilizer source that as a result of denitrification processes has the same $\delta^{15}N$ as manure. The solution in this case is to use a multi-isotope approach. An example of how fractionation can be helpful in tracing nitrogen sources is when ammonia volatilizes from open lagoons, there is a large change in the $\delta^{15}N$ value of the ammonia in the waste left in the lagoon that enables tracking of that manure if there were a spill or leak.

Isotope tracer analysis has not been used as much in the past in agricultural settings as it could have been. Dr. Kendall believes this is the result of controversy regarding a 1971 paper by Kohl, et al., that was criticized heavily by soil scientists. The response to this controversy was that the natural abundance approach for estimating the contributions of fertilizer-derived nitrate in surface waters essentially was abandoned in the United States for approximately 20 years. Most of the work at the U.S. Geological Survey (USGS) now has focused on a multi-isotope or multitracer approach to resolving nitrogen source questions. Several dozen studies have traced sources of nitrogen and investigated nitrogen transformations in agricultural, urban, and forested watersheds.

The most commonly applied method of the multi-isotope tracer approach measures $\delta^{18}O$ and $\delta^{15}N$ of nitrate to assess nitrate in groundwater. A number of other isotope systems can be analyzed to provide information on groundwater and surface water systems. Some options that are used less frequently are analyzing $\delta^{15}N$ in dissolved organic nitrogen and ammonia or examining $\delta^{18}O$ in phosphate or dissolved oxygen. Recent work on newer isotopes, for example isotopes of lithium or strontium, either alone or as part of a multi-isotope approach, has allowed different sources of animal wastes to be distinguished from one another.

Dr. Kendall reviewed potential applications of isotopes for tracing agricultural pollution. One application is to distinguish fertilizer from animal waste as a source of nitrate. In rivers, streams, and wetlands this is more complicated in that more biogeochemical and hydrologic data must be acquired to provide information about processes in the water that could confuse the ability to distinguish nitrate sources. Additional chemical or isotope tracer information can assist in such situations, and Dr. Kendall provided data from her San Joaquin multi-isotope study as an example. Another effective application of $\delta^{15}N$ is to compare soil nitrate versus nitrate from an animal waste source. $\delta^{15}N$ usually does not work to distinguish septic waste from animal manure or to differentiate among manure from different kinds of farm animals. In these instances, it is better to use a multi-isotope or multitracer approach.

Isotope analyses can be obtained from many sources. EPA, USGS, USDA, and many universities have stable isotope laboratories that can provide services and possibly collaborations.

Microbial Source Tracking Guide
Orin Shanks, ORD, National Risk Management Research Laboratory (NRMRL)

Dr. Shanks presented an overview of the rationale and a brief outline of EPA's *Microbial Source Tracking Guide Document* created by NRMRL with Dr. Jorge Santo Domingo as the lead author and contact. Methods were classified on three aspects: (1) qualitative or quantitative abilities;

(2) whether the method is phenotypic or genotypic; and (3) whether the method is library dependent or library independent. In the *Tracking Guide Document*, a library is defined as a set of characteristics for a particular source identifier that has come from a particular watershed and particular animals.

Microbial source tracking methods are useful to supplement sanitary surveys to identify sources of beach contaminants or Total Maximum Daily Load (TMDL) violations and for risk analysis purposes in determining human verus non-human contamination. New methods and technologies are proliferating, and the most useful method depends on circumstances of each case study.

The *Tracking Guide Document* should be distributed for review in late April 2005. A section on decision criteria includes decision trees and flow charts to help guide users on what methods to use and when they should be used. A section on the various source tracking methods summarizes the current methods, including how the methods work, cost, equipment needed, advantages and disadvantages, and references. If the method needs a library, there is information on library construction and validation and recommendations on sampling needed to take into account spatial and temporal variability. Performance standards are included to address quality control. The document also addresses the assumptions and limitations of microbial source tracking with topics such as host-specificity of target microorganism, geographic range, and temporal stability. The final section presents eight case studies on applications of microbial source tracking, with information on how sampling was performed, the utility of the method, and lessons learned.

Panel Discussion for Question 3—Have the Needs Been Met, and Are There Remaining Technical Needs?

Bob Brobst, EPA, Region 8; Bonita Johnson, EPA, Region 4; Orin Shanks, EPA, NRMRL; Lee Thomas, EPA, Region 4, Carol Kendall, USGS; Paul Shriner, EPA, Office of Water; and Sam Myoda, Delaware Department of Natural Resources

Introductory Comments by New Panelists

Mr. Bob Brobst works for the Water Program in EPA, Region 8 and serves on EPA's Pathogen Equivalency Committee. Ms. Bonita Johnson is a microbiologist with EPA, Region 4, who works on microbial source tracking and serves on ORD's multi-year planning committee for pathogens. Mr. Sam Myoda works for the Delaware Department of Natural Resources, which uses source tracking on a daily basis and integrates those data into CAFO permits, water quality standards, and TMDLs.

Discussion on the Use of *Escherichia coli* for Source Tracking

A participant presented information from a research paper that explored *E. coli* in source tracking of animal wastes. The authors could not identify its source. Ms. Johnson noted that although she was not familiar with the study, she did agree that *E. coli* was not host specific. Most researchers use Enterococci for source tracking purposes.

A participant mentioned a colleague's poster of a study that used *E. coli* for differentiation between animals and humans and included antibiotic resistance patterns. A large library is

needed to enable such tracking, but additional research needs to be done on the size of library required.

Molecular Methods for Source Tracking

Ms. Johnson commented that genotypic methods have been in existence for years and have been used in clinical and food studies. She uses a multiplex polymerase chain reaction (PCR) assay to identify up to 25 species of bacteria through seven different groups of primers. She has modified the method for use with environmental samples.

Mr. Myoda noted that, in Delaware, they use ribotyping as a source tracking method. Even with 100,000 fingerprints in the library, only 60 to 80 percent source identification of water samples is achieved. He emphasized the need for developing library independent methods.

Isotope Analysis

A participant asked about the cost of isotope analysis. Mr. Thomas responded that for a typical site, 20 samples are collected and analyzed at a cost of about $200/sample.

Dr. Landy asked Dr. Kendall if she had an information packet that would help states and regions determine if a method would be useful for them. She replied that a handout prepared for this meeting highlights the progress made and the utility of multi-isotope approaches. In addition, she recommended conducting multiple analyses. Dr. Kendall commented that these analyses may be temporarily expensive because only a few laboratories are presently providing some of the newer analyses. She believes that the prices will drop tremendously as the number of samples analyzed rises.

State Needs

Mr. Myoda commented that although EPA's *Microbial Source Tracking Guide Document* will provide information and overviews of a variety of microbial source tracking methods, it does not endorse any method. The burden and liability of choosing and defending the right method is left to the state. Mr. Myoda stated that the research needs of states will not be met because of the timelines involved. Delaware has a 3-year, court-ordered timeline to develop its TMDLs. The different source tracking methods cannot be validated in that time. He thinks research efforts should focus on direct pathogen detection to address the actual risks from the organisms causing illnesses.

Regional Needs

Ms. Johnson noted that in addition to research needs, resources are an issue for regions as the equipment to do source tracking can be expensive. Additional research is needed in the areas of fate and transport of microorganisms, sediment resuspension and regrowth of bacteria, and spatial and temporal variability for library-dependent methods. She reiterated that questions remain regarding library size, and more studies are needed to determine the optimum number.

SESSION III—PHARMACEUTICALS AND PATHOGENS

Question 4: What specific analytic methods (and associated sampling, preservation, and preparation techniques) should be used in an environmental setting for the veterinary pharmaceuticals and microorganisms most likely to be found in the environment and most likely to be linked to adverse human health effects (e.g., drugs such as tetracyclines, sulfonamides, and trenbolone; and pathogens such as *Cryptosporidium parvum*, *Campylobacter* spp., and *E. coli* O157:H7)?

Veterinary Pharmaceuticals and Microorganisms—Regional Perspective

Robert Brobst, EPA, Region 8

Mr. Brobst presented the many challenges associated with sampling and analysis of veterinary pharmaceuticals and microorganisms from a complex mixture of liquids and solids such as manure. It is important to develop a sampling plan. For microorganisms, if the concern is a specific species, sampling methods must be identified for that species. If the goal is to detect contamination from AFOs, an indicator organism may be used. Fecal coliforms have been used as indicators of fecal contamination in water for decades, but there are questions about the relevance of using such indicator organisms to assess public health problems that arise from AFO contamination. The advantages are that these organisms are easily detected and can be sampled at a low cost.

The sample matrix will affect the ability to detect organisms of interest. The cleaner the sample, the more methods that will be effective at detecting pathogens and chemicals of interest. Pathogens and pharmaceuticals can adsorb to solid surfaces causing detection problems. Sample preservation and time before analysis are issues for both pathogen and pharmaceutical detection methods.

For veterinary pharmaceuticals, there are no indicator compounds used to examine the fate and transport of these compounds from AFOs. One of the challenges is the variety of compounds with various degradation byproducts. Methods development and standardization for detection of both microorganisms and veterinary pharmaceuticals from AFOs are in their early stages but must be addressed to ensure accurate data.

State of Analysis for Pharmaceuticals and Other Organic Contaminants in Multiple Media

Mike Meyer, USGS

Dr. Meyer noted that the diversity of media, such as liquid waste, manure, water, soils, and sediments, that scientists and regulators want to test for the presence of agricultural contamination provides an analysis challenge. In addition, a variety of chemicals, such as antibiotics and endocrine-disrupting compounds, are of interest.

Extraction is the first step in analysis, and there are many types of materials and technologies available for solid phase extraction methods for liquids and for sample cleanup. Dr. Meyer shared examples of various solid phase extraction methods used in his laboratory, including a tandem reverse phase mixed mode technology used for extracting multiple classes of tetracycline. A challenge in environmental sampling is getting enough material for detection. Solid phase extraction provides concentration factors of 1,000 to 2,000. There are online solid

phase extraction-liquid chromatography/mass spectroscopy units that will extract and analyze samples at the same time; however, these units are expensive.

At USGS, methods development has provided research on the detection of 158 compounds in water and 83 compounds in sediment, including antibiotics, prescription and nonprescription drugs, and a variety of household and industrial compounds. Mass spectrometry usually is paired with gas chromatography (GC/MS) for analysis of volatiles such as priority pollutants, insecticides, and other hydrocarbons. With more polar compounds such as surfactants and hormones, derivitization is required prior to GC/MS analysis. Liquid chromatography with mass spectrometry (LC/MS) is a method for nonvolatile compounds, such as hormones, steroids, herbicides, fungicides, and organometallics. Multiple modes of ionization include electrospray interface and atmospheric pressure chemical ionization that span a continuum of ion types. Matrix effects can be a problem when samples are complex mixtures; for example, polar compounds are particularly hard to separate from humic material. In summary, Dr. Meyer noted that LC/MS-MS is preferable for specificity, and the sensitivity of detection methods is proportional to cost.

Immunoassays are another method for detecting compounds and include variations such as enzyme-linked immunosorbent assays and radioimmunoassays. The general concept of an immunoassay is a competitive reaction with a known amount of conjugate. A problem is the possibility of cross-reactivity with similar compounds. There are immunoassay kits available for antibiotics, hormones, surfactants, pesticides, and vitellogenin. To use such assays effectively, it is important to understand that detection levels vary and that data on assay dependability in different matrices often are lacking.

Analytical Techniques for Animal Feeding Operations (AFO) Pathogens and Indicators
Chip Simmons, University of North Carolina

Dr. Simmons presented information on analytical techniques for AFO pathogens and indicators. Presently, AFOs are not regulated for pathogens. Pathogen analysis and surveillance studies for environmental samples are technically demanding, often tedious, generally slow to produce results, sometimes unreliable, and expensive. This type of analysis and monitoring is done routinely in the health care field as an essential part of patient treatment and care and provides a national surveillance system, though only a handful of organisms are reported at a national level. Pathogen detection is performed regularly for meat, poultry, and milk, occasionally for biosolids from human municipal treatment facilities, but rarely for monitoring environmental waters.

The traditional approach to assessing the sanitary quality of water with regard to fecal contamination is to use bacterial indicators, such as total coliforms, fecal coliforms, *E. coli*, Enterococci, and, potentially, *Clostridium perfringens*. Somatic and male-specific coliphages have been studied as viral indicators of fecal contamination. Because of the specificity of host types for these coliphages, host selection allows for detection of different types of coliphages. The male-specific coliphages may be feces specific and, by grouping the serotypes, it may be possible to distinguish between human and animal contamination. One problem is that the swine gut is very similar to that of humans, and swine may harbor the same serotypes as humans.

Few initial concentration methods can efficiently concentrate all classes of pathogens. Most EPA methods are directed at one class of pathogens, such as the 1MDS Filter Method for viruses

and Method 1623 for *Cryptosporidium* and *Giardia*. Dr. Simmons' research group was interested in developing a method that would be effective for detecting all pathogens of interest. Their method includes an ultrafilter that is used for kidney dialysis patients, which is sterile and meets very strict QA/QC standards. The method has been found to be very effective. In addition to methods for water, there are methods for biosolids and air. Air samplers include simple membrane filters, slit samplers, Andersen air samplers, and liquid impingers. High-volume air samplers, such as liquid cyclone scrubbers and electrostatic precipitators, can be very expensive.

In a project at the University of North Carolina, Dr. Simmons and colleagues are exploring vectors that could move pathogens offsite. They are working with an entomologist at North Carolina State University to develop methods for housefly collection and sample processing.

Dr. Simmons presented an overview of detection methods for various classes of pathogens. Membrane filter assays on a variety of media and multiple fermentation tube methods are used for detecting total and fecal coliform bacteria. Biochemical assays, such as Colilert™ and Colisure™, that incorporate fluorescence are newer. EPA uses two coliphage detection methods: Method 1601, a two-step enrichment method, and Method 1602, a single agar layer assay. PCR is a molecular method that relies on amplification of target DNA. In addition to detection, further characterization of pathogens can be accomplished using biochemical test kits, methods that detect antimicrobial resistance patterns, and a variety of molecular methods.

Panel Discussion for Question 4—Have the Needs Been Met, and Are There Remaining Technical Needs?

Bob Brobst, EPA, Region 8; Mike Meyer, USGS; Chip Simmons, University of North Carolina; and Tracy Hancock, USGS

Introductory Comments by New Panelists

Dr. Tracy Hancock is a hydrologist with the USGS, and she works with the National Water Quality Assessment Program. Her interest is in the source, fate, and transport of agricultural chemicals. Recently, she and her colleagues have focused on arsenic from the landspreading of poultry waste in the Delmarva peninsula and the whole Potomac River Basin in Maryland. They teamed up with chemists at the USGS National Water Quality Laboratory to identify specific species of arsenic in waste, water, and soils samples. They are trying to take a watershed approach, and the study has now been extended into the Shenandoah Valley of Virginia using a USDA grant.

Remaining Science Needs

Ms. Mindy Lemoine, EPA, Region 3, asked the panelists to address remaining science needs before questions responding to questions.

- Dr. Meyer identified three areas of need with regard to veterinary pharmaceuticals and hormones. There is a need to (1) analyze degradation products and chemical pathways and determine whether their transport coincides with pathogen transport; (2) analyze stable isotope compounds for topology and frequency of occurrence of compounds and metabolites; and (3) conduct more interdisciplinary research. There is a need for small-scale studies. For

example, in the case of antibiotic resistance, information is needed to determine how much antibiotic is needed for an organism to maintain resistance.

- Dr. Simmons stated that questions remain regarding the effective use of indicators and which indicators should be used. He and his colleagues advocate the use of a suite of indicators by selecting those appropriate for the different classes of pathogens. Dr. Simmons also wanted to highlight the need to address questions from a risk-based approach that focuses on what is an acceptable level of risk and what are acceptable levels of pathogen reduction to decrease the health burden to the population.

Comments and Questions on Microbial Detection Methods

A comment was made supporting the selection of a minimum number of indicators. The World Health Organization has stated that developing countries do not have the capability to study all of the possible pathogens so there needs to be a target organism to measure to assess water quality. The participant commented that this approach also is valid in the United States.

Dr. Moorman, USDA, National Soil Tilth Laboratory, asked about the possibilities for using multiplex PCR. Dr. Simmons noted that multiplex PCR may be useful as a first step, but there are questions regarding the meaning of a positive PCR result.

Mr. Lance Price, Johns Hopkins University, commented on the importance of antibiotic resistance in determining the health risk of some organisms and the need to detect antibiotic resistance via the screening methods.

Systems Approach

Ms. Janice Ward, USGS, stated that the presentations and discussions often were compartmentalizing issues to simplify them. The environmental context is more complex. If there are multiple issues, multiple lines of evidence should be used to tie things together.

Dr. Meyer noted that USGS has established protocols on different pharmaceuticals. USDA has sampled CAFOs for years. This is a good time for collaborative efforts.

Studies Needed on Health and Ecological Impacts

Dr. Fred Pickney, U.S. Fish and Wildlife Service (FWS), urged participants to focus on the ecological impacts as well as public health. There is a need for basic studies to determine the sources of various fish effects. These studies should examine CAFOs, raw sewage, and septic systems.

Dr. Sobsey, University of North Carolina, stressed the need for health effects data if health risks are to be addressed. There is a need for toxicological studies or other health effects studies. He noted that these studies are challenging, expensive, and difficult to design and require collaborative efforts. Such studies have been conducted for drinking water, recreational waters, and shellfish harvesting waters. Various agencies, including EPA and the Centers for Disease Control and Prevention (CDC), have experience in this area. These agencies need to commit to conducting good epidemiological studies on the health effects from CAFOs.

Question 5: How can we determine the fate, transport, and environmental impacts of pharmaceuticals and pathogens? Are there technologies to mitigate exposures?

Regional Perspective
John Larson, EPA, Region 8

Mr. Larson presented a regional perspective on the environmental fate, transport, and impacts of pharmaceuticals and pathogens from AFOs. He is the agricultural advisor for Region 8, based in Denver, and he covers various programs related to agriculture including air, water, pesticides, and wastes.

It is important that regions have current information so they can to respond to requests for information and provide science-based answers to questions from regulatory partners and those in the agricultural industry. Regions need to know what to look for in monitoring programs. Regarding indicators for pharmaceuticals, there is a need to determine what might appear first in the water supply that could provide an indication that there is a problem. In addition, research on the potential hazards and ways to reduce exposure is needed.

The regions need health effects information such as acute toxicity and chronic toxicity of various pharmaceuticals to mammals, birds, fish, insects, and aquatic invertebrates. It also is important to identify possible residues of pharmaceuticals in food, feed, or water and the signs and symptoms of toxic exposure. The regions need information on the environmental effects of pathogens and pharmaceuticals, including degradation mechanisms, half-lives in soil and water, partition coefficients, and bioaccumulation. Emphasis should be placed on making these data available and accessible for regional staff in the field. Mr. Larson emphasized the need for the best scientific information because regional staff rely on this information when interacting with constituents and partners to address environmental issues and to protect human and animal health and the environment.

Veterinary Pharmaceuticals: Potential Environmental Impact and Treatment Strategies
John Cicmanec, EPA, ORD, NRMRL

Dr. Cicmanec noted that there are many veterinary pharmaceuticals, but they can be classified into groups of compounds such as antibiotics, anthelmintics, hormones, pesticides, vaccines, and x-ray contrast media (iodine- and barium-based). Often in large-animal practices, there will be complex mixtures of chemicals; this provides challenges for tracking and controlling compounds.

A number of potential endocrine-disrupting chemicals are used, and little is known about the fate of these compounds after excretion by animals. Information from a European study found that in liquid manure, the half-life of trenbolone is 267 days. In farm field studies, trenbolone was detected after application, and melengesterol was detected at the end of harvest showing that these compounds will persist.

The various categories of antibiotics include sulfonamides, quinolones, beta-lactams, aminoglycosides, and macrolides. In Europe in 1998, 10,900 tons of antibiotics were used with 7,000 tons going to human use and 3,900 tons going to animal use. In the United States, this is reversed. In 1997, 12,000 tons of antibiotics were used in the United States, with 4,800 tons

going to human use and 7,200 tons going to animal use. In Europe, only four antibiotics (monensin, avilamycin, flavomycin, and salinomycin) are approved for animal use for growth enhancement.

Dr. Cicmanec presented general information about antibiotic fate in the environment. The macrolides and sulfonamides generally persist in the environment. Tetracyclines, penicillins, and fluoroquinolones degrade rapidly. Usual concentrations range from 1 to 5 ng/L but can vary up to 300 ng/L. The processes to remove pharmaceutical compounds from the environment include sorption to particles, ultraviolet light, bacterial degradation, reverse osmosis, bank filtration, natural attenuation, nanofiltration, and photolysis. European studies with human pharmaceuticals have shown that the elimination of pharmaceutical compounds from wastewater depends primarily upon sludge retention time.

Dr. Cicmanec emphasized the importance of antibiotic resistance issues, even though EPA has chosen to spend more money on endocrine disruptors. Data from the Food and Drug Administration's (FDA) Microbial Risk Assessment group have shown that 30 to 60 percent of poultry have streptogramin-resistant *Enterococcus faecalis* (SREF), and the incidence among humans in the United States already has reached 0.4 to 1 percent of the population. In Europe where this class of antibiotics has been used for a greater period of time, the incidence of SREF among humans is up to 10 percent. Dr. Cicmanec reiterated the importance of antibiotic resistance as an issue of concern and noted the need to be aware of the linkages when the same class of antibiotic is used in both animal and human populations.

Overview of Pathogens Associated With AFOs—What Organisms and Why?
Mark Sobsey, University of North Carolina

Dr. Sobsey presented information on zoonotic pathogens, which are microorganisms of animal origin that can also infect humans. There are a variety of routes of exposure for animal-to-human transmission, such as direct contact; indirect contact; food, water, and air pathways; and vectors. Animal wastes contain human pathogens, such as viruses, bacteria and parasites, at high concentrations (millions to billions/gram of feces). Antibiotic use causes high proportions of antibiotic-resistant bacteria in animal wastes. Animal waste pathogens have caused disease and death in humans from contaminated food, through animal contact by farm workers and other people, and probably through environmental contamination in air and water.

The list of possible zoonotic pathogens is extensive and includes viruses, bacteria, protozoan parasites, helminths, and prions. Many of these agents are responsible for known cases and outbreaks of foodborne and waterborne diseases. Consequences include temporary morbidity to mortality, especially in high-risk individuals. Many of these pathogens can occur in a variety of animals.

Dr. Sobsey presented a long list of issues to be addressed with regard to zoonotic pathogens in the environment. For this workshop, the basic question is: What is the contribution of AFOs and pastureland systems to the total burden of infectious disease from zoonotic pathogens? Because there are so many other routes by which people are exposed to these organisms, it is important to assess the relative contribution of pathogens from animal agriculture. Dr. Sobsey acknowledged that this is not known.

Biological factors, environmental changes, and human behaviors contribute to pathogen emergence and reemergence. Given these concerns, there are questions about practices and systems that will be protective for animals, food, and the environment. Animal manure systems potentially contribute to environmental impacts through food, water, soil, and air pollution. Certain processes and management will reduce microbial load, but only one or two orders of magnitude reduction can be achieved with presently used systems. Dr. Sobsey noted that systems designed purposefully to achieve high levels of pathogen reduction are feasible but expensive, so hard choices need to be made. He stated that the EPA CAFO regulation probably is not adequate for pathogens, and there is a need to identify best management practices for pathogen reduction and containment. To address the issue of pathogens from AFOs, a risk-based approach, using risk assessment and risk management, should be applied.

Environmental Concerns Associated With Veterinary Pharmaceuticals
Gregory Beatty, EPA, Office of Wastewater Management

Mr. Beatty presented information that was collected during the revision of the CAFO regulations. The pharmaceuticals of concern are antibiotics and hormones. The potential effect to human health from antibiotics results from the possibility of antibiotics in the food as well as the potential of increasing antibiotic-resistant bacteria. Problems with hormones result from their action as endocrine disruptors that can alter the hormone pathways regulating the reproductive processes of humans and animals.

The primary mechanisms of antibiotic elimination are through the urine and bile. These compounds are believed eventually to be excreted either unchanged or in metabolite form. Little information is available regarding the concentrations of antibiotics in animal wastes or their fate and transport in the environment. A key concern is the potential emergence of antibiotic-resistant pathogens in surface and drinking water. The use of broad spectrum antibiotics is particularly problematic. Normally, 2 percent of normal bacterial populations in animals is resistant to a given antibiotic, but when animals are regularly exposed to antibiotics, 10 percent of the bacterial populations is found to be resistant.

Hormones are used to increase productivity in the beef and dairy industries. A portion of these hormones pass through the cattle and are found in manure. Androgens detected in waterbodies downstream of feedlots affect fish in the water. Hormones also are found in poultry manure but poultry are not fed hormones, so there is speculation that this is naturally occurring. Runoff from fields with land-applied manure has been reported to contain estrogens, estradiol, progesterone, and testosterone. Interaction with organic matter can lead to increased concentration in surface and ground water. Little is known about the degradation processes of these compounds in soil. The effects of these chemicals on the environment and their impacts on human health through environmental exposures are not understood, and studies currently are being conducted to investigate these effects.

FDA Guidance for Environmental Risk Assessment—Veterinary Products
Charles Eirkson, FDA, Center for Veterinary Medicine

Mr. Eirkson acknowledged two colleagues on the FDA Environmental Safety Team in the Center for Veterinary Medicine (CVM), Drs. Eric Silberhorn and Raanan Bloom. FDA has been conducting environmental reviews since the mid-1970s when the National Environmental Policy

Act (NEPA) was enacted. From the 1970s to the 1990s, the focus was on subjective reviews and collection of data in environmental assessments. In the 1990s, there was a shift toward risk-based assessments with a need to calculate the predicted environmental concentrations in terrestrial and aquaculture systems. FDA currently is forming working groups to address this need and would appreciate input from EPA and others. FDA also is participating with the Society of Environmental Toxicology and Chemistry on a workshop on veterinary pharmaceuticals in the environment.

Mr. Eirkson highlighted the ongoing cooperation between the various Offices at the FDA CVM and EPA as well as with USGS, USDA, and FWS. The CVM's Office for New Animal Drug Evaluation worked with the EPA on the Concentrated Aquatic Animal Production Effluent Limitations Guidelines and New Source Performance Standards. FDA's responsibilities in the environment under NEPA are to provide either a categorical exclusion or an environmental risk assessment of all new drugs; however, FDA would need to rely on EPA to enforce standards for new drugs in surface waters under the Clean Water Act. Presently, a Memorandum of Agreement is being developed for review and enforcement of new drugs in the aquaculture industry. There is a potential to extend this agreement to CAFOs

CVM's Office of Surveillance and Compliance works with EPA to determine review responsibilities for various new products. Some joint compliance activities have occurred in regard to pharmaceutical manufacturing and other joint activities are possible. CVM's Office of Research has collaborated with EPA and USDA to investigate antimicrobial resistance issues. In addition, FDA's Office of the Commissioner presently has a committee directed at the presidential level in the Office of Science and Technology Policy addressing the issues of animal and human pharmaceuticals in the environment.

Panel Discussion for Question 5—Have the Needs Been Met, and Are There Remaining Technical Needs?

John Cicmanec, EPA, ORD; Mark Sobsey, University of North Carolina; Mike Meyer, USGS; John Larson; EPA, Region 8; Gregory Beatty, EPA, Office of Wastewater Management; and Charles Eirkson, FDA

Antibiotics

Dr. Elise Striz, EPA NRMRL, wondered if panelists had talked to the pharmaceutical industry and reviewed the literature on treatment. There is a great deal of legacy information on treatment from the pharmaceutical industry. Dr. Striz also asked if National Pollutant Discharge Elimination System (NPDES) permits at the CAFO facilities target antibiotic waste streams and have target levels for antibiotics in their waste streams. Dr. Beatty said that the permits do not include target levels for antibiotics. When developing the CAFO Rule, EPA had very little information on the fate and transport of antibiotics and hormones in the environment.

Dr. Liz Wagstrom, veterinarian for the National Pork Board, asked for clarification from Dr. Cicmanec on the statement that in the European Union (EU) there were only four antibiotics still approved for animal use. She stated that although the four antibiotics mentioned might be the only ones approved for growth promotion, the EU has approved a wide variety of antibiotics for therapeutic use; and therapeutic use has grown 70 to 80 percent since the banning of the use of

some antibiotics for growth promotion. Dr. Cicmanec agreed and did not mean to leave the impression that antibiotics were not used for therapeutic purposes in the EU.

Prions

Mr. Mark Dittrich, Minnesota Department of Agriculture, directed a question to Dr. Sobsey on prions in bioaerosols, asking for details on the previous outbreaks studied and the transmission pathways. Dr. Sobsey answered that there was no evidence for bioaerosol route of transmission; they usually are ingested. He believes, though, that an understanding of the pathways of transmission of prions among animals is lacking. Any agent that might be respired and deposited in the lungs could move back up to the throat and then be swallowed. There is evidence that viruses have been transmitted over long-distance aerosol routes. Mr. Dittrich wanted to clarify that Dr. Sobsey had no information on transmission of prions from elk or white tail deer via air routes in the United States. Dr. Sobsey confirmed that he did not. Mr. Larson commented that, for chronic wasting disease and scrapie, animal-to-animal transmission is a big factor but the mechanism is not known.

Dr. Cicmanec clarified that little is known about prions in the natural host. Much of the work has been done with mouse and hamster models, and these systems are used to test different disinfectant treatment processes. Because of the difficulty of working with these agents, answers must be derived indirectly. He is concerned that EPA wants to classify these agents as microorganisms. Prions are proteins and he is not sure the public is served by classifying them as microorganisms.

Pathogen Dispersal

Dr. Robarge asked for perspective from the panel on pathogen dispersal and agriculture. Dr. Sobsey responded that there has been no research on the potential risks and consequences of exposure to pathogens in animal agriculture. Quantitative microbial risk assessment can deduce the risks, but those assessments will be fraught with high levels of uncertainty. Epidemiologic studies should be conducted to answer the obvious question: Do the most-exposed people have a high level of disease burden that can be attributed to their contact with animals and animal waste? One such study is being planned in North Carolina—a prospective cohort study on potential risks of acquisition of antimicrobial-resistant colonizing bacteria and salmonellosis in swine workers compared with crop farm workers and neighbors of both farms. More funding is needed to determine the risks.

Dr. Alan Kolok, University of Nebraska, noted the regional nature of the problem. In Nebraska, the farmworkers and cropworkers often are the same people, so there is a challenge in disassociating health effects. Another example of this problem is at the watershed scale where fish are affected by CAFOs, sewage sources and row-crop contaminants. Dr. Sobsey acknowledged that there are challenges, but he believes EPA has a lot of experience with such challenges. For example, EPA examined household exposure from multiple agents and through multiple pathways. More advanced mathematical models are needed, and there is a need for stakeholders to help design the studies, but the studies are feasible. Dr. Pickney noted that similar ecotoxicological studies can be done for fish and wildlife response.

Mr. Eirkson wondered about pathogen dispersal effects resulting from the changing nature of agriculture with generally increasing size of farms and increasing AFO concentration in certain parts of the country. Dr. Landy noted that there are a number of reports that the dynamics of diseases are changing as a result of concentration. Dr. Robarge stated that, although this change is occurring, there are and have been vectors all along. Has going to a larger farm triggered a greater risk? Are there data to back that up? Dr. Sobsey acknowledged that there is no information about whether or not there are significant releases from the farm. Increasing the load of any constituent of interest, however, potentially will affect the ability to control a release. Studies are needed to determine if the control methods work well enough to contain the problem.

Dr. Cicmanec stated that there is the capacity to spread diseases to many more animals because of farm size and centralization. Producers are aware that the animal diseases must be addressed quickly to avoid economic loss. Dr. Wagstrom stated that the National Animal Health Monitoring System study showed that all producers, regardless of size, use antibiotics as infection control measures but on larger farms a veterinarian is usually involved.

Hormones

Dr. Steve Hutchins, EPA, NRMRL, highlighted a need for risk assessment of hormones and their analogues. Mr. Eirkson stated that FDA has data online for the environmental assessment of veterinary pharmaceuticals. A few environmental assessments were done on human drugs between 1992 and 1997 and can be obtained by contacting FDA.

Dr. Landy asked whether a drug can be revisited if problems occur after FDA approval. Mr. Eirkson said that for environmental purposes, a drug would only be revisited if there was new action or change in the drug. With regard to public health purposes, FDA does have the power to revisit action on a drug.

Opportunities for Collaboration

Dr. Pat Millner, USDA, mentioned the intricate pathways for spread of antibiotic resistance. She noted that there are existing resources that could address the problem as many state laboratories conduct manure analysis for nutrient management purposes. Other assays could be done on these samples. USGS data exist on where watersheds and streams are located, and clinical data on antibiotic-resistant organisms are available from state health departments. Dr. Millner noted the opportunity to make use of the existing network and data.

Question 6: What is the strength of the evidence that demonstrates linkages between exposures to AFO contaminants and incidence of disease, especially infectious diseases caused by pathogenic organisms originating from AFO wastes (other than acute problems where it is obvious that agricultural runoff has entered drinking water supplies)?

Exposure Versus Disease—Regional Perspective
Stephanie Harris, EPA, Region 10

Dr. Harris is a veterinarian and microbiologist with Region 10 who has been called as an expert witness on human health effects from CAFOs and has accompanied farm inspectors on visits to CAFOs. At the regional level, staff need scientific information to connect outbreaks to causes as

well as to handle the regulatory issues associated with CAFOs. All admit that CAFOs have the potential for adverse human health effects but the information often is circumstantial.

Dr. Harris provided case studies to illustrate the concerns. There were 921 illnesses with 116 confirmed cases of infection by *E. coli* O157:H7 from children active in 4-H activities at the New York State Fair. The source of the infection was believed to be a contaminated wellhead that had tested positive for fecal coliform *E. coli*; however, the source of the contamination was not identified. Possible sources included septic contamination from the 4-H dormitories and animal barnyard runoff.

The second case was *Cryptosporidium* confirmed in a child after visiting a home and ingesting strawberries that may have been contaminated from the spraying of untreated waste on nearby farm fields. Again, the cause was not defined as the child was in day care, which is another source of possible contamination. Epidemiologic study and further testing may have helped clarify the cause in this case.

Dr. Harris would like more background information and access to epidemiologic experts who could assist regions in investigations, better information and guidance on microbial source tracking, and rapid test methods. In addition, regulatory issues impact the ability of regional staff to perform their duties. She is concerned that the changes in NPDES regulations may not be protective of public health and may cause extra difficulty for inspectors.

Health Concerns Associated With Airborne Exposure to AFO Contaminants
Charles Purdy, USDA, ARS

Dr. Purdy's research objectives are to provide information on the aerosolized contaminants in AFOs that can affect human health, focusing on identifying the contaminants, their sources, and the amount that causes sickness. The challenges for this research include the fact that aerosols are complex substances with multiple methods for measuring them, there are few aerosol standards, and individuals vary in their sensitivity to the contaminants that may occur in aerosols. Feedyard dust is the major complaint of downwind neighbors, and agricultural dust is regulated by EPA and state authorities. The health conditions associated with aerosol contaminants include allergic hypersensitivities, organic dust toxic syndrome, endotoxin inflammatory reaction, byssinosis, and possibly infections.

Dr. Purdy presented research data in which air samples were collected around animal feedlots and analyzed for PM_{10} and $PM_{2.5}$ particles, bacteria, and fungi. In his study, 19 gram-positive bacterial genera were identified, along with only a few gram-negative bacteria. No culturable gram-negative enteric bacteria were found in the dust samples. PM_{10} and $PM_{2.5}$ measurements were significantly higher downwind of the feedlots and also were found to be higher in the summer than in winter months.

Dr. Purdy also explored the effect of manure dust on sheep and goats and attempted to deduce the reaction of animals to the endotoxins in the dust. The experiment included both coarse and fine dust and used different treatment methods to separate the effects of the particle from the effects of the endotoxins. Endotoxins are present in AFO coarse and fine dust and are not affected by autoclaving. These endotoxins cause inflammatory reactions in both humans and

animals. Hypersensitive allergic reactions can follow fine dust inhalation, and this fine dust is more toxic to humans and animals than coarse dust.

Infectious Diseases That May Be Transmitted to Humans From Animal Feeding Operations
John Cicmanec, EPA, ORD, NRMRL

Dr. Cicmanec's group researches the hypothesis that the field application of animal waste increases the risk of waterborne and foodborne diseases. Domestic animals are the major reservoir for the major foodborne disease causing organisms, *Salmonella* spp., *Listeria monocytogenes*, *Campylobacter* spp. and *E. coli* O157:H7. Dr. Cicmanec noted that there are many published cases in which outbreaks were caused by animal pathogens or manure runoff. The data are not as complete as for chemical risk assessment, but EPA does not spend as much money on this issue as it does on chemical risk assessment. Dr. Cicmanec believes that the evidence from chemical risk assessment does not show as many deaths as can be attributed of waterborne pathogens from animal sources.

Dr. Cicmanec participates in a microbial risk assessment group for food that has members from FDA, CDC, and USDA. He encouraged EPA to be more involved in this group. He briefly presented information about the problems and risks of waterborne pathogens and noted that much of the information came from a World Health Organization conference on the subject. There is a wide range of infective doses for different organisms. Low infective doses result in the need for high control and treatment methods. He noted that microbial risk assessment is complicated because of the interaction of numbers of organisms and the presence of other organisms.

Dr. Cicmanec presented some ORD recommendations for treatments in the CAFO regulations (e.g., facultative lagoon storage, windrow composting, and anaerobic digestion). Some of these are low cost options, but they do have similarities to Class B Sludge Treatment Processes. Dr. Cicmanec noted that an issue that may need to be addressed is whether animal waste treatment should be examined in the same manner as human waste treatment.

Dr. Cicmanec described a system to assess movement of pathogens in a stepwise manner and treatment effects on risk for a variety of pathogens from biosolids. There is a need to acknowledge that the ability to predict outbreaks underestimates the actual number of infections because for many diseases the ratio of reported cases to actual number of cases is very high.

Investigating Disease Outbreaks Associated With AFOs
Presented by John Cicmanec, EPA, ORD, NRMRL for Gunther Craun, Gunther F. Craun & Associates and Rebecca Calderon, EPA, ORD, NHEERL

The epidemiologic methods are well established and available to link exposure to contaminated water or pathogens and illness; however, many outbreaks can go unnoticed if cases are not detected. Waterborne outbreak data are available from EPA and CDC, and this information can help identify problems that may need regulation or changes in monitoring and current operational practices. There are limitations in these data, as outbreaks are voluntarily reported and disease surveillance activities may not be adequate to detect all outbreaks. In addition, endemic or non-outbreak waterborne risks are not included in the outbreak data. There is a

continuum of disease from asymptomatic infection and mild illness to death, and not all infections cause illness that can be detected by current surveillance activities.

Of the outbreaks of known etiology reported from 1971 to 2000, slightly less than half of the drinking water outbreaks and more than three-quarters of the outbreaks associated with untreated recreational water were caused by zoonotic pathogens. The zoonotic pathogens associated with outbreaks include *Giardia*, *Cryptosporidium*, *Campylobacter*, *Salmonella*, *E. coli* 0157:H7, and *E. coli* 0121:H19.

Specific events such as heavy rains or seepage of sewage combined with inadequate water treatment or operation have been responsible for an outbreaks. Investigations also have identified wild or domestic animals as the likely source of contamination in a number of outbreaks. However, information is not available in the outbreak database to determine whether AFOs contributed to water contamination. To assess outbreak risks associated with AFOs, there needs to be better surveillance to detect outbreaks, more complete investigations of sources of contamination, and improved laboratory capabilities to provide information about additional zoonotic agents and possible animal sources. A thorough outbreak investigation should be conducted by a multidisciplinary team of epidemiologists, engineers, and microbiologists. It is also important for risk assessors to develop lines of communication with local health agency officials who conduct disease surveillance and investigate outbreaks.

Perspectives on the Science: What Do We Know, and What Do We Need To Know About Microbiological Risks of Food Animal Production?
Ellen Silbergeld, The Johns Hopkins University School of Public Health

Dr. Silbergeld is an epidemiologist and professor of environmental health sciences and health policy. She focused her presentation on the human impacts from pathogens but recognized that zoonoses are important issues for the agricultural industry and the environment. From a perspective of public health and epidemiology, the focus of concern is emerging pathogenic diseases and antibiotic resistance. The effects from these problems are not just death from infection but also long-term autoimmune-mediated impacts on human health from organisms, such as *Chlamydia* and *Campylobacter*, that are found in and around AFOs.

All uses of antibiotics inevitably select for resistance, and the same classes of drugs are used in food animal production and clinical medicine. The crowding of animals within confinements, with often suboptimal hygiene, facilitates the emergence and spread of drug resistant infections, in a manner similar to the spread of disease where humans are crowded together. The conditions of widespread, prolonged exposure to antibiotics at sublethal doses with little dose control in CAFOs compounds these problems. There is a variety of evidence on the relationship between use of antibiotics and the emergence of antibiotic resistance. Dr. Silbergeld presented an example from Spain that showed the temporal relationship between the introduction of fluoroquinolone for poultry use and the development of quinolone-resistant human isolates of *Campylobacter.*

The tools for microbial tracking at a molecular level have long been employed in the molecular epidemiology of human infectious disease outbreaks. The tools are available, and there needs to be a way to share them.

Dr. Silbergeld suggested that the hazard has not been adequately defined. She proposed that the problem is the flow of resistance genes among species or integron-mediated resistance determinants that have many routes of exposure and transfer in the environment. She presented data from her research group that indicated that this is a prevalent issue in poultry and poultry litter in the Delmarva region of Maryland. The results of her studies show that workers who handle live chickens are at risk of exposure to bacteria from poultry, and these bacteria often are drug resistant. In addition, studies found that arsenicals are compounds of great concern that are used extensively in broiler feeding operations and have been shown to contaminate groundwater.

Dr. Silbergeld addressed the use of available population-based surveillance methods. She acknowledged that it is only worth investing in the control of antimicrobial resistance from AFOs if AFOs are a significant part of the problem. There is no active surveillance in this country for antimicrobial resistance. The existing passive monitoring programs (NARMS and FOODNET) are incomplete in their coverage and have systematic biases to assume a foodborne route. A high priority must be placed on collecting data to ascertain the risks from AFOs. Chemical risk assessment cannot be used to assess microbial risks because the issues of multidrug resistance, microbial reservoirs, horizontal gene transfer of resistance determinants, and the ranges of infectious doses resulting from various host characteristics are not a part of the models for chemical risk assessment. Funding is needed to incorporate the insights of molecular and population microbiology in developing biologically based risk-assessment methods for microbial issues.

Panel Discussion for Question 6—Have the Needs Been Met, and Are There Remaining Technical Needs? What Are the Critical Questions That Need To Be Answered To Move Beyond the Rhetoric Associated With This Issue?
Liz Wagstrom, National Pork Board; Paul Martin, Western United Dairymen; Ellen Silbergeld, The Johns Hopkins School of Public Health; Charles Purdy, USDA, ARS; Mark Sobsey, University of North Carolina; John Cicmanec, EPA, ORD, NRMRL

Introductory Comments by New Panelists

Dr. Liz Wagstrom, veterinarian and epidemiologist with the National Pork Board, shared some of the pork industries' priorities in the area of microbial pathogens. The industry recently funded studies on the effects of small amounts of antibiotics in water on the development and persistence of resistance and is conducting a critical literature review on the subject of fate and transport of zoonotic pathogens and antibiotic resistance within manure-storage structures and after land application. She provided a list of ideal characteristics of research studies, including the importance of proper controls, the need for risk-based assessments, and the need for more information on deep pits and incorporation practices utilized in the Midwest.

Mr. Paul Martin of Western United Dairymen in California stated that the dairy industry is committed to food safety and a safe livestock industry; however, they recognize the public is easily frightened. To move beyond the rhetoric, Mr. Martin suggested addressing how information is presented, blending individual studies into a practical systems approach to be applied on the farm, and examining the economic system under which farmers operate.

Air Sampling

Mr. Secrest asked if there is a method for sampling airborne bacteria that does not bias the sample. Dr. Silbergeld referred to her colleague's poster and noted that one concern is the large amount of particulate matter that may mask detection of bacteria. In addition, differential sampling schemes may be required to collect information on the fate of respirable bacteria in humans and animals.

Pathogens and Well Water

Dr. Mark Risse, University of Georgia, noted that many farm families depend on wells for their drinking water. The wellhead protection program samples for nitrate in the water but not for pathogens. Is nitrate an indicator of pathogens in the water? Dr. Sobsey responded that the presence and concentrations of pathogens cannot be predicted based on the presence of nutrients. It is possible that nutrients and pathogens would both be detected in contaminated water but they are not correlated. It is not expensive to measure indicator organisms as a first cut. One out of six Americans drink unregulated groundwater and would have no information regarding well contamination. Surveys in the 1960s and 1970s found high percentages of contaminated wells. Dr. Silbergeld noted that coliform testing is inadequate to accurately assess the risks of pathogens in well water as studies by Dr. Sobsey and others have shown. It is possible to perform rapid DNA-based detection methods, as is done in clinical laboratories.

Ms. Johnson supported the monitoring of well water. She believes that, at a minimum, total coliform should be tested and if there are positives, test for *E. coli* and Enterococci. These tests are inexpensive, and little training is needed to conduct them. Laboratories also can ribotype *E. coli* to provide information on the source of contamination. From a regional perspective, it is necessary to work with the tools that are available.

Dr. Showers, North Carolina State University, commented that both nutrient and pathogen transport are driven by hydrological events. If continuous detection methods are not employed, events will be missed. For example, after the hurricanes in North Carolina, there was contamination of poorly maintained wells from water running into the wells from the surface. Dr. Showers proposed a stepwise approach in which nitrate contamination is assessed. ^{15}N is used to see if the nitrate is associated with waste, and then more expensive tests for pathogens could be performed. Dr. Sobsey agreed that there would be much to gain from microbiologists and geochemists working together. Linking together their efforts could provide new opportunities and tools.

Testing for Antimicrobial Resistance

Dr. Moorman noted that there are a variety of ways to test for microbial resistance, but there are no consensus methods for detecting integrons. Guidance is needed regarding what is acceptable. Dr. Silbergeld noted that in the clinical field there is rapid development of consensus methods for measuring resistance determinants; there needs to be close crosstalk with clinical research.

Education for Farm Workers

Dr. Sobsey stated that there may be a need to increase understanding and education among farm families and workers of the basic steps for infection controls, such as hand washing, management of clothing, and extent of contact with family before cleaning up. Dr. Wagstrom indicated that the National Pork Board is developing a program on worker and community health utilizing existing worker safety material. One issue is understanding the barriers to workers' utilizing protective gear. Dr. Wagstrom stated that it is already a requirement in many swine facilities to shower into and out of the barns and that barn-specific clothes never go outside of the building.

Hygiene

Dr. Wagstrom responded to Dr. Silbergeld's comment regarding suboptimal hygiene of CAFOs. Dr. Wagstrom explained that the design of swine CAFOs' multisite production with separate breeding, nursery, and finishing herds, maximizes the health and hygiene of animals by keeping together cohorts of animals of the same immune status and age. All animals are moved together, and, between groups, the barns are washed and disinfected. It is not unusual for microbial testing to be conducted in these barns. Most of the barns have slotted floors where the waste drops away from the animals to holding pits. It is easier to clean barns today than in the past. Dr. Silbergeld responded that storing waste underneath living animals is similar to having hospital patients lying on top of their own bedpans. She mentioned studies of samples taken from many different types of CAFOs after the standard disinfection processes, in which pathogens and drug-resistant pathogens were recovered. Increased AFO hygiene practices in Scandinavia achieved the same growth rates as were achieved with the use of subtherapeutic levels of antibiotics. Dr. Silbergeld admitted there is progress to be made in hospitals also, but she emphasized that the situation of confining host animals with their waste is conducive to generation and transmission of serious and emerging infectious diseases. Dr. Wagstrom reiterated that barns are easier to clean now and progress has been made.

SESSION IV—RISK MANAGEMENT

Question 7: What extra tools (i.e., models and software) are available to farmers, watershed authorities, consultants, and other stakeholders that can help them identify specific conditions (e.g., weather, soil type, and hydrogeological characteristics) and geographical locations where animal feeding operations would present a higher risk to water quality?

Risk Management—National Perspective

Al Havinga, EPA, OECA

Mr. Havinga works for the Office of Compliance, Agriculture Division. He presented information on the needs of inspectors and permit writers to implement the CAFO Rule. It is estimated that 18,500 CAFOs will need permits in the next year or two under the CAFO Rule. The process is being driven by permitting, compliance, and nutrient management plan deadlines in 2006. The 2003 CAFO Regulation required NPDES permits for all CAFOs, and land application discharges are limited primarily through BMPs, with state technical standards addressing land application when the soil is saturated, a large rainfall is forecast, or the soil is frozen or snow covered.

Some tools that were produced for this rule include the *Producers' Compliance Guide for CAFOs*, the *NPDES Permit Writers' Guidance Manual and Example NPDES Permit for Concentrated Animal Feeding Operations*, technical training, and checklists and updates on the national databases for permit and compliance tracking. OECA also will develop and implement training sessions and performance measures and define compliance and significant noncompliance for facilities such as CAFOs. From 2005 to 2007, OECA will focus on CAFOs using compliance assistance tools, incentives, inspections, and enforcement activities to assist state capacity. This will be a priority until 95 percent of the CAFOs are permitted, 80 percent of the CAFOs comply, and 95 percent of the CAFOs are inspected.

To meet the implementation priorities, there is a need to know where the CAFOs are located. Soil and manure testing may need to be standardized. Inspectors need tools to easily determine adequate storage, sufficient land application area, and nutrient balance. Tools that target where compliance assistance and permitting or inspecting CAFOs would provide the greatest environmental benefit are needed along with research that allows for measurement of environmental quality. Future TMDLs and nutrient water quality criteria will require teasing out the pollution reduction portion from CAFOs.

Tools for Managing Risks to Water Quality
Steve Jann, EPA, Region 5

Mr. Jann focused his presentation on issues surrounding land application of manure. Significant policy advances have allowed for progress, including the Unified National Strategy for AFOs, the clean water regulations for CAFOs, the NRCS Conservation Practice Standards, and the *NPDES Permit Writers' Guidance Manual and Example NPDES Permit for CAFOs*. Three aspects have been addressed in these documents to minimize the risk of runoff and discharge by limiting application of manure on saturated soil, when a significant rainfall is forecast, and in the winter and on frozen ground.

To help permitters and farmers decide if the soil is saturated, there are tools such as NRCS available water capacity and antecedent moisture condition measurements. For forecast rain events, tools include the National Weather Service forecasting and either the NRCS equation for net storm rain or the tables in Appendix L of *Managing Manure Nutrients at CAFOs*. Runoff from liquid manure application on frozen soil can be calculated using an adjustment to the equation for net storm rain or taken from values published in Appendix L of *Managing Manure Nutrients at CAFOs*, tables 1a and 1b. To evaluate the risk of runoff in melted snow, Appendix L combines data on biological oxygen demand (BOD) in runoff from manured land with NRCS hydrology equations, and an overland flow treatment equation.

Region 5 needs information that would enhance Appendix L, such as data on BOD of runoff from different types of manure and research on the nonsettleable fraction of BOD in manure and wastewater. Data exist for waste from mature dairy cow operations, swine facilities, layer houses, and broilers, but no data are available on other types of farming operations. Further refinement of the hydrology equations incorporating information on crop residue greater than 20 percent is needed along with information on the effects of solid manure application on runoff curve numbers. New and better tools are needed that incorporate climate data in calculating the storage capacity required to meet land application standards and avoid overflows. In addition to

storage issues, research is needed to assess and minimize the risk of liquid manure or wastewater discharge via subsurface drains in areas, such as Region 5, where tile drainage is a reality.

Risk Management and Water Quality: State of the Science
Tom Hunt, University of Wisconsin

Dr. Hunt provided background on the definition of risk and risk management and briefly explored the aspects of knowledge, tools, actions, and communications needed for assuring an outcome through risk management. There are simple models that prioritize which risk to address first by assessing potential impact and the probability of something happening. Available tools are imperfect predictors of agricultural impacts. There are multiple models, and the more research that is done, the more accurate, applicable, and practical the models can become. Dr. Hunt noted that there is a management component that needs to be assessed in determining whether or not a farm can meet environmental standards. There are farms that appear to be likely candidates for environmental problems, but because of good management, they do not have problems.

Dr. Hunt provided background on the Wisconsin Buffer Initiative that is examining the issue of setbacks along the riparian zone, addressing issues such as whether or not there should be uniform or variable setbacks and whether riparian buffers should be targeted to certain areas. The project looks at a variety of spatial scales and uses research and data collection in addition to the tools of risk management.

As in many other areas, phosphorus is accumulating in the soil in Wisconsin, and there are phosphorus management guidelines using soil test P thresholds or the Wisconsin P Index. A tool called SNAP-Plus will be made available to farmers to allow them to calculate P Index. Dr. Hunt's group also is utilizing the Precision Agricultural Landscape Modeling System (PALMS), which combines a soil and canopy model with a diffusive wave model for distributed runoff. This system has been applied to farms in Wisconsin and allows determination of the best buffer placement, which may be more effective than applying a standard setback. The model also could be applied to a watershed level.

Dr. Hunt provided information on work being performed at Pioneer Farm in Wisconsin. Pioneer Farm is modeled after a farm in the Netherlands and is the result of agricultural groups in Wisconsin realizing that they need to be proactive in addressing issues and problems related to agriculture. Long-term soil test data for phosphorus are available and the farm has multiple runoff monitoring stations set up in collaboration with USGS throughout the 430 acres of the farm. The data collected are used to calibrate and validate the models. There is high correlation between sediment load and total P load. There are effects of the cropping system on the total P load. This research also measures the impact of winter manure applications at their sites.

On the Pioneer Farm, a P Index value has been determined for all fields. The system of single-crop subwatersheds and paired watersheds allows for calibration and testing of assumptions in the P Index. In general, the P Index is more conservative than actual measurements, and Dr. Hunt believes that is good. This relationship did not hold, in one instance, and this exception showed the challenge in dealing with events that cause channelized flow and gully erosion. How can such events be regulated, and how can policy and BMPs be adapted to address such events? There is a low correlation between the P Index and soil test P values though correlation between

actual P load and the P Index is better. There still are questions about what various numbers mean and the relevance of the numbers, but Dr. Hunt is optimistic that the Wisconsin P Index is reliable.

Dr. Hunt showed three-dimensional mapping of parts of Pioneer Farm to highlight ArcGIS and ArcInfo as communication tools with the potential for wide applicability, such as illustrating and tracking contamination of water from AFOs. These tools could be used effectively to communicate with local and state politicians and regulators regarding funding and regulatory concerns.

Panel Discussion for Question 7—Have the Needs Been Met, and Are There Remaining Technical Needs?

Steve Jann, EPA, Region 5; Al Havinga, EPA, OECA; Rick Wilson, Ohio Environmental Protection Agency; Ray Massey, University of Missouri—Columbia; and Tom Hunt, University of Wisconsin

Introductory Comments by New Panelists

Mr. Rick Wilson of the Ohio EPA introduced himself as a CAFO inspector. He emphasized the importance of communicating with farmers about the regulations as well as management practices that prevent pollution. He brought information from a workshop on preferential flow in subsurface drains that includes a PowerPoint presentation and video that describe how manure enters drainage tiles and the potential of earthworm burrows as a mechanism of transport to subsurface drainage.

Dr. Ray Massey is an agricultural economist from the University of Missouri. He developed tools to help farmers view environmental risk from a variety of management options. Questions to be addressed include: What critical success factors should farmers be addressing? What information is needed for farmers to be successful in management, and how do farmers use this information to make decisions?

Winter Manure Spreading Issues

Dr. Striz asked about the potential for including crop condition and management among the risk factors for land application. She noted that farmers apply manure to land in the winter to meet freeboard requirements because they do not get evaporation off lagoons in the winter. Mr. Jann answered that the hydrology references do allow for input of crop residue cover. In the winter in the north, it is likely that no crops are growing so this has been factored into the equations. Winter spreading has a clear risk of nutrient and manure runoff from snow melt, but it also has been a long-standing agricultural practice. The models were developed because there is a need to make judgements about the safety of land application in the winter while taking site-specific conditions into account. EPA does not prohibit winter spreading but has required states to develop standards on nutrient management including standards that would apply in the wintertime.

Dr. Mark Powell, USDA, Dairy Forage Research Center, requested the panel's perspective on factoring the realities of farming situations in the upper Midwest into risk equations along with manure management restrictions on wintertime spreading. Much of the manure spreading done

in the winter on frozen soil is a result of the reality that wintertime is when farmers have time and labor available to do that task. Mr. Jann stated that the comment highlights that there are different needs for different farmers and different farms. It is important to balance compelling farming needs with the broad needs of the public and the environment. Such needs might be accommodated by choices regarding location and methods of application.

Dr. Massey noted that the goal should to reduce the probability of risk, for example, building a larger storage area so manure does not have to be spread in the winter. There needs to be flexibility in the system to meet an objective. Dr. Massey has done research looking at how farmers make decisions about wet weather events. He learned that the freeboard limit is a hard and fast rule that farmers will not break, even though there may not be an environmental risk associated with exceeding the freeboard limit. Farmers will spread manure on the land, which may or may not have environmental consequences, if they believe they have no flexibility in their freeboard limit.

BOD Versus TOC Measurements

Dr. Robarge commented that analysis of BOD measurements is time consuming and expensive. He and his colleagues use total organic carbon (TOC) measurements. Can TOC be substituted for BOD? Mr. Jann noted that the literature on oxygen demand in runoff used chemical oxygen demand (COD). The equation required input for BOD, so a conversion was made to allow 5-day BOD to be equated to total BOD, which was considered analogous to COD.

P Index

Dr. Robarge said that his research group developed its own P Index. He asked the panelists to comment on other P Indexes, their confidence in the indices being used, and the indices' applicability for decision making. Dr. Hunt believes the P Index is a good risk analysis tool and predictor in the upper Midwest. The work done to calibrate the Index was extensive and now his group is working on validation with good preliminary results. Dr. Brad Joern, Purdue University, clarified that the P Index is only a relative ranking of the suitability of fields for manure application.

Air Emissions

Ms. Daphne Wilson, EPA, Region 4, asked how the CAFO Rule implementation and NPDES permitting addressed effects on air emissions. Mr. Havinga stated that, though the issue was raised, there was not enough information on the air aspects when the rules were being considered to address air concerns. Presently, many of the regulations are "stovepiped," with separate rules for surface water, air, or drinking water. Mr. Havinga believes there is an opportunity to examine broader risk assessment analysis; however, there may be limitation in the way EPA receives authority from Congress.

Priority Watersheds

Dr. Risse inquired about the definition of priority watersheds. Mr. Havinga responded that it is up to each region to establish a set of priority watersheds. This would include a set of regional

criteria to look at CAFOs that would be different than for combined sewer overflows or stormwater. Regions need to send their lists to headquarters by April 2005.

Research Needs

In closing, Ms. Lemoine asked the panelists to briefly address the next steps needed for tools:

- Mr. Jann wanted additional measurements of constituents, such as pathogens and BOD, in runoff where manure has been applied.

- Mr. Havinga noted that many tools are available. Perhaps applications of existing tools can be developed in new areas for new users.

- Dr. Hunt cited the needs to define the problem more clearly, ensure integration of the system to include all aspects of the environment, understand what the public is willing to pay, and obtain a better understanding of what is happening in the water column.

- Mr. Wilson stated that, from a TMDL standpoint, there is a need to demonstrate reduction in nitrogen and phosphorus. There may not be enough data or sampling capability to measure such reduction. He questioned if the technical standards are sufficient to provide the reductions needed.

- Dr. Massey encouraged the use of a systems perspective to examine total environmental quality standards that include the science knowledge and an understanding of how people use information and make decisions.

SESSION V—MANURE MANAGEMENT

Question 8: What are the most effective strategies and practices for minimizing the movement of pollutants from animal confinement areas, manure storage areas, and land applications of manure into surface and ground water and limiting emissions into the atmosphere? Include:

a. **How reducing entry into one media may affect loadings into other media;**
b. **For land application of manure, how pollutant movement is affected by: (1) the form and amount of manure that is applied; (2) the timing, location, and method of application; and (3) the presence or absence of tile drainage systems in land application fields; and**
c. **Consideration of the costs and ease of implementation of the identified technologies and practices.**

Regional Perspective
Abu Senkayi, EPA, Region 6

Dr. Senkayi was not able to attend the meeting.

Manure Management—National Perspective
Roberta Parry, EPA, Office of Water

Ms. Parry presented the EPA Office of Water's national perspective on the various manure management methods. The methods can be divided into production and land application areas. Many of these items are listed in the CAFOs regulations. Because of the site-specific nature of AFOs, Ms. Parry is not sure that there can be one national tool. An effective strategy needs to balance items such as animal type, waste collection system, economics, available land, and the pollutant of concern. More than 160 NRCS Conservation Practice Standards exist and the CAFO Rule allows for innovative techniques, but the ability to determine compliance is needed.

There are so many combinations and possibilities for manure management that inspectors may not be able to assess them adequately. The major variables in any plan are the manure test, the application equipment, and the application method. Inspectors can assess if soil and manure tests are being performed; if there is enough land for manure application based on nitrogen and phosphorus parameters; and if any visible practices, such as buffers and residue management, are present. The issue of manure management also can be explored from an educator or policymaker perspective. For educators, areas such as basic landscape practices, manure and soil testing, and feed management can be addressed. On the policy side, feed content, decision-making tools, and incentives can be developed to assist producers in managing manure.

It is important to direct solutions to the proper level. Producers may not control many aspects of waste production, handling, fate, and transport, such as feed, climate, topography of the watershed, and availability of land and labor. It may be necessary to step back from a specific farm scale to a total watershed approach that requires broader solutions.

State of the Science
John Haines, EPA, ORD, NRMRL

Dr. Haines discussed the status of the reduction of pollution transport with regard to manure management. There are multiple pollutants of interest including soils and sediments, phosphorus, nitrogen, and microorganisms. A literature search revealed ranges of reduction based on two types of control: vegetative buffer strips and wetlands. Removal of nitrogen, phosphorus, and sediments by vegetative buffer strips ranged from 18 to 99 percent, depending on the study and pollutant of interest over a range of slopes and widths. Removal of nitrogen and phosphorus by wetlands ranged from 38 to 73 percent, again depending on the pollutant of interest over a range of slopes and widths. Microorganisms can be filtered using vegetative buffer strips and wetlands. For water quality purposes, however, the level of removal needed is so high (99.9999 percent) that it cannot be achieved without harsh methods.

The existence of tile drains will affect pollutant transport, and research has established a zone of influence that is about 1 meter wide at the soil surface. Extensive research on the land application of manure with respect to nitrogen and phosphorus content provides a broad range of values for both liquid and solid manure as well as by animal type. For some types of animal waste, the amount of land needed for proper application to reduce pollutant transport is prohibitive. The literature research supported the importance of timing, with respect to seasonal and rainfall parameters, and location, particularly with regard to setback from water courses.

The research also revealed mixed pros and cons from both surface and incorporation application methods.

Integrated systems combine two to four management practices to get stepwise improvement of waste treatment. Manure storage of 6 months to 1 year prior to land application can reduce microorganism load by three or four orders of magnitude and may reduce nitrogen losses; however, there may be some tradeoff with nutrients and the air. When vegetative buffer strips are applied above wetlands, there is a reduction in sediment, microorganism, and phosphorus transport. The system can be engineered to encourage denitrification and to provide limited groundwater treatment. A more expensive system could be composed of a methane digester and solids composting followed by land application. Such a system would reduce the mass of the waste and the microorganism load as well as generate energy. A final example given combined lagoon storage prior to land application with vegetative buffer strips and wetlands as treatment methods after land application. The utility of this system is highly dependent on the topography of the land. It can reduce nitrogen, phosphorus, and microorganisms, and modifications can be made to recover methane.

Dr. Haines cited research needs regarding the evaluation of integrated manure management systems. Different levels of analytical methods are needed to address microorganism tracking from simple indicators to methods for exact pathogen and source identification. Nitrogen and phosphorus movement has been well studied and modeled, but there is a need for the same information on pathogen fate and transport.

Question 9: What are the best alternative uses of manure, other than land application?

Alternative Uses of Manure Other Than Land Application—Regional Perspective
Hank Zygmunt, EPA, Region 3

Mr. Zygmunt is the agricultural advisor in EPA Region 3. Each regional office has an agricultural advisor and workgroup that partners with agricultural organizations and others. He reviewed current trends in the livestock industry, including integration and concentration of animals and concentration of manure in fewer watersheds. EPA and many USDA programs are addressing their efforts at the watershed level. The impetus for alternative technologies is a number of problems, such as excess manure nutrients, limited amount of land, and concentrations of AFOs. Other drivers include water quality, public health impacts, and regulatory actions such as TMDL and CAFO regulations.

Alternatives can be separated into three areas: (1) conversion to value-added product; (2) conversion and use as an energy source; and (3) innovative and emerging technologies. A report on the EPA Web Site entitled *Alternative Technologies: Uses for Manure* provides details on this subject. Mr. Zygmunt highlighted a plant coming online in Benson County, Minnesota, that has a long-term contract with turkey growers to receive waste for electricity production. Mushroom cultivation using horse manure is an alternative to land application in Pennsylvania. There also is interest in pursuing discussions on the use of manure for soil reclamation in brownfields and coal mine areas.

Mr. Zygmunt summarized various alternatives being tried in the Region 3 states of Pennsylvania, Delaware, Maryland, West Virginia, and Virginia, including energy harvest grants for anaerobic

digesters, transport mechanisms for alternative uses, and pelletizing plants. The success of alternatives depends on public perception, awareness, and support; planning and selection of technology; and policies and supportive programs. Many alternatives are being discussed, but they need to be verified from both a technology and an economic standpoint. The sustainability of the livestock and poultry industry must be factored into the discussion of viable options.

Alternative Uses of Manure—National Perspective
Roberta Parry, EPA, Office of Water

Ms. Parry provided an overview of the alternative use categories, the major incentives and impediments to alternative uses, success stories, and reasons for failures. Although many alternative uses, such as energy, feed, and some nonagricultural uses, have been proposed for manure, the vast amount of the waste is, and will continue to be, applied to land. The incentives for investing in alternative uses result from state and federal regulation, citizen suits, government subsidies, and industry expansion. Lack of markets, along with the cost of the technologies, will continue to be major impediments to alternative uses, particularly in areas of manure use for energy and soil amendments.

Alternatives have been successful when there was a guaranteed market for the product and the system was based on a strong business plan and not a subsidy. Energy uses are successful if there is an on-farm use for the energy as in swine nurseries, dairy operations, or greenhouses. Although pollution prevention has not received much attention as an alternative use, it can be very effective and more emphasis should be given to this area. Failures of alternatives often are related to lack of markets and cost issues of reliance on subsidies and cost-sharing or grants that do not allow for long-term sustainability of the product.

Ms. Parry concluded by emphasizing that the entire environmental impact should be assessed, as alternative uses are not necessarily superior and include concerns such as air quality emissions from transportation, composting, and co-firing; soil quality concerns of compaction from land application; and water quality concerns regarding nutrient and other residuals from manure uses.

What Are the Best Alternative Uses of Manure, Other Than Land Application?
Frank Humenik, North Carolina State University, Center for Manure Management

Dr. Humenik noted that historically, animal waste was returned to the land for sustainable agriculture. Today, increasing public concerns and regulations are pressuring producers to find alternative uses for animal waste, especially for high-phosphorus wastes such as poultry and lagoon sludge. There are economic and environmental implications when the land application of manure is constrained. He emphasized that the goal of the future should be for conservation and utilization of valuable animal wastes, including processing and marketing of manure to alternative valuable byproducts for off-farm use, to reduce environmental impacts, meet societal needs, and protect natural resources for future generations.

Manure management systems have changed over the history of agriculture from land application to storage in lagoons to treatment. Dr. Humenik noted that treatment often results in loss of natural resources by conversion to nitrogen gas and carbon dioxide. Lagoons have changed during the last 30 years as storage requirements and leakage regulations have increased. Covering of lagoons allows for odor reduction and nitrogen conservation.

In North Carolina, the Attorney General entered into agreements with Smithfield Foods and Premium Standard Farms for the development of environmentally superior waste management technologies for swine waste. These technologies are compared to the lagoon spray irrigation field systems used commonly in North Carolina and must meet permit and technical requirements and be economically feasible. Eighteen technologies are being evaluated and 10 of them fall under alternative utilization. Many of these technologies are advanced beyond what is used for industrial waste or being adapted for animal waste. Technologies must be assessed for applicability for local conditions. Alternatives must be presented so farmers can choose what is best for their situations. Dr. Humenik presented an example of a farmer who uses an ambient temperature anaerobic digester for methane production, which is used for electricity production, and lagoon effluent to fertilize tomatoes in a greenhouse. The system allows for swine waste treatment and bioresource recovery.

Dr. Humenik believes that the best alternative use is "designer" manure that has reduced volume, moisture, odor, and pathogens as well as increased constituent content. Most of the nitrogen is in the urine, and most of the phosphorus is in the fecal matter; if the two can be separated, resources can be conserved and converted.

Technology is not enough. Business feasibility tools, such as market, customer needs, and target costing analysis, are needed to evaluate potential products, revenues, and markets. There are many potential byproducts that could be used but economic feasibility must be assured. National coordination is important. The National Center for Manure and Animal Waste Management provides white papers and research, the Livestock and Poultry Environmental Stewardship Curriculum provides information and educational tools, and EPA's Environmental Technology Verification program provides information on whether equipment works for animal waste. Dr. Humenik reemphasized the need for both conservation and utilization of these important natural resources.

Biodiesel/Smithfield Manure Management Programs
Garth Boyd, Smithfield Foods, Inc.

Dr. Boyd stated that Smithfield Foods traditionally was a meat processing company but, in the last 5 years, has obtained beef and pork production companies. The ideal treatment technology would utilize the energy and nutrients in manure while reducing air emissions, odors, and pathogens. There have been many failed technologies and few sustainable ones. Smithfield Foods has invested heavily in a technology called BEST BioFuels. Before showing a 7- minute promotional DVD that highlighted the BEST BioFuel program at Circle 4 Farms in Utah, Dr. Boyd described Circle 4 Farms, which is a 40,000 acre property in the high desert of Utah that sells 1 million pigs a year. This unique situation provided the opportunity for a system where manure could be piped from 23 farms to a central location with digesters. Dr. Boyd noted that this situation is not characteristic of what takes place at other locations owned by Smithfield Foods. Processing waste from the 300,000 animals at Circle 4 Farms accounts for only 2 percent of total annual production in the United States for Smithfield Foods. The economic test for this technology has not been met as the company is just beginning construction of a biodiesel plant that will accept the biomethanol produced.

Technologies at Premium Standard Farms
Matt Gabris for Dave Townsend, Premium Standard Farms

Mr. Gabris presented information on the Crystal Peak Technology that Premium Standard Farms is implementing with a $9.6 million investment on a 107,000 finishing hog operation. This is a big risk for Premium Standard Farms, even though there is a contract with J.R. Simplot that guarantees a market for the fertilizer product for 3 years. The plant represents about 5 years of research and development for the company, with help from North Carolina State University and other universities. The fertilizer quality of the end product is high, with a 12-8-8 NPK ratio containing 30 to 40 percent slow release nitrogen with no odor, pathogens, or heavy metals issues. The end users will be golf courses and horticultural users across the United States, and positive comments have been received in the field trials.

The plant is under construction on a site in northern Missouri. It includes central piping of solids from an internal recirculation process in the barns to the anaerobic digesters; a drying process that provides granulation and air pollution control; and brine and water recovery through a unique freeze/thaw process. It is estimated that the plant will break even in 10 years at current product pricing. The product has many advantages, but there is a need to prove the technology, market the product, and improve economics before building another plant.

Panel Discussion for Questions 8 & 9—Have the Needs Been Met, and Are There Remaining Technical Needs?

Hank Zygmunt, EPA, Region 3; Roberta Parry, EPA, Office of Water; and Frank Humenik, Kelly Zering, and Len Bull, North Carolina State University; Tom Ferguson, AgriRecycle; Bill Satterfield, Delmarva Poultry Industry; Garth Boyd, Smithfield Foods; and Matt Gabris, Premium Standard Farms

Introductory Comments by New Panelists

Mr. Bill Satterfield is the Executive Director for the Delmarva Poultry Industry, Inc., a broiler chicken industry association in Delaware, the Eastern Shore of Maryland, and Virginia. Mr. Satterfield described poultry manure as solid, mostly sawdust. On the Delmarva peninsula, manure is cleaned out of the poultry houses every 2 to 4 years. Individual on-farm uses of manure are not practical for broiler growers in this area, and the farms are not big operations with the capital to have on-farm energy solutions for the manure. At a meeting of EPA staff, scientists, and private-sector participants on the Chesapeake Bay Program, the Chesapeake Bay Executive Council endorsed a directive to call upon administrators and governors in the region to buy a certain percentage of manure-based fertilizers.

Mr. Tom Ferguson, Perdue AgriRecycle, noted the importance of educating the public about manure. The products are safe and good to use. His company has established a market for manure with a production cost of $60 per ton. There is a need to find a better way to make granulated product and to collaborate with the biosolid industry (the biggest competitor) that can receive government subsidies.

Dr. Len Bull, North Carolina State University, mentioned the need to examine "out of the box" ideas. It is important to keep in mind that the production system in effect today is driven by what made the animal industry successful; therefore, there is a need to pay attention to an integrated process that takes into account the economics of the alternative processes considered.

Dr. Kelly Zering, an economist at North Carolina State University, noted that attaching a value to the environmental benefits that result from various alternative uses would assist the public and regulatory agencies in deciding how much to spend to achieve the environmental benefits. At North Carolina State University, he and his colleagues have been engaged in measuring or estimating the costs and returns associated with the various technologies proposed and being tested in the agreement with Smithfield Foods. The data show that it is costly to process manure beyond what currently is done. Every time the manure is moved or transformed in some way, another cost is incurred; therefore, the alternative use must produce enough revenue to cover the cost, as farmers are operating on a thin competitive margin.

Electricity Production Issues

Dr. Humenik noted that using a digester for manure treatment and electricity production is technically sound but may not be economically justifiable. He provided an example of one farmer who has a digester and receives only 1.5 cents per kilowatt-hour when he puts his electricity on the grid, but must pay 7.5 cents per kilowatt-hour to buy electricity off of the grid. Because of this inequity, the farmer will no longer put electricity on the grid. If the methane is not used to produce electricity, it will be flared, which is a waste of natural resources.

Dr. Landy asked about the reason that utility companies pay low rates for electricity supplied to the grid by farmers. Is it greed or are there engineering concerns? Has political pressure been put on the companies to pay a reasonable price for the electricity? Dr. Boyd cited a situation in North Carolina where he cannot get an interconnection agreement with the local cooperative to get on the grid even with a green power premium contract. The utility companies are for-profit companies with much invested in their centralized systems, and there is time and effort involved in small producers who want to put a minimum amount of electricity on the grid. There may be legitimate safety concerns, but there are mechanisms to address safety concerns. Dr. Boyd is pessimistic about the prospects in North Carolina and believes that the situation can only be resolved with a legislative solution. Dr. Humenik noted that some states have done better, such as California. Dr. Deanne Meyer, University of California–Davis, stated that the situation in California is not much better and she concurred with Dr. Boyd's assessment. The utility companies must accept electricity from facilities that produce over 1,000 kW, but most of the AFOs that she works with produce between 100 and 1,000 kW. The interconnect legislation has not solved the problem; for one farmer, it took 18 months and $97,000 of paperwork and time to get an interconnect agreement.

Mr. Satterfield noted that there is the opportunity to burn manure onsite without worrying about interconnect. They are hoping that a state prison in their region that now burns woodchips for steam to power the prison will convert to poultry manure, which has a high wood content from the shavings.

Dr. David Belcher, Cornell University, noted that New York has net metering renewable portfolio standards, and there has been some interest from third parties where an outside investor purchases the digester and the rights to sell the electricity, and the farmer contracts for some electricity and often needs to buy back the solids. Dr. Belcher also commented that value-added processes such as digestion or composting are affected by management. The farms that are most successful are those that have workers dedicated to the processes and not all farms can do that. A number of farmers might be interested but cannot borrow money to install digesters.

Economics and Size of CAFOs

Dr. Robarge commented that CAFOs raise health concerns, but from the presentations and the discussions it sounds as though large is better in terms of the economics of manure management. He asked for feedback from industry representatives on whether the benefits of staying large will overcome the health concerns that are being raised. Dr. Boyd believes that large is good from a food safety and environmental standpoint. Although the risk may be large if facilities are managed improperly, properly managed facilities pose minimal risk. Mr. Gabris added that Premium Standard implemented biosecurity and health plans that allowed for movement control, and animal health is good. Mr. Satterfield stated that large vertically integrated systems allow for the ability to make changes.

Question on AgriRecycle Contracts

Mr. Neil Zahradka, Virginia Department of Environmental Quality, asked Mr. Ferguson about payments or charges to contract growers, if manure was being turned away, and whether the plant is at capacity. Mr. Ferguson stated that there is no charge to the grower but the grower is not paid; the company comes to the farm and cleans out the houses and bears the entire cost. The plant is not operating at capacity, and manure is turned down every day. The company provides 10-year contracts. The cost of transport for the company is between $7 and $10 per ton delivered.

Perception of Manure

Mr. Richard Pepino, EPA, Region 3, wanted to know how industry could change the image of manure as a risk or liability. Mr. Ferguson restated that education is key to informing people that manure is a resource. Dr. Humenik noted that policies to deal with some of the problems of manure, such as the health concerns, may be effective. Mr. Bull said that his group is applying for a grant to use an anaerobic treatment lagoon system as the basis to address the biological processes. Understanding these biological processes may help both with the cost aspects of treatment as well as the health concerns.

Question on Smithfield's Biogas Project

Dr. Striz asked about legislative support for the biogas project. Dr. Boyd replied that the jobs bill passed last month has a $1 per gallon biodiesel credit, which is definitely a boost for the product. There have been no subsidies for the construction of the project.

Question 10: What environmental assessment methodologies/approaches are available to evaluate farming operations and practices to determine impacts and to determine the contributions of these practices toward causing, or effectiveness in preventing, adverse environmental consequences?

Regional Perspective
Connie Roberts, EPA, Region 4

Ms. Roberts, agricultural coordinator for Region 4, is based in Atlanta within the Water Management Division. She stated that working with Cooperative State Research, Education, and

Extension Service (CSREES or Extension) and NRCS is important in addressing the concerns and discussing the methodologies that work in the region. She summarized some of the programs and highlighted some of the needs in Region 4.

Region 4 is reorganizing toward a watershed-based approach and supports activities through technical assistance and Section 319(h) grant dollars. Ms. Roberts mentioned the Georgia Voluntary Poultry Nutrient Management Program, the On-farm Assessment and Environmental Review Program, and Farm*A*Syst. Region 4 recognizes that with voluntary programs there is a need for methodologies to ensure that suggested practices are being implemented in a timely fashion, with regular operation and maintenance activities. Other tools that would be helpful include economic benefit analyses that are applicable and understandable to the farmers and efficiency numbers for environmental management practices that are accessible to staff for assessing programs.

A new program being considered in Region 4 is adaptation of Performance Track to the agricultural industry. The program is designed to recognize top environmental performers—those that go above and beyond what is needed to stay in compliance.

Environmental Assessment Methodologies/Approaches—National Perspective
Gregory Beatty, EPA, Office of Wastewater Management

Mr. Beatty presented information on the models EPA used to determine the environmental quality of a variety of regulatory scenarios when revising the CAFO regulations. National water quality was examined through analysis of improvements in water quality and suitability of water for recreational activities. Reduced incidences of fish kills, improved commercial shellfishing, and a reduction in nitrogen contamination of private wells were other expected changes analyzed. He outlined the approach used for assessing improvements in water quality and referred the audience to the technical development document on the EPA Web Site for more details on the models and analyses.

Assessing improvements in water quality included development of model facilities, modeling of "edge-of-field" pollutant releases, calculation of the number of AFOs, modeling of the change in surface water pollutant concentrations, and assessing the value of water quality changes. Recognizing the diversity of AFOs, EPA used 76 different model facilities to calculate pollutant production, determine the application rates and nutrient removal capabilities, and calculate excess nutrients applied. Analysis of pollutants leaving the facilities considered loadings from manure application, storage structures, and feedlots. Surface water modeling utilized the National Water Pollution Control Assessment Model (NWPCAM), which allows for estimates to be made in the changes in loadings under different regulatory scenarios. NWPCAM also was used to assess the public's willingness to pay for reduction of pollutants and increased water quality.

Environmental Assessment Tools for Evaluating Livestock Operations
Mark Risse, University of Georgia

Dr. Risse focused his presentation on the tools or methodologies available for farmers or inspectors and regulators to determine whether a farmer is doing a good job of environmental management. There is very little science that exists on this question. Dr. Risse does not know of

any studies that have examined at a single farm operation and measured water quality changes over time based on management practices. There also is a lack of basic survey data on the management practices of different types of farms in different regions. Dr. Risse referred to a few studies by rural sociologists on factors influencing BMP adoption, but emphasized there is not much research in this area.

Environmental assessment programs are available through the NRCS, EPA, Extension, state partnerships, and industry. NRCS, within the USDA, is the leader in technical assistance, standard development, and cost-share funding of agricultural practices within conservation districts, with many environmental programs for livestock farmers. EPA tools mentioned included the Technical Fundamentals for CAFOs for Permit Writers and Inspectors course, the AFO Virtual Center, and the National Agricultural Compliance and Assistance Center. CSREES, the federal side of land grant universities, can provide local delivery of tools to farmers.

Dr. Risse highlighted Farm*A*Syst, which can be used as a self-assessment tool. He believes the program works best when a third party administers the program with the farmer. Almost every state in the country has this program, and many of these programs across the country were funded with EPA Section 319(h) money. Dr. Risse has been involved in a nine-state project implementing environmental management systems for livestock operations and developing almost 100. These systems seem to work better on larger farms and with farmers who wanted to be more involved in planning and management.

There are many programs, such as the Michigan Agriculture Environmental Assurance Program and P.E.A.C.C.E in Pennsylvania, where there is a partnership with Extension for education, use of Farm*A*Syst or other program for assessment and planning, or certification for the farmer through NRCS. These are successful voluntary programs in different states that can be seen as models. Most commodity groups also have voluntary environmental programs in which producers can participate.

Dr. Risse believes that successful programs provide information and education to producers from individuals and organizations that are respected and trusted by the producers. In addition, partnerships, incentives that go beyond compliance, and inclusion of producers in the process contribute to successful programs. Dr. Risse suggested that EPA work with USDA food inspectors to combine food safety and environmental goals and inspections. He believes that environmental management systems offer an opportunity for the agriculture industry and should be explored further. He highlighted the need for a regulatory assessment tool that addresses the interpretation of state and federal regulations across agencies and takes into account the overall environmental picture, including water and air.

Panel Discussion for Question 10—Have the Needs Been Met, and Are There Remaining Technical Needs?

Mark Risse, University of Georgia; Connie Roberts, EPA, Region 4; Gregory Beatty, EPA, Office of Water; and Lisa Ann McKinley, CSREES Liaison

Introductory Comments by New Panelists

Ms. Lisa McKinley introduced herself as a liaison between CSREES and EPA and highlighted the history of NRCS, CSREES, and EPA working together and providing a national framework with modifications for state and local needs. The area of assessment in agriculture is important, and everyone agrees that it needs to be done. After producers have completed environmental assessments, the challenge is to determine what producers actually will do and what impact this will have on the environment. A second challenge is to look at agriculture as a complete system when addressing environmental issues.

Effectiveness of Tools for Different Size Facilities

Mr. Powell commented that, in the dairy industry, there is a diversity of farm sizes, and the farms dispersed across a geographic region. How applicable are tools such as Farm*A*Syst in addressing the needs of both small farms and large operations? Dr. Risse stated that the results are mixed. For some situations, such as the worksheets for wellhead protection practices, the program will work regardless of the farm size. The program may be lacking in assessing the overall nutrient management impacts of various types of manure storage and utilization systems. Ms. McKinley stated that the program has been successful at addressing regional needs.

TMDLs

Mr. Fred Suffian, EPA, Region 3, commented that TMDLs have not been addressed. In his region, many TMDLs have been developed to meet consent decrees and load reductions and allocations are used by EPA as interim indicators of environmental progress. He sees a need to bridge the gap between the on-farm assessment models and the processes being used to develop TMDLs. Dr. Risse reiterated that there is no research to demonstrate how much farm water quality improves if assessment models are implemented. Unless the benefits obtained through the educational or assessment efforts can be documented, he does not believe that TMDL programs will utilize these programs in determining loads. Ms. Roberts stated that she and her colleagues try to incorporate education, even though there is no technical basis for how well it works. They are doing their best to tie TMDLs into the agricultural program through the watershed-based approach.

Water Quality Research

Dr. Moorman stated that it often is difficult and time consuming to research water quality impacts from a single farm, particularly when attempting to document the effects of conservation practices. It is easier to address research at a watershed level and that does not necessarily correlate with placement of individual farms. In addition, many water quality problems are caused by rainfall events and in years with no runoff events, the data will not be available to determine the effectiveness of a practice. Dr. Moorman shared information on the Conservation Effects Assessment program through NRCS and ARS that is designed to provide data on the

degree of water quality improvement expected from various NRCS conservation practices. The study was initiated 2 years and uses a system of 12 research watersheds and extensive modeling efforts.

National Communication and Coordination

Dr. Meyer, University of California–Davis, commented that manure management is a multimedia issue that requires a variety of individuals with knowledge of the system and its various parts, such as nutrient management, animal production, and individual and regulatory decision-making processes. The National Center for Manure and Animal Waste Management has been a valuable resource for her, and there has been some participation from individuals at EPA but no commitment from the Agency. She asked Dr. Landy to respond to the question of how to improve national coordination and combine the knowledge on these issues. Dr. Landy agreed that there are problems within EPA in addressing multimedia issues, but noted that this workshop is a first attempt to bring the regional staff together and expose them to the research. The plan is to follow up after the workshop with regional staff and partner agencies to collaborate on the various issues. Although all the issues of communication will not be solved, this is a start that will focus on the research needs.

Dr. Meyer provided background on the National Center, which was started through the CSREES Fund for Rural America and has researchers from16 or more institutions. She wanted participants to know that resources such as the Livestock and Poultry Environmental Stewardship Curriculum are available so that limited dollars are not spent duplicating effort. Dr. Meyer also noted that continuity of staff who are committed to working and meeting with the research community provides better working relationships and stronger environmental results. Ms. Parry encouraged regional staff to look at the CSREES Web Site and participate in workgroups. Mr. Martin, Western United Dairymen, agreed that allowing everyone to participate in discussions on problems and solutions will change attitudes; he has seen that in his industry. Dr. Sobsey thought that it was important for lines of communication to remain open to overcome perceptions of bias. With a shortage of dollars for research and implementation, there needs to be a collective process to address problems. Scientists can do the research, but it is up to others to make people aware of the risks to public health and the environment that may elicit funding for the issues in animal agriculture.

ADJOURNMENT

Dr. Landy thanked all of the participants and stated that there would be no formal afternoon planning session as noted on the agenda, but there would be an informal discussion over lunch. Signup sheets were made available for individuals interested in participating in one of the five workgroups that will follow up on the different sessions from the workshop to help clarify the needs and determine how to meet the remaining technical needs through conference calls and e-mail exchanges.

Regional Science Workshop:
Animal Feeding Operations (AFOs)
Science and Technical Support Needs

College Park, MD
December 6–9, 2004

Appendix A: Research Needs

SESSION I. AIR EMISSION CHARACTERIZATION AND MANAGEMENT

Basic Research Needs

For what air pollutants are contributions from CAFOs significant?

What role does ammonia play in contributing to fine particulate matter?

For ammonia control, do we know the control, and will it help or hurt the situation with emissions of particulate matter and other pollutants? What do we know about the interplay between ammonia and NOx and SOx?

VOC is known as a precursor to ozone, and information is not known about VOC from AFOs.

More information is needed to understand the flow gradients of air pollutants from sources.

Data on emissions from manure application processes is needed.

Applied Research Needs

For sampling of emissions, what type of ammonia and at what frequency and spatial scale should we be concerned about? Are there similar questions about other pollutants?

Modelers need data to help support modeling. One example mentioned was uncertainty in the data for dry deposition of ammonia.

Technology Transfer Needs

Analyze and disseminate the data in a quicker turn-around time and to a wider audience.

Standard measurement protocols.

Begin looking at uniting emission factors and mass balance/process-oriented models and thinking.

Include environmental and economic analysis in determining control methods.

SESSION II. CONTAMINANT SOURCE TRACKING

Basic Research Needs

Research in the fate and transport of microorganisms as well as questions of sediment resuspension and regrowth of bacteria.

More research/funding for library independent methods.

More research on spatial and temporal variability.

Applied Research Needs

More research/guidance needed on the numbers needed in libraries for source tracking that depends on libraries. Need to balance the numbers needed to provide information but also contain cost, labor, and time.

Regional and national library data—Is it feasible to collect such data? For what methods might this make sense?

Technology Transfer Needs

Information about the holding time requirement for *E. coli* sampling.

Technology Translation Needs (Including Training and Education)

Regions and states need guidance on what source tracking methods to use.

SESSION III. PHARMACEUTICALS AND PATHOGENS

Basic Research Needs

Research into the degradation products of pharmaceuticals, their fate and transport, and their movement with pathogens.

What hormones are coming from natural sources (the animals) versus treatment with pharmaceuticals?

Applied Research Needs

More analytical stable isotope information for various pharmaceutical compounds for topological and frequency of occurrence studies.

Studies to identify indicators and determine those that should be used both for pharmaceuticals and pathogens.

Investigate risk-based approaches and address question of what is acceptable risk and the level of pathogens that may be associated with given risk levels.

Health effects statements for pathogens and pharmaceuticals are needed to address environmental and public health risks.

Large epidemiology studies are critical to investigate the health effects from pathogens and/or pharmaceuticals.

Rapid test methods for inspectors and those assigning permits.

Better surveillance to detect possible outbreaks. Need for better systems to coordinate/collect information.

More complete investigations of sources of contamination.

Technology Transfer Needs

Make information available to regions on health and environmental effects of pharmaceuticals.

More interdisciplinary research, for example, correlation of pharmaceutical tracking with pathogen tracking.

Increased interaction between FDA, USDA, EPA, USGS, sharing of data.

Technology Translation Needs (Including Training and Education)

Regions need background and/or access to epidemiology investigations and epidemiologists.

Better understanding/guidance on microbial source tracking at the regional level.

SESSION IV. RISK MANAGEMENT

Basic Research Needs

What is the nonsettleable fraction of BOD in manure and wastewater?

How much BOD is in runoff following N-based applications of various types of waste, including beef cattle manure, turkey manure, cattle open lot runoff, egg wash water, or feed storage runoff?

How much BOD is in runoff following 1-year P-based applications of manure or wastewater?

How, if at all, should the hydrology equations be adjusted when crop residue cover is significantly greater than 20 percent or solid manure or waste feed has been applied to mineral soils?

Applied Research Needs

Information on where the CAFOs and medium AFOs are located.

Research to determine and quantify environmental risk from land application of manure over drainage tiles.

Screening tools to help inspectors easily determine if a facility has adequate storage and sufficient land application areas and is addressing nutrient balance needs.

Research on the effectiveness of nonregulatory or volunteer programs on water quality.

Better understanding of routine discharges as well as cataclysmic events that will affect water quality.

Technology Transfer Needs

Standardization of soil testing and manure testing across states/regions.

Tools that target where compliance assistance and permitting or inspecting CAFOs would provide the greatest environmental benefit.

Consider the application of existing tools in new areas for new users.

What are the critical success factors that farmers should be addressing? What information is needed for farmers to be successful in management, and how do farmers use this information to make decisions?

SESSION V. MANURE MANAGEMENT

Basic Research Needs
Understanding of vadose zone transport.

Understanding pathogen fate and transport.

Applied Research Needs
Evaluation of integrated systems for managing pathogen and pollutant movement from animal waste.

Research into the effects of various management techniques on water quality.

Research into optimal monitoring design for determining proper manure management.

Research on the effectiveness of nonregulatory or volunteer programs on manure management practices and resulting environmental benefit.

Research into effectiveness of diet manipulation on reduction of nutrient problems in waste stream.

There needs to be a focus to look at the agriculture industry as a complete system rather than in parts when assessing environmental impacts.

Technology Transfer Needs
Development of profitable animal housing/waste management systems.

Assessment and communication of economic value for environmental benefits for inclusion into models and for assessing a whole system.

Information on the effectiveness of management practices needed at the regional level.

Integration of recommendation of management practices and the development of regulations such as TMDLs.

Technology Translation Needs (Including Training and Education)
Strong business plan and cost analysis needed for alternative use of manure to succeed.

Education of public to ease fears of manure products.

Encourage EPA regional staff to seek collaborations with scientists in local area and attendance at national meetings.

Regional Science Workshop: Animal Feeding Operations (AFOs) Science and Technical Support Needs

College Park, MD
December 6–9, 2004

Appendix B: Participants List

Jenn Aiosa
University of Maryland, College Park
Cooperative State Research, Education, and Extension Service
Mid-Atlantic Regional Water Quality Program
1211 Symons Hall
College Park, MD 20742
Telephone: (301) 405-5849
E-mail: jaiosa@umd.edu

Patsy Allen
Maryland Department of the Environment
Department of Wastewater Permits
1800 Washington Boulevard
Baltimore, MD 21230
Telephone: (410) 537-3625
E-mail: pallen@mde.state.md.us

Osman Arikan
U.S. Department of Agriculture
Agricultural Research Service
Animal Manure and Byproducts Laboratory
Building 306, Room 116A
Beltsville Agriculture Research Center-East
Beltsville, MD 20705
Telephone: (301) 504-8101
E-mail: arikano@ba.ars.usda.gov

Alan Banwart
U.S. Environmental Protection Agency
Region 7
Water, Wetlands, and Pesticides Division
901 N Fifth Street
Kansas City, KS 66101
Telephone: (913) 551-7819
E-mail: banwart.alan@epa.gov

Sarah Bauer
U.S. Environmental Protection Agency
Office of Research and Development (8104R)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-3267
E-mail: bauer.sarah@epa.gov

Thomas Baugh
U.S. Environmental Protection Agency
Region 4
Office of the Regional Administrator
61 Forsyth Street, SW, 14th Floor
Atlanta, GA 30303
Telephone: (404) 562-8275
E-mail: baugh.thomasl@epa.gov

Gregory Beatty
U.S. Environmental Protection Agency
Office of Water
Office of Wastewater Management
Ariel Rios Building (4203M)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-0724
E-mail: beatty.gregory@epa.gov

Jennifer Becker
University of Maryland, College Park
Biological Resources Engineering
1433 Animal Sciences Building
College Park, MD 20742-2315
Telephone: (301) 405-1179
E-mail: jgbecker@umd.edu

David Belcher
Cornell University
Department of Biological and Environmental Engineering
222 Riley Robb Hall
Ithaca, NY 14853
Telephone: (607) 255-1819
E-mail: dmb45@cornell.edu

Phil Benedict
Vermont Agency of Agriculture
Agricultural Resource Management and Environmental Stewardship
116 State Street, Drawer 20
Montpelier, VT 05620
Telephone: (802) 828-3472
E-mail: phil@agr.state.vt.us

Sean Bergin
U.S. Environmental Protection Agency
Region 7
Department of Environmental Services
901 N Fifth Street
Kansas City, KS 66101-2907
Telephone: (913) 551-7499
E-mail: bergin.sean@epa.gov

Terry Black
Pennsylvania Department of Environmental Protection
Bureau of Air Quality
400 Market Street, 12th Floor
Harrisburg, PA 17101
Telephone: (717) 787-9495
E-mail: tblack@state.pa.us

Raanan Bloom
U.S. Food and Drug Administration
Center for Veterinary Medicine
Office of New Animal Drug Evaluation
7500 Standish Place
Rockville, MD 20855
Telephone: (301) 827-8546
E-mail: rbloom@cvm.fda.gov

Tim Bondelid
RTI International
Environmental Health and Safety Division
1615 M Street, NW, Suite 740
Washington, DC 20036
Telephone: .(202) 728-1961
E-mail: timothy@rti.org

Garth Boyd
Smithfield Foods, Inc.
277 Faison McGowen Road
Kenansville, NC 28349
Telephone: (910) 296-0302
E-mail: garthboyd@smithfieldfoods.com

Ross Braun
U.S. Department of Agriculture
Natural Resources Conservation Service
5601 Sunnyside Avenue, Room 2-2276B
MSC 5473
Beltsville, MD 20705
Telephone: (301) 504-2195
E-mail: ross.braun@usda.gov

Douglas Brennan
Pennsylvania Department of Environmental Protection
Bureau of Regulatory Counsel
400 Market Street, 9th Floor
Harrisburg, PA 17101
Telephone: (717) 787-9373
E-mail: dobrennan@state.pa.us

John Brenner
U.S. Department of Agriculture
Natural Resources Conservation Service
West National Technical Service Center
U.S. Bancorp Tower
111 SW Fifth Avenue, Suite 1200
Portland, OR 97204
Telephone: (503) 273-2409
E-mail: john.brenner@usda.gov

Robert Brobst
U.S. Environmental Protection Agency
Region 8
National Pollutant Discharge Elimination System
Water Permits Unit
999 18th Street, Suite 300 (8P-W-P)
Denver, CO 80202
Telephone: (303) 312-6129
E-mail: brobst.bob@epa.gov

Leonard Bull
North Carolina State University
Animal Science and Animal and Poultry Waste Management
Center
PO Box 7608
Raleigh, NC 27695-7608
Telephone: (919) 515-6836
E-mail: leonard_bull@ncsu.edu

Katherine Bunting-Howarth
Delaware Department of Natural Resources and Environmental Control
Division of Water Resources
89 Kings Highway
Dover, DE 19901
Telephone: (302) 739-4860
E-mail: katherine.howarth@state.de.us

Lewis Carr
University of Maryland, College Park
Department of Biological Resources Engineering
1461 Animal Science/Agricultural Engineering Building
College Park, MD 20742
Telephone: (410) 742-1178
E-mail: lcarr@umd.edu

Amy Chapin
The Johns Hopkins School of Public Health
Department of Environmental Health Sciences
615 N Wolfe Street, Room W7034
Baltimore, MD 21205
Telephone: (410) 955-3094
E-mail: achapin@jhsph.edu

John Cicmanec
U.S. Environmental Protection Agency
Technology Transfer Division
26 W Martin Luther King Drive (G-75)
Cincinnati, OH 45268
Telephone: (513) 569-7481
E-mail: cicmanec.john@epa.gov

Andrea Coats
U.S. Environmental Protection Agency
Region 2
290 Broadway
New York, NY 10007
Telephone: (212) 637-3850
E-mail: coats.andrea@epa.gov

John Davis
U.S. Department of Agriculture
Natural Resources Conservation Service
Animal Husbandry and Clean Water Division
5601 Sunnyside Avenue, MS 5473
Beltsville, MD 20705
Telephone: (301) 505-2225
E-mail: j.russell.davis@usda.gov

Michael Davis
U.S. Environmental Protection Agency
Region 7
Environmental Services Division
901 N Fifth Street
Kansas City, KS 66101
Telephone: (913) 551-7096
E-mail: davis.michael@epa.gov

Mark Dittrich
Minnesota Department of Agriculture
Resources Management and Development
90 W Plato Boulevard
St. Paul, MN 55107
Telephone: (651) 296-1482
E-mail: mark.dittrich@state.mn.us

Kerry Drake
U.S. Environmental Protection Agency
Region 9
Air Division
75 Hawthorne Street (AIR-1)
San Francisco, CA 94105
Telephone: (415) 947-4157
E-mail: drake.kerry@epa.gov

Charles Eirkson
U.S. Food and Drug Administration
Department of Environmental Safety
5600 Fishers Lane, HFV-103
Rockville, MD 20855
Telephone: (301) 827-8561
E-mail: ceirkson@cvm.fda.gov

Mike Eisner
Maryland Department of Environment
Water Management Administration
1800 Washington Boulevard
Baltimore, MD 21230
Telephone: (410) 537-3771
E-mail: meisner@mde.state.md.us

Tom Ferguson
Perdue AgriRecycle
28338 Enviro Way
Seaford, DE 19973
Telephone: (302) 628-2366
E-mail: tom.ferguson@perdue.com

Donald Fiesta
Pennsylvania Department of Environmental Protection
Department of Nutrient Management
400 Market Street, 11th Floor
PO Box 8465
Harrisburg, PA 17101-8465
Telephone: (717) 772-5644
E-mail: dfiesta@state.pa.us

Ray Frederick
U.S. Environmental Protection Agency
Region 2
National Risk Management Research Laboratory
Urban Watershed Management Branch
2890 Woodbridge Avenue (MS 104)
Edison, NJ 08837
Telephone: (732) 321-6627
E-mail: frederick.ray@epa.gov

Matt Gabris
Premium Standard Farms
805 Pennsylvania Avenue, Suite 200
Kansas City, MO 64105
Telephone: (816) 843-1415
E-mail: matt.gabris@psfarms.com

Maria Cruz Garcia
U.S. Department of Agriculture
Agricultural Research Service
2611 W Lucas Street
Florence, SC 29501
Telephone: (843) 669-5203
E-mail: garcia@florence.ars.usda.gov

Donald Garofalo
U.S. Environmental Protection Agency
Office of Research and Development
National Exposure Research Laboratory
Environmental Sciences Division
555 National Center
12201 Sunrise Valley Drive
Reston, VA 20192
Telephone: (703) 648-4285
E-mail: garofalo.donald@epa.gov

Jay Graham
The Johns Hopkins University
Bloomberg School of Public Health
Department of Environmental Health Sciences
615 N Wolfe Street
Baltimore, MD 21205
Telephone: (443) 286-8335
E-mail: jgraham@jhsph.edu

Elvis Graves
U.S. Department of Agriculture
Natural Resources Conservation Service
200 E Northwood Street, Suite 410
Greensboro, NC 27253
Telephone: (335) 370-3331
E-mail: elvis.graves@gnb.usda.gov

Brenda Groskinsky
U.S. Environmental Protection Agency
Region 7
901 N Fifth Street
Kansas City, KS 66101
Telephone: (913) 551-7188
E-mail: groskinsky.brenda@epa.gov

Christopher Gross
U.S. Department of Agriculture
Natural Resources Conservation Service
Natural Water and Climate Center
5601 Sunnyside Avenue, Room 1-2150C, MS 5420
Beltsville, MD 20705-5420
Telephone: (301) 504-3954
E-mail: chris.gross@usda.gov

John Haines
U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory
26 W Martin Luther King Drive (421)
Cincinnati, OH 45268
Telephone: (513) 569-7446
E-mail: haines.john@epa.gov

David Hair
U.S. Environmental Protection Agency
Office of Water
Office of Wastewater Management
Water Permits Division
Ariel Rios Building (4203M)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-0588
E-mail: hair.david@epa.gov

Tracy Hancock
U.S. Geological Survey
1730 E Parham Road
Richmond, VA 23228
Telephone: (804) 261-2618
E-mail: thancock@usgs.gov

D. Bruce Harris
U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory
Air Pollution Prevention and Control Division
109 TW Alexander Drive (E343-02)
Research Triangle Park, NC 27711
Telephone: (919) 541-7807
E-mail: harris.bruce@epa.gov

Stephanie Harris
U.S. Environmental Protection Agency
Region 10
Manchester Laboratory
7411 Beach Drive, East
Port Orchard, WA 98366
Telephone: (360) 871-8710
E-mail: harris.stephanie@epa.gov

Al Havinga
U.S. Environmental Protection Agency
Office of Enforcement and Compliance Assurance
Office of Compliance, Agriculture Division
Ariel Rios Building (2225A)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-4147
E-mail: havinga.al@epa.gov

Ronald Heavner
U.S. Department of Agriculture
National Resources Conservation Service
Conservation Engineering Division
1400 Independence Avenue, SW, Room 6136-S
Washington, DC 20250
Telephone: (202) 720-6107
E-mail: ron.heavner@usda.gov

Albert Heber
Purdue University
Department of Agricultural and Biological Engineering
225 S University Street
West Lafayette, IN 47907
Telephone: (765) 494-1214
E-mail: heber@purdue.edu

Richard Hegg
U.S. Department of Agriculture
Cooperative State Research, Education, and Extension Service
800 9th Street, SW, Room 3430
Washington, DC 20024
Telephone: (202) 401-6550
E-mail: rhegg@csrees.usda.gov

Philip Hess
Purdue University
Agronomy Department
915 W State Street
West Lafayette, IN 47907
Telephone: (765) 494-8050
E-mail: pjhess@purdue.edu

Stephen Hollenbeck
Delaware Department of Agriculture
Department of Nutrient Management
2320 S Dupont Highway
Dover, DE 19901
Telephone: (302) 698-4557
E-mail: steven.hollenbeck@state.de.us

Heather Horne
GeoLogics Corporation
5285 Shawnee Road, Suite 300
Alexandria, VA 22312
Telephone: (703) 891-6121
E-mail: hhorne@geologics.com

Richard Huddleston
Idaho Department of Environment Quality
Water Quality Division
1410 N Hilton Street
Boise, ID 83706
Telephone: (208) 373-0561
E-mail: rhuddles@deq.state.id.us

Frank Humenik
North Carolina State University
Department of Biological and Agricultural Engineering
909 Capability Drive
Raleigh, NC 27695-7927
Telephone: (919) 515-6767
E-mail: frank_humenik@ncsu.edu

Tom Hunt
University of Wisconsin, Platteville
School of Agriculture
207 Pioneer Tower
Platteville, WI 53818
Telephone: (608) 342-1898
E-mail: huntt@uwplatt.edu

Stephen Hutchins
U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory
Ground Water and Ecosystems Restoration Division
919 Kerr Research Drive
Ada, OK 74820
Telephone: (580) 436-8563
E-mail: hutchins.steve@epa.gov

Steve Jann
U.S. Environmental Protection Agency
Region 5
National Pollution Discharge Elimination System Branch
77 W Jackson Boulevard (WN-16J)
Chicago, IL 60604
Telephone: (312) 886-2446
E-mail: jann.stephen@epa.gov

Michael Jawson
U.S. Department of Agriculture
Agricultural Research Service
George Washington Carver Center, Room 4-2264
5601 Sunnyside Avenue
Beltsville, MD 20705
Telephone: (301) 504-5281
E-mail: mdj@ars.usda.gov

Brad Joern
Purdue University
Department of Agronomy
915 W State Street
West Lafayette, IN 47907
Telephone: (765) 494-9767
E-mail: bjoern@purdue.edu

Bonita Johnson
U.S. Environmental Protection Agency
Region 4
Science and Ecosystem Support Division
Ecological Assessment Branch
980 College Station Road
Athens, GA 30605
Telephone: (706) 355-8725
E-mail: johnson.bonita@epa.gov

Greg Johnson
U.S. Department of Agriculture
National Resources Conservation Service
West National Technical Support Center
111 SW Fifth Avenue, Suite 1200
Portland, OR 97204
Telephone: (503) 273-2424
E-mail: greg.johnson@por.usda.gov

Carol Kendall
U. S. Geological Survey
Water Resources Division
National Research Program
345 Middlefield Road, MS 434
Menlo Park, CA 94025
Telephone: (650) 329-4576
E-mail: ckendall@usgs.gov

Ken Kephart
Pennsylvania State University
Department of Dairy and Animal Science
306 Agricultural Science and Industries Building
University Park, PA 16802
Telephone: (814) 863-3671
E-mail: kbk2@psu.edu

David Klauder
U.S. Environmental Protection Agency
Office of Research and Development
Office of Science Policy
Ariel Rios Building (8104R)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-6496
E-mail: klauder.david@epa.gov

Alan Kolok
University of Nebraska, Omaha
Department of Biology
6001 Dodge Street
Omaha, NE 68182-0040
Telephone: (402) 554-3545
E-mail: akolok@mail.unomaha.edu

Stephen Kraemer
U.S. Environmental Protection Agency
Ecosystems Research Division
960 College Station Road
Athens, GA 30605-2700
Telephone: (706) 355-8340
E-mail: kraemer.stephen@epa.gov

Sheryl Kunickis
U.S. Department of Agriculture
Natural Resources Conservation Service
14th and Independence Avenue, SW
South Building, Room 5238
Washington, DC 20250
Telephone: (202) 720-8723
E-mail: sheryl.kunickis@usda.gov

Ronald Landy
U.S. Environmental Protection Agency
Region 3
Environmental Science Center
701 Mapes Road
Fort Meade, MD 20755
Telephone: (410) 305-2757
E-mail: landy.ronald@epa.gov

John Larson
U.S. Environmental Protection Agency
Region 8
999 18th Street, Suite 300 (8P-SA)
Denver, CO 80202
Telephone: (303) 312-6030
E-mail: larson.john@epa.gov

Mindy Lemoine
U.S. Environmental Protection Agency
Region 3
Environmental Innovation Branch (3ES40)
1650 Arch Street
Philadelphia, PA 19038
Telephone: (215) 814-2736
E-mail: lemoine.mindy@epa.gov

James Liebman
U.S. Environmental Protection Agency
Region 9
Agriculture Program
75 Hawthorne Street (CMD-1)
San Francisco, CA 94105
Telephone: (415) 947-4241
E-mail: liebman.james@epa.gov

John Lory
University of Missouri
Department of Agronomy
210 Waters Hall
Columbia, MO 65203
Telephone: (573) 884-7815
E-mail: loryj@missouri.edu

Greg Mallon
Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030
Telephone: (703) 385-6000
E-mail: greg.mallon@tetratech-ffx.com

Paul Martin
Western United Dairymen
8090 Valley Ford Road
Petaluma, CA 94952
Telephone: (707) 763-8874
E-mail: paulwud@callatg.com

Ray Massey
University of Missouri
Department of Agricultural Economics
223 Mumford Hall
Columbia, MO 65211
Telephone: (573) 884-7788
E-mail: masseyr@missouri.edu

Shawn McKenzie
The Johns Hopkins University
Bloomberg School of Public Health
615 N Wolfe Street
Baltimore, MD 21205
Telephone: (410) 502-7578
E-mail: smckenzi@jhsph.edu

Lisa Ann McKinley
U.S. Environmental Protection Agency
Region 4
Cooperative State Research, Education, and Extension Service
61 Forsyth Street, SW
Atlanta, GA 30303
Telephone: (404) 562-9403
E-mail: mckinley.lisa@epa.gov

Donna Mennitto
The Johns Hopkins University
Bloomberg School of Public Health
Department of Environmental Health Sciences
615 N Wolfe Street
Baltimore, MD 21205
Telephone: (410) 502-2317
E-mail: dmennitt@jhsph.edu

Deanne Meyer
University of California, Davis
Department of Animal Science
One Shields Avenue
Davis, CA 95616
Telephone: (530) 752-9391
E-mail: dmeyer@ucdavis.edu

Michael Meyer
U.S. Geological Survey
Research Laboratory
4821 Quail Crest Place
Lawrence, KS 66049
Telephone: (785) 832-3564
E-mail: mmeyer@usgs.gov

Fred Michel, Jr.
Ohio State University
Ohio Agricultural Research and Development Center
Department of Food, Agricultural, and Biological Engineering
1680 Madison Avenue
Wooster, OH 44691
Telephone: (330) 263-3859
E-mail: michel.36@osu.edu

Pat Millner
U.S. Department of Agriculture
Agricultural Research Service
Beltsville Agricultural Research Center
Environmental Microbial Safety Lab
10300 Baltimore Avenue
Beltsville, MD 20705
Telephone: (301) 504-8387
E-mail: millnerp@ba.ars.usda.gov

Frank Mitloehner
University of California, Davis
Department of Animal Science
2151 Meyer Hall
One Shields Avenue
Davis, CA 95616
Telephone: (530) 752-3936
E-mail: fmmitloehner@ucdavis.edu

Joseph Monroe
West Virginia Department of Agriculture
Department of Regulatory and Environmental Affairs
60 B Moorefield Industrial Park Road
Moorefield, WV 26836
Telephone: (304) 538-2397
E-mail: mmonroe@ag.state.wv.us

Thomas Moorman
U.S. Department of Agriculture
Agricultural Research Service
National Soil Tilth Laboratory
2150 Pammel Drive
Ames, IA 50011
Telephone: (515) 294-2308
E-mail: moorman@nstl.gov

Connie Musgrove
University of Maryland, College Park
1207 Symons Hall
College Park, MD 20742
Telephone: (301) 405-1215
E-mail: cm321@umail.umd.edu

Sam Myoda
Delaware Department of Natural Resources and Environmental Control
Division of Water Resources
820 Silver Lake Boulevard, Suite 220
Dover, DE 19904
Telephone: (302) 739-4590
E-mail: samuel.myoda@state.de.us

Keeve Nachman
The Johns Hopkins University
Bloomberg School of Public Health
Department of Health Policy and Management
624 N Broadway
Baltimore, MD 21205
Telephone: (410) 614-2188
E-mail: knachman@jhsph.edu

Wayne Newbill
Idaho Association of Soil Conservation Districts
6003 Overland Road, Suite 204
Boise, ID 83709
Telephone: (208) 338-4321
E-mail: wnewbill@idahoag.us

Lola Olabode
Water Environment Research Foundation
Department of Human and Environmental Health
635 Slaters Lane, Suite 300
Alexandria, VA 22314
Telephone: (703) 684-2470
E-mail: lolabode@werf.org

Yakov Pachepsky
U.S. Department of Agriculture
Agricultural Research Service
Environmental Microbial Safety Laboratory
173 Powder Mill Road
Beltsville, MD 20705
Telephone: (301) 504-7468
E-mail: ypachepsky@anri.barc.usda.gov

Roberta Parry
U.S. Environmental Protection Agency
Office of Water
Ariel Rios Building (4101M)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-0508
E-mail: parry.roberta@epa.gov

Richard Pepino
U.S. Environmental Protection Agency
Region 3
Water Protection Division
1650 Arch Street (3WP00)
Philadelphia, PA 19103
Telephone: (215) 814-2703
E-mail: pepino.richard@epa.gov

Richard Pfeiffer
U.S. Department of Agriculture
Agriculture Research Service
National Soil Tilth Laboratory
2150 Pammel Drive
Ames, IA 50011
Telephone: (515) 294-0136
E-mail: pfeiffer@nstl.gov

Thomas Pierce
U.S. Environmental Protection Agency
National Oceanic and Atmospheric Administration
Office of Research and Development
109 TW Alexander Drive (E243-04)
Research Triangle Park, NC 27711
Telephone: (919) 541-1375
E-mail: pierce.tom@epa.gov

Fred Pinkney
U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
Environmental Contaminants Program
177 Admiral Cochrane Drive
Annapolis, MD 21401
Telephone: (410) 573-4519
E-mail: fred_pinkney@fws.gov

Mark Powell
U.S. Department of Agriculture
Agricultural Research Service
Dairy Forage Research Center
1925 Linden Drive, West
Madison, WI 53706
Telephone: (608) 264-5044
E-mail: jmpowel2@wisc.edu

Lance Price
The Johns Hopkins School of Public Health
Department of Environmental Health Sciences
615 N Wolfe Street
Baltimore, MD 21205
Telephone: (410) 955-8678
E-mail: lprice@jhsph.edu

Charles Purdy
U.S. Department of Agriculture
Agricultural Research Service
Department of Microbiology
2300 Experiment Road
Bushland, TX 79012
Telephone: (806) 356-5764
E-mail: cwpurdy@cprl.ars.usda.gov

Lori Rhoades
GeoLogics Corporation
5285 Shawnee Road, Suite 300
Alexandria, VA 22312
Telephone: (703) 750-4000
E-mail: lrhoades@geologics.com

John Rhoderick
Maryland Department of Agriculture
Office of Resource Conservation
50 Harry S Truman Parkway
Annapolis, MD 21401
Telephone: (410) 841-5865
E-mail: rhoderjc@mda.state.md.us

Mark Rice
North Carolina State University
Department of Biological and Agricultural Engineering
Campus Box 7927
Raleigh, NC 27695
Telephone: (919) 515-6794
E-mail: mark_rice@ncsu.edu

Christina Richmond
West Virginia Department of Agriculture
60 B Moorefield Industrial Park Road
Moorefield, WV 26836
Telephone: (304) 538-2397
E-mail: crichmond@ag.state.wv.us

Mark Risse
University of Georgia
Department of Agricultural Engineering
618 Driftmier Engineering Center
Athens, GA 30602
Telephone: (706) 542-9067
E-mail: mrisse@engr.uga.edu

Wayne Robarge
North Carolina State University
Department of Soil Science
100 Derieux Place
Box 7619
Raleigh, NC 27695-7619
Telephone: (919) 515-1454
E-mail: wayne_robarge@ncsu.edu

Cindy Roberts
U.S. Environmental Protection Agency
Office of Research and Development
Office of Science Policy
Ariel Rios Building (8104R)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-1999
E-mail: roberts.cindy@epa.gov

Connie Roberts
U.S. Environmental Protection Agency
Region 4
Water Management Division
61 Forsyth Street
Atlanta, GA 30303
Telephone: (404) 562-9406
E-mail: roberts.connie@epa.gov

Chris Robinson
Delaware Nutrient Management
2320 S Dupont Highway
Dover, DE 19901
Telephone: (302) 695-4500
E-mail: christopher.robinson@state.de.us

William Rohrer
Delaware Department of Agriculture
2320 S Dupont Highway
Dover, Delaware 19901
Telephone: (302) 698-4500
E-mail: william.rohrer@state.de.us

Mary Ann Rozum
U.S. Department of Agriculture
Cooperative State Research Education and Extension Service
1400 Independence Avenue, SW, MSC 2210
Washington, DC 22181
Telephone: (202) 401-4533
E-mail: mrozum@csrees.usda.gov

Ali Sadeghi
U.S. Department of Agriculture
Agricultural Research Service
10300 Baltimore Avenue
BARC-West, B-007, Room 211
Beltsville, MD 20705
Telephone: (301) 504-6693
E-mail: sadeghia@ba.ars.usda.gov

Bill Satterfield
Delmarva Poultry Industry, Inc.
16686 County Seat Hwy.
Georgetown, DE 19947
Telephone: (301) 856-9037

Beth Sauerhaft
U.S. Environmental Protection Agency
Office of the Administrator
Ariel Rios Building (1101A)
1200 Pennsylvania Avenue, NW
Washington, DC 20640
Telephone: (202) 564-7273
E-mail: sauerhaft.beth@epa.gov

Jon Scholl
U.S. Environmental Protection Agency
Office of the Administrator
Ariel Rios Building (1101A)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-7177
E-mail: scholl.jon@epa.gov

William Schrock
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
109 TW Alexander Drive (C504-04)
Research Triangle Park, NC 27711
Telephone: (919) 541-5032
E-mail: schrock.bill@epa.gov

Cary Secrest
U.S. Environmental Protection Agency
Office of Enforcement and Compliance Assurance
Office of Regulatory Enforcement
Air Enforcement Division
Ariel Rios Building (2242A)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-8661
E-mail: secrest.cary@epa.gov

Orin Shanks
U.S. Environmental Protection Agency
Office of Research and Development
26 W Martin Luther King Drive (387)
Cincinnati, OH 45268
Telephone: (513) 569-7314
E-mail: shanks.orin@epa.gov

William Showers
North Carolina State University
Department of Marine, Earth, and Atmospheric Sciences
1125 Jordan Hall
Box 8208
Raleigh, NC 27695
Telephone: (919) 515-7143
E-mail: w_showers@ncsu.edu

Paul Shriner
U.S. Environmental Protection Agency
Office of Water
Office of Science and Technology
Engineering and Analysis Division
Ariel Rios Building (4303T)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 566-1076
E-mail: shriner.paul@epa.gov

Ellen Silbergeld
The Johns Hopkins University
Bloomberg School of Public Health
Department of Epidemiology
615 N Wolfe Street, Room E6644
Baltimore, MD 21205
Telephone: (410) 955-8678
E-mail: esilberg@jhsph.edu

Eric Silberhorn
U.S. Food and Drug Administration
Center for Veterinary Medicine
7500 Standish Place, HFV-103
Rockville, MD 20855
Telephone: (301) 827-8545
E-mail: eric.silberhorn@fda.gov

Chip Simmons
The University of North Carolina, Chapel Hill
School of Public Health
Department of Environmental Sciences and Engineering
Campus Box 7431
Chapel Hill, NC 27599-7431
Telephone: (919) 966-7316
E-mail: osimmons@email.unc.edu

Michael Simon
Idaho Department of Environmental Quality
Department of Air Quality
1410 N Hilton Street
Boise, ID 83706
Telephone: (208) 373-0212
E-mail: msimon@deq.state.id.us

Mark Sobsey
The University of North Carolina, Chapel Hill
Department if Environmental Sciences and Engineering
McGavran-Greenberg Hall, Room 4114A, MSC 7431
Chapel Hill, NC 27599-7431
Telephone: (919) 966-7303
E-mail: sobsey@email.unc.edu

Laurel Staley
U.S. Environmental Protection Agency
26 W Martin Luther King Drive (481)
Cincinnati, OH 45268
Telephone: (513) 569-7863
E-mail: staley.laurel@epa.gov

Arin Stark
University of Missouri
Center for Agricultural, Resource, and Environmental Systems
Department of Agricultural Economics
130 Mumford Hall
Columbia, MO 65211
Telephone: (573) 884-3711
E-mail: starka@missouri.edu

Ken Staver
University of Maryland, College Park
College of Agriculture and Natural Resources
Wye Research and Education Center
124 Wye Narrows Drive
PO Box 169
Queenstown, MD 21658
Telephone: (410) 827-8056

Elise Striz
U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
9191 Kerr Research Drive
Ada, OK 73026
Telephone: (580) 436-8594
E-mail: striz.elise@epa.gov

Fred Suffian
U.S. Environmental Protection Agency
Office of Watersheds
1650 Arch Street (3WP12)
Philadelphia, PA 19103
Telephone: (215) 814-5753
E-mail: suffian.fred@epa.gov

Ann Louise Sumner
Battelle
Measurement and Data Analysis Sciences
505 King Avenue
Columbus, OH 43201
Telephone: (614) 424-3973
E-mail: sumnera@battelle.org

Greg Susanke
U.S. Environmental Protection Agency
Office of Research and Development
Ariel Rios Building (8104R)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-9945
E-mail: susanke.greg@epa.gov

Richard Swenson
U.S. Department of Agriculture
Natural Resources Conservation Service
5601 Sunnyside Avenue
Beltsville, MD 20705
Telephone: (301) 504-2198
E-mail: richard.swenson@usda.gov

Jim Tesoriero
U.S. Geological Survey
Water Resources Division
3916 Sunset Ridge Road
Raleigh, NC 27607
Telephone: (919) 571-4082
E-mail: tesorier@usgs.gov

Lee Thomas
U.S. Environmental Protection Agency
Region 4
Water Programs Enforcement Branch
61 Forsyth Street, SW
Atlanta, GA 30303
Telephone: (404) 562-9786
E-mail: thomas.lee@epa.gov

Danielle Tillman
U.S. Environmental Protection Agency
Office of Research and Development
Ariel Rios Building (8104R)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-9839
E-mail: tillman.danielle@epa.gov

Jake Vandevort
University of Maryland, College Park
Cooperative State Research, Education, and Extension Service
Mid-Atlantic Regional Water Quality Program
1203 Symons Hall
College Park, MD 20742
Telephone: (301) 405-1215
E-mail: jvandevo@umd.edu

Matias Vanotti
U.S. Department of Agriculture
Agricultural Research Service
2611 W Lucas Street
Florence, SC 29501
Telephone: (843) 669-5203
E-mail: vanotti@florence.ars.usda.gov

Liz Wagstrom
National Pork Board
Department of Science and Technology
PO Box 9114
Des Moines, IA 50306
Telephone: (515) 223-2633
E-mail: liz.wagstrom@porkboard.org

John Walker
U.S. Environmental Protection Agency
Air Pollution Prevention and Control Division
109 TW Alexander Drive (E305-02)
Research Triangle Park, NC 27711
Telephone: (919) 541-2288
E-mail: walker.johnt@epa.gov

Terence Walmsley
Fibrowatt, LLC
Makefield Executive Quarters, Suite 704A
301 Oxford Valley Road
Yardley, PA 19067
Telephone: (215) 321-4866
E-mail: terry.walmsley@fibrowattusa.com

Janice Ward
U.S. Geological Survey
Denver Federal Center
Department of Interior
PO Box 25046, MS 401
Lakewood, CO 80225
Telephone: (303) 236-1871
E-mail: jward@usgs.gov

David Whitall
National Oceanic and Atmospheric Administration
Center for Coastal Monitoring and Assessment
1305 East West Highway, N/SCI 1
Silver Spring, MD 20910
Telephone: (301) 713-3028
E-mail: dave.whitall@noaa.gov

Charlotte White
U.S. Environmental Protection Agency
Office of Water
Office of Wastewater Management
Ariel Rios Building (4203M)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Telephone: (202) 564-8559
E-mail: white.charlotte@epa.gov

John Williams
U.S. Environmental Protection Agency
Region 4
Science and Ecosystems Support Division
Enforcement and Investigations Branch
980 College Station Road
Athens, GA 30605
Telephone: (706) 355-8735
E-mail: williams.johnl@epa.gov

Daphne Wilson
U.S. Environmental Protection Agency
Region 4
Air, Pesticides, and Toxic Management Division
61 Forsyth Street
Atlanta, GA 30303
Telephone: (404) 562-9098
E-mail: wilson.daphne@epa.gov

Rick Wilson
Ohio Environmental Protection Agency
Division of Surface Water
122 S Front Street
Columbus, OH 43216-1049
Telephone: (614) 644-2032
E-mail: rick.wilson@epa.state.oh.us

Stanley Wolfe
West Virginia Department of Environmental Protection
Department of Environmental Enforcement
2031 Pleasant Valley Road, Suite 1
Fairmont, WV 26554
Telephone: (304) 368-3960
E-mail: swolfe@wvdep.org

Lance Yonkos
University of Maryland, College Park
College of Agriculture and Natural Sciences
Wye Research and Education Center
124 Wye Narrows Drive
PO Box 169
Queenstown, MD 21658
Telephone: (410) 827-8056
E-mail: ly11@umail.umd.edu

Neil Zahradka
Virginia Department of Environmental Quality
629 E Main Street
PO Box 10009
Richmond, VA 23240
Telephone: (804) 698-4102
E-mail: nrzahradka@deq.virginia.gov

Kelly Zering
North Carolina State University
Department of Agricultural and Resource Economics
Campus Box 8109
Raleigh, NC 27695-8109
Telephone: (919) 515-6089
E-mail: kelly_zering@ncsu.edu

Hank Zygmunt
U.S. Environmental Protection Agency
Region 3
Chesapeake Bay Program Office
1650 Arch Street (3CB00)
Philadelphia, PA 19103
Telephone: (215) 814-5750
E-mail: zygmunt.hank@epa.gov

Regional Science Workshop:
Animal Feeding Operations (AFOs)
Science and Technical Support Needs

College Park, MD
December 6–9, 2004

Appendix C: Workshop Evaluation Summary

The U.S. Environmental Protection Agency (EPA) held a Regional Science Workshop on Animal Feeding Operations (AFOs) Science and Technical Support Needs. The purpose of the workshop was to discuss the ongoing research at EPA, U.S. Department of Agriculture, U.S. Geological Survey, academic, and other laboratories that can support the regions in addressing the issues of excess nutrients, sediments from runoff, aerosols, veterinary pharmaceuticals, metals, hormones, and pathogens. The workshop also served to identify remaining technical support and research needs and develop collaborative research plans to address immediate and future needs.

An evaluation of the workshop was conducted to elicit information from attendees regarding the workshop organization and logistics, the information presented, and potential improvements in future workshops. A total of 10 elements were developed for the evaluation form (see Appendix A). All ten elements allowed attendees to rate the sessions and elements of the meeting on a scale of 1 (poor) to 4 (excellent). A fill-in-the-blank-section allowed the attendees to state the most and least informative sessions. Three open-ended questions allowed attendees to provide any other comments or suggestions for future workshops. Attendees also could provide additional comments regarding each of these questions. A summary of the evaluation findings is provided below. Results received for each evaluation question, including ratings and comments, follow the summary of findings.

Part I. Summary of Findings: Sessions

1. Of the 151 meeting participants, 22 completed the evaluation questionnaire, for an overall response rate of 15%.

2. The attendees rated their overall impression of the meeting. Of the 22 respondents, 14 (64%) provided a rating of 3, and 8 (36%) provided a rating of 4, for an average rating of 3.36.

3. The attendees rated the Keynote Sessions. Of the 22 respondents, 1 (5%) provided a rating of 2, 13 (59%) provided a rating of 3, and 8 (36%) provided a rating of 4, for an average rating of 3.32.

4. The attendees rated the Plenary Sessions. Of 21 respondents, 1 (5%) provided a rating of 2, 13 (62%) provided a rating of 3, and 7 (33%) provided a rating of 4, for an average rating of 3.29.

5. The attendees rated the Topic Sessions. Of 21 respondents, 13 (62%) provided a rating of 3, and 8 (38%) provided a rating of 4, for an average rating of 3.38.

6. The attendees rated the Closing Session. Of 10 respondents, 1 (10%) provided a rating of 2, 8 (80%) provided a rating of 3, and 1 (10%) provided a rating of 4, for an average rating of 3.00.

7. A total of 20 respondents provided comments about the meeting sessions.

Responses to Evaluation Questions

Part I. Summary of Findings: Sessions

Question 1: Overall Impression of Meeting

Rating: Number of Responses: 22
Highest Rating: 4
Lowest Rating: 3
Average Rating: 3.36

Question 2: Keynote Sessions

Rating: Number of Responses: 22
Highest Rating: 4
Lowest Rating: 2
Average Rating: 3.32

Question 3: Plenary Sessions

Rating: Number of Responses: 21
Highest Rating: 4
Lowest Rating: 2
Average Rating: 3.29

Question 4: Topic Sessions

Rating: Number of Responses: 21
Highest Rating: 4
Lowest Rating: 3
Average Rating: 3.38

Question 5: Closing Session

Rating: Number of Responses: 10
Highest Rating: 4
Lowest Rating: 2
Average Rating: 3.00

Part II. Summary of Findings: Meeting Elements

1. The attendees rated the meeting materials. Of the 22 respondents, 4 (18%) provided a rating of 2, 9 (41%) provided a rating of 3, and 9 (41%) provided a rating of 4, for an average rating of 3.23.

2. The attendees rated the registration process. Of the 22 respondents, 1 (5%) provided a rating of 2, 8 (36%) provided a rating of 3, and 13 (59%) provided a rating of 4, for an average rating of 3.55.

3. The attendees rated the hotel accommodations. Of 18 respondents, 1 (6%) provided a rating of 1, 1 (6%) provided a rating of 2, 6 (33%) provided a rating of 3, and 10 (56%) provided a rating of 4, for an average rating of 3.39.

4. The attendees rated the helpfulness of onsite support staff. Of 21 respondents, 6 (29%) provided a rating of 3, and 15 (71%) provided a rating of 4, for an average rating of 3.71.

5. The attendees rated the meeting room. Of the 22 respondents, 2 (9%) provided a rating of 2, 5 (23%) provided a rating of 3, and 15 (68%) provided a rating of 4, for an average rating of 3.59.

Part II. Summary of Findings: Meeting Elements

Question 1: Meeting Materials

Rating: Number of Responses: 22
Highest Rating: 4
Lowest Rating: 2
Average Rating: 3.23

Question 2: Registration Process

Rating: Number of Responses: 22
Highest Rating: 4
Lowest Rating: 2
Average Rating: 3.55

Question 3: Hotel Accommodations

Rating: Number of Responses: 18
Highest Rating: 4
Lowest Rating: 1
Average Rating: 3.39

Question 4: Helpfulness of Onsite Support Staff

Rating: Number of Responses: 21
Highest Rating: 4
Lowest Rating: 3
Average Rating: 3.71

Question 5: Meeting Room (sound, space, lighting)

Rating: Number of Responses: 22
Highest Rating: 4
Lowest Rating: 2
Average Rating: 3.59

The most informative session was:

- Air session
- Manure Management—morning. It was very easy to follow. It showed good alternatives.
- Brought together a wide spectrum of expertise from key agencies. The different needs/approaches of each were made evident. I learned about EPA air and water quality initiatives, especially.
- Air Components, because I work in air.
- Question 9, because it gave a good overall view of the alternatives for manure.
- All were good.
- Atmospheric Aerosol
- Manure Management
- Session III: Pharmaceuticals and Pathogens
- Air Quality and Manure Management
- Air Quality (1st) and Antibiotics/Pathogens (2nd and 3rd). There was a good discussion regarding ammonia and pathogens.
- Contaminant Source Tracking
- Pathogens, because it helped me to understand many concerns with CAFOs and their size and controls.
- Public Health—Wednesday at 10 a.m.
- Session III: Pharmaceuticals, because it was a good discussion.

The least informative session was:

- Bacterial Source Tracking. The session was too technical.
- The poster session was poorly organized. Not enough time during the meeting was given to this. Many workshop attendees arrived after the formal poster session.
- Manure Management, because I have no clue about this.
- None
- Regulatory Review, because I already knew the information.
- Risk Management
- Session V, because I was already very familiar with this topic.

General Comments:

What did you learn that you are most likely to take back and share with staff?

- The status and schedule of the regulatory activities was important information. Some specific technical information also will be reported back.
- Pathogen/pharmaceutical information
- There were some very good posters that I will be looking into more and many thoughts on pathogens, waste management, and nutrient management. I will take them back.
- Closing session didn't happen. I was disappointed that we left without some concrete actions.
- Who all is working on what!
- Alternative Technologies for Manure Management
- Work toward a multimedia approach
- Too much to list here
- The industry is still missing the point with their one-way communication attitude.
- The need for additional science and education
- A better understanding of the breadth of the research, but still need to continue these types of workshops.
- The extensive research that has been done in reference to air and AFOs.
- That EPA should be a strong partner in our efforts. Will become acquainted more with regional/local EPA.
- A wide variety of issues were covered. A summary of the entire meeting will be shared with staff and states.
- $PM_{2.5}$ SIPs due in 2007

What followup activities from this workshop would you recommend or like to participate in?

- Not sure, but if my expertise can benefit EPA, I'd like to share it.
- More interagency working on pathogens, pharmaceuticals, and health risks.
- As an ORD researcher, I want to keep up with what the regions and program offices want in this area and to establish ways to meet their needs!

- Continue with development of "areas of interest." Have a followup meeting (say 2 years from now) or just before complete implementation of CAFO registration in spring 2006.
- Workgroups
- Need to actively pursue agency (USDA, EPA, etc.) funding for interdisciplinary research on CAFO sites and watersheds.
- Missing proceedings
- After understanding what gaps exist, need to focus on certain research/technological areas and hold a series of these focused workshops and come up with recommendations for future research and technological development.
- Workgroups
- Policy development/discussion related to manure management.
- Another meeting addressing 2 to 3 followup objectives in 2 years.

What could be done to make future workshops on this topic more informative and/or productive?

- The day of poster ahead not effective. Do as a mixer between day one and two.
- The PowerPoints not in the book was slightly annoying.
- Don't expect speakers to start their own PowerPoints.
- Do not have posters on the first day. People meet and catch up and don't have time to get into posters. It is best to have time set aside later for more attention to posters.
- Have some products (from this workshop) in the workbook/guide; MST guide update on research.
- Concurrent sessions
- Better coordination of speakers for panels. There was too much duplication.
- Nothing
- At this point we need to focus on specific research areas, such as alternative technology; treating/testing for pathogens; and more information on EDCs.
- A better description of animal agriculture in the United States—geographic distribution of animal species, diversity of production practices. What do we wish for producers to be doing that they currently are not?

Additional Comments:

- The program was too long. Divide the focus on air quality and pharmaceuticals/pathogens.
- Very good
- This was a very good meeting to bring people up to speed on who is doing what, outside of the periodic USGS meetings. Good to hear regional needs! Tools not generally ready, still needs more work, but this identified areas for collaboration.
- The poster session was especially helpful. Hopefully, posters will be available online.
- Nice job on the workshop! The room was very nice. Thanks for working so hard to keep the program on time and flowing.
- By making the poster session a pre-opening session, we had few participants other than fellow presenters. Plus there were no set times for presenters to be at their posters (6 hours was too long of a window). Better to put poster sessions mid-meeting, afternoons with happy hour, and with focused time at the station.
- At some point, the groundwater impacts will need to be addressed, in addition to surface water issues.
- After each presentation or session, it would have been helpful to have stronger summary statements of research/technological needs (i.e., where the gaps are).
- Formation of workgroups is a wonderful thing, especially because development for air permitting needs much work.
- Need agriculture/alternative energy conference
- The meeting materials were fair. They were a bit bulky. Perhaps a CD-ROM with presentations and a single summary sheet for notes would be better.
- The hotel accommodations were poor. I was very unhappy with the room because I had to ask the desk for help with room issues more than once!
- The meeting room was fair. Not enough "elbow room"—provision of binder was great, but not enough table space if you were "shoulder to shoulder."
- Great job keeping speakers on time, but need to allow more time for questions (if not needed, keeps you ahead of schedule because some speakers always run over).
- The meeting materials were not too useful with the small table space available. Suggest either more space or smaller format or no materials at all. If slides are available on CD or online, there is not much use for binders. Besides they are a pain to take back. I think I will just take home my notes and print from the Web site.