12/3/12 Draft

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: SAB Review of Emissions-Estimating Methodologies for Broiler Animal Feeding Operations and for Lagoons and Basins at Swine and Dairy Animal Feeding Operations

Dear Administrator Jackson:

This Science Advisory Board (SAB) report responds to a request from the EPA's Office of Air and Radiation (OAR) to review and provide advice on scientific issues associated with development of Emissions-Estimating Methodologies (EEMs) at two types of animal feeding operations (AFOs): EEMs for barns or buildings at confined broiler AFO facilities and an EEM for open lagoons and basins at swine and dairy AFO facilities. EEMs are tools for estimating air pollutant emissions from industries where site-specific emissions data are not available.

The EPA developed these EEMs to address requirements of a 2005 voluntary air compliance consent agreement between the EPA and nearly 14,000 broiler, dairy, egg layer and swine AFOs. Under the agreement, the EPA will also develop EEMs for egg-layers, swine and dairy confinement facilities. The EEMs will be used by the AFO industry to estimate daily and annual emissions for use in determining regulatory responsibilities under the Clean Air Act, the Comprehensive Environmental Response, Compensation, and Liability Act and the Emergency Planning and Community Right-to-Know Act. The pollutants monitored under the agreement include: ammonia, hydrogen sulfide, particulate matter and volatile organic compounds. As part of the agreement, the EPA is charged with developing EEMs for broiler, dairy, egg layer and swine AFO sectors. There is a provision in the 2005 consent agreement that, if the SAB decides that the available data are not adequate to support development of the EEMs, the EPA can delay development of the EEMs until adequate data are available.

The EPA developed the broiler and lagoon EEMs after reviewing data on emissions from two key sources: (a) data received in response to an agency 2011 Call for Information seeking additional data on AFOs and emissions to ensure a review of the broadest range of available scientific data and (b) the National Air Emissions Monitoring Study (NAEMS). The NAEMS is a two-year study of emissions from AFOs that produce pigs, broiler chickens, egg, and milk. The study was funded by the AFO industry as part of the 2005 voluntary air compliance agreement with the EPA.

The EPA's draft EEMs are described in two draft February 2012 documents: ‘‘Development of Emissions-Estimating Methodologies for Broiler Animal Feeding Operations’’ (Broiler Report), and ‘‘Development of Emissions-Estimating Methodologies for Lagoons and Basins at Swine and Dairy Animal Feeding Operations’’ (Lagoon Report). The documents describe the sites monitored and the data submitted to the EPA. They provide a detailed discussion of the statistical methodology used to develop the draft EEMs for AFOs throughout the country. The statistical analyses evaluated parameters to determine if they were predictor variables appropriate to use to develop the EEMs.

The EPA developed broiler EEMs for ammonia, hydrogen sulfide, particulate matter and volatile organic compounds using NAEMS emissions and process information collected from two confinement facilities on one broiler operation in California and from two broiler operations in Kentucky. The EPA developed swine and dairy lagoon EEMs for ammonia by combining NAEMS emissions and process information collected from three dairies, three swine breeding and gestation farms and three swine growing and finishing farms.

The SAB finds that the models and the EEMs to be derived from them have limited application to farms across the United States. The models were based on data from three broiler facilities and nine swine and dairy facilities. The models used to develop EEMs represent a very small fraction of the one-half million AFOs in the country. The EEMs developed from these limited data, however, are intended to be applied to AFOs throughout the country. The EEMs use a small number of factors considered to affect emissions and employ mathematical models with some key variables that cannot be extrapolated beyond the range of values, conditions, and types of farms in the limited data set. Such models are not well suited for extrapolation to conditions beyond those represented in the data set and therefore the EEMs may not be assumed to be accurate predictors of emissions from other farms in the United States. The SAB recommends that the EPA not apply the current versions of the statistical and modeling tools for estimating emissions beyond the farms in the data set. The EPA should consider using data collected through mechanisms outside of the consent agreement, including data appearing in or supporting peer-reviewed literature and additional data that the EPA has collected since receipt of the data responding to EPA’s Call for Information. These additional sources of information would expand the data set and the applicability of the model.

In addition, the SAB does not support the combination of swine and dairy lagoon/basin datasets to develop swine and dairy EEMs and finds significant problems with the EPA’s approach of using static predictor variables as surrogates for data on dynamic lagoon/basin conditions. The SAB finds significant uncertainties associated with the broiler volatile organic compounds data used in the EPA’s analysis and concludes that these data are insufficient to support development of a broiler EEM for volatile organic compounds at this time. The EEMs and associated reports should be revised to improve the statistical analyses of the datasets and to reflect processes that influence emissions at AFO sectors more appropriately.

The SAB strongly recommends that the EPA develop a process-based modeling approach to predict air emissions from broiler confinement facilities and swine and dairy lagoons/basins. A process-based model would quantify the flows of materials from one process on a farm to the next (e.g., flows from feed through the animal housing to manure storage to field application and crop production). Process-based models would require consideration of emissions from each component of the farm system based on the concentrations and amount of reactants that lead to the emission from that component. Process-based models would be more likely to be successful in representing a broad range of conditions than the empirical models (i.e., models based on empirical observations rather than on mathematically describable relationships of the system modeled) that are currently being used by the EPA because process-based models represent the chemical, biological and physical processes and constraints to be addressed by EEMs. This recommendation is consistent with recommendations provided to the EPA in the 2003 National Research Council report *Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs*. In their most rigorous forms, process-based models for developing EEMs are data intensive. Process considerations, however, can be incorporated into models at a variety of levels of complexity. The EPA should consider developing EEMs at a variety of levels of complexity to provide options for producers with different levels of data availability and data and model uncertainty. While the NAEMS does not provide sufficient data to implement a rigorous process-based modeling approach, it is sufficient to start the development and evaluation of a process-based modeling approach that would reflect the heterogeneity of AFOs. The EPA should identify critical data gaps and begin the process of identifying key parameters to include within process-based models. The EPA should also consider conducting a full mass balance analysis to help identify key parameters to be used in a process-based modeling approach. The SAB has identified in this report several key factors and parameters affecting emissions that the EPA should consider to help develop process-based modeling. The report recommends several alternative approaches for developing a draft process-based lagoon/basin EEM for ammonia emission. The SAB also makes several recommendations regarding the EPA's handling of negative and zero values for both direct concentration measurement and calculated emission values.

The SAB recognizes that the EPA may need to apply statistical approaches to assess emissions while it is developing and evaluating process-based models. The SAB provides suggestions in this report to improve the agency's statistical approach for developing EEMs.

The SAB appreciates the opportunity to provide the EPA with advice on this important subject. We look forward to receiving the agency's response and to providing future advice on this topic.

Enclosures

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ACRONYMS AND ABBREVIATIONS

AFOs	Animal Feeding Operations
AFO Panel	SAB Animal Feeding Operations Emissions Review Panel
ASAE	American Society of Agricultural Engineers
bLS	Backward Lagrangian Stochastic Model
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH_4	Methane
EEMs	Emissions-Estimating Methodologies
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Emission Rate
H_2S	Hydrogen Sulfide
MDL	Minimum Detection Level
NAEMS	National Air Emissions Monitoring Study
N	Nitrogen
NH_3	Ammonia
NH_4	Ammonium
OAR	Office of Air and Radiation
PM	Particulate Matter
QA/QC	Quality Assurance/Quality Control
RPM	Radial Plume Mapping
S	Sulfur
SAB	EPA Science Advisory Board
SAS	Statistical Analysis Software
SPV	Static Predictor Variables
THM	Trihalomethanes
TSP	Total Suspended Particulates
VOCs	Volatile Organic Compounds
VR	Ventilation Rate

1. EXECUTIVE SUMMARY

Overview

The EPA's Office of Air and Radiation (OAR) requested the Science Advisory Board (SAB) to review two draft documents related to animal feeding operations (AFOs) emissions [''Development of Emissions-Estimating Methodologies for Broiler Animal Feeding Operations''(hereafter, the "Broiler Report"] and ''Development of Emissions-Estimating Methodologies for Lagoons and Basins at Swine and Dairy Animal Feeding Operations'' (hereafter, the "Lagoon Report)}. In these documents, EPA described draft emissions-estimating methodologies (EEMs) for broiler AFOs and for lagoons and basins at swine and dairy AFOs to address requirements of a 2005 voluntary air compliance consent agreement between the EPA and nearly 14,000 broiler, dairy, egg layer, and swine AFOs[1]. The EPA requested the SAB to provide advice on scientific issues associated with development of the EEMs. The SAB was asked to comment on various aspects of the EPA's draft reports, including the overall approach for developing the EEMs, combination of lagoon and basin data, use of static predictor variables within the EEMs, specific approaches for development of the ammonia (lagoon NH_3) and broiler volatile organic compound (VOC) EEMs and handling of negative and zero data results.

The EPA developed draft EEMs for broiler confinement facilities and for open lagoons and basins at swine and dairy AFOs after reviewing data on emissions from two key sources: a) the National Air Emissions Monitoring Study (NAEMS)[2] and b) data that the EPA received in response to a Call for Information[3] seeking additional data on AFOs and emissions to ensure that the agency reviewed the broadest range of available scientific data. The NAEMS was a two-year study of emissions from AFOs that raise pigs and broiler chickens, and from egg-laying operations and dairies. The study was funded by the AFO industry as part of the 2005 voluntary air compliance agreement with the EPA.

The SAB Animal Feeding Operations Air Emissions Review Panel (AFO Panel) reviewed the draft EPA documents, considered public comments and held a public meeting on March 14, 15 and 16, 2012 to develop advice on the scientific adequacy, suitability and appropriateness of the EPA's EEMs and draft reports. At the March 2012 public meeting, the SAB Panel considered oral comments from the public. The panel requested additional data and information from the EPA which the agency provided in July[4] and August[5] 2012. The Panel held a follow-up public teleconference call on August 13, 2012 to review

[1] See *Federal Register Notice* Volume 70, Number 60, Pages 4958-4977, published on January 31, 2005.
[2] See http://www.epa.gov/oecaagct/airmonitoringstudy.html.
[3] See *Federal Register Notice* Volume 76, Number 12, Pages 3060-3062, published on January 19, 2011.
[4] See EPA's July 2012 Report, "Additional Data for SAB Review: EPA's Emissions Estimating Methodologies for Animal Feeding Operations for Broiler Sector and for Swine and Dairy Lagoons and Basins", available at http://yosemite.epa.gov/sab/sabproduct.nsf/B69FE142E3285B6385257A390047842C/$File/Additional+Data-EPA+Emissions+Estimating+Methods+for+AFOs-Broiler+Sector+and+Swine+&+Dairy+Lagoons+&+Basins-July+2012.pdf.
[5] See EPA's August 2012 Report, "Additional Supplemental Data in response to Question 3.2.1. as outlined in EPA's July 2, 2012 response document entitled "Additional Data for SAB Review: EPA's Emissions Estimating Methodologies for Animal Feeding Operations for Broiler Sector and for Swine and Dairy Lagoons and Basins", available at http://yosemite.epa.gov/sab/sabproduct.nsf/566AFE582D17F01685257A54007265CA/$File/Supplement+to+Additional+Data+for+SAB+Review-EPA's+Emissions+Estimating+Methodologies+for+Animal+Feeding+Operations.pdf.

the EPA's responses and additional data. The Panel considered whether the EPA's supplemental responses changed any of the Panel's preliminary findings and recommendations identified at the March 2012 SAB Panel meeting. The AFO Panel held a public teleconference on October 24, 2012, to discuss substantive comments from Panel members on this draft SAB report. The body of this report provides the advice and recommendations of the SAB through the efforts of the SAB Animal Feeding Operations Emissions Review Panel.

In its review of the EEMs, the SAB finds that the EPA used a small number of broiler, swine and dairy facilities to develop draft EEMs, and the EEMs developed from this limited sample are intended to be applied to AFOs throughout the country. The methods used in developing the EEMs are not well suited for extrapolation to conditions beyond those represented in the data set. Therefore the EEMs may not be assumed to be accurate predictors of emissions from other farms in the United States. The SAB advises the EPA not to apply the current versions of the models for estimating emissions beyond those covered in the data set.

There is a provision in the Consent Agreement that, if the SAB decides that the available data are not adequate to support development of the EEMs, the EPA can delay development of the EEMs until adequate data are available[6]. As outlined in responses to specific charge questions below, the EPA should consider using data collected through mechanisms outside of the consent agreement, including data published in peer-reviewed literature, to expand the data set. SAB strongly recommends that the EPA not combine the swine and dairy datasets. A combination of these two datasets would overlook the basic differences in microbial processes and waste characteristics and undermine the credibility of conclusions drawn from such analyses. The SAB finds significant limitations inherent in the EPA's approach of using static predictor variables as surrogates for data on dynamic lagoon/basin conditions because such an approach obscures key emission processes and variable interactions. The approach fails to account for regional and inter-species variability among the fundamental drivers of emission processes. In addition, there are significant uncertainties associated with the broiler VOC data used in the EPA's analysis, and these data are insufficient to support development of a broiler EEM for VOCs at this time.

The SAB strongly recommends that the EPA use a process-based modeling approach to predict air emissions from broiler confinement facilities and swine and dairy lagoons/basins. This recommendation is consistent with recommendations provided to EPA in the 2003 National Research Council report *Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs*. Process-based models are more likely to be successful in representing the broad range of AFO conditions than the statistical models used in the draft Broiler and Lagoon Reports because process-based models represent the chemical, biological and physical processes and constraints to be addressed by EEMs.

A process-based model would quantify the flows of materials from one process on a farm to the next The EPA should develop a modeling approach that allows opportunity to add data as additional information becomes available. The SAB also encourages EPA to estimate uncertainty associated with predictions from the modeling approaches that are developed.

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[6] See *Federal Register Notice* Volume 70, Number 60, Pages 4958-4977, published on January 31, 2005.

In addition, the SAB recommends that after the EPA updates its approaches for developing EEMs for broiler confinement facilities and swine and dairy lagoons/basins consistent with SAB's advice, the agency should use these updated approaches to develop draft EEMs for egg-layers, swine and dairy confinement facilities. The EPA should develop a process-based modeling approach to make predictions of air emissions from these sectors.

The SAB recognizes that there are potential drawbacks with developing and applying process-based models to assess emissions at AFO facilities. Since a single set of processes may not control emissions all farms across the nation in a particular AFO sector, a large number of parameters and static variables may be required to address the variety of factors that affect emissions within a sector. Also, interactions between the parameters may need to be assessed and incorporated into the modeling approach. Since different farms may have different processes that control emissions, process based models should be robust enough so that input variables would discriminate between these different conditions. The EPA should estimate and evaluate uncertainty associated with different modeling approaches during the model building exercise, to determine the degree to which different models might be required.

A more detailed description of the technical recommendations is included in this SAB report, and the responses to specific charge questions are highlighted below.

Charge Question 1: EPA'S Approach for Developing the EEMS

Please comment on the statistical approach used by the EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition please comment on the approach for developing draft EEMs for egg-layers, swine and dairy confinement houses.

The EPA developed separate broiler confinement facility EEMs for ammonia (NH_3), particulate matter $(PM)_{10}$, $PM_{2.5}$,total suspended particulates (TSP), volatile organic compounds (VOCs), and hydrogen sulfide (H_2S) using emissions and process information collected from one broiler operation in California and from two broiler operations in Kentucky. The EPA developed a swine and dairy lagoon open source EEM for NH_3 using emissions and process information collected from three dairies, three breeding and gestation swine farms, and three swine growing and finishing farms. EPA used Statistical Analysis Software (SAS) to evaluate parameters statistically to determine if predictor variables could be used by the EPA to develop these EEMs. Based on the results of the EPA's predictor analysis, broiler EEMs were developed using the following input parameters: bird inventory; ambient meteorological parameters (i.e., temperature, relative humidity, and barometric pressure), and confinement parameters (i.e., house temperature and relative humidity). EPA's swine and dairy lagoon NH_3 EEM was developed using the following input parameters: ambient temperature, relative humidity, solar radiation, and wind speed.

The SAB has a number of suggestions for improving the modeling approach used by the EPA for developing the draft EEMs for broiler confinement facilities and swine and dairy lagoons/basins. The EEMs developed from the limited data are intended to be applied to AFOs throughout the country. The SAB finds that the EPA's EEMs in both reports are based on statistical analyses of datasets that use a small number of input parameters. They are dependent mathematically on key variables (e.g., bird weight) that cannot be confidently extrapolated beyond the range of values in the data set. The data are not well suited for extrapolation to conditions beyond those represented in the data set and therefore the EEMs derived from them may not be assumed to be accurate predictors of emissions from other farms in the United States.

The SAB recommends that the EPA should not apply the current versions of the statistical and modeling tools for estimating emissions beyond the range of values in the data set. The EPA should consider using data collected through mechanisms outside the consent agreement, including data published in or that support literature, raw data from key studies, and additional data that the EPA has collected since receiving data in response to the Call for Information[7] that the EPA released that sought additional data on AFOs and emissions. Literature that should be considered are included as references to this SAB report. The Broiler and Lagoon Reports should include model uncertainty analysis that recognizes the limitations of using a small number of locations. The EPA should estimate and evaluate uncertainty associated with different modeling approaches during the model building exercise to determine the degree to which different models might be required. The EPA should consider approaches in addition to the cross-validation method used to evaluate the EEMs.

In addition, application of polynomial regression for nonlinear models (e.g., the use of cubic functions to represent nonlinear dependence in average mass of animals) leads to poor predictions near the extremes of the experimental conditions and when the models are extrapolated outside of the data set range ,as would be likely in application of the EEMs to AFOs nationwide. The EPA should restrict the range of mass that should be reported if the cubic model is used and orthogonal polynomials should be used if a polynomial approach is taken. The EPA should also provide more information on the merits of applying such regression analysis within this project. The agency should create a modeling approach that can be applied using default parameters that can be simply attained. The EPA should also develop a modeling approach that allows opportunity to add data if data is available that would reflect the heterogeneity of AFOs.

The SAB also strongly recommends that the EPA should develop a process-based modeling approach to predict air emissions from broiler confinement facilities and swine and dairy lagoons/basins. A process-based model would quantify the flows of materials from one process on a farm to the next (e.g., flows from feed through the animal housing to manure). Process-based models represent the chemical and physical processes in an EEM and are more likely than the current models to be successful in representing a broad range of conditions. The EPA should consider developing EEMs at a variety of levels of complexity to provide options for producers with different levels of data availability. A simple approach might use a small number of variables to place constraints on predicted emissions, such as limiting total predicted ammonia emissions based on the nitrogen available in feed. A more complex approach to the same emissions might attempt to perform a mass balance on nitrogen. The EPA should also identify critical data gaps associated with development of such modeling approaches and begin the process for identifying the key parameters to be included within the process-based models. The EPA should consider conducting a full mass balance analysis to help in the assessment of key parameters that would be used in a process-based modeling approach.

[7] See *Federal Register Notice* Volume 76, Number 12, Pages 3060-3062, published on January 19, 2011.

The SAB has identified in this report key factors and parameters that the EPA should consider within process-based modeling approaches. The NAEMS does not provide sufficient data to evaluate and estimate coefficients for a modeling approach for estimating emissions that incorporates all of the key factors and parameters. In particular, the NAEMS data set does not include sufficient information for the steps from feed development to manure collection. Also, the NAEMS swine and dairy lagoons/basins data are particularly limited regarding feed input data, nutrient and chemical loading inputs into lagoons, and the chemical and physical composition and pH of lagoons.

Charge Question 2: Combination of Lagoon and Basin Data

Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.

After conducting an initial analysis of the NAEMS data submitted for swine and dairy lagoons/basins, the EPA began developing a draft EEM for NH_3. The EPA's review of the literature indicated that lagoon/basin emissions were influenced by several factors, including lagoon/basin pH and temperature. To enable the dataset used to develop the draft EEM to represent all seasonal meteorological conditions for the entire two-year monitoring period, the EPA decided to combine the swine and dairy data to develop the draft NH_3 EEM, and is considering whether to combine the swine and dairy data to develop the draft H_2S EEM. Although this combination of data sets attempts to resolve problems associated with inadequate sample design by combining data from separate species, the SAB strongly recommends that the EPA not combine the swine and dairy datasets. The differences in nutrient concentration and manure composition between swine and dairy lagoons and dairy basins make it erroneous to combine the data from these sources. Lagoons and basins are not the same and operate very differently; a lagoon is used to provide biological treatment and long term storage, and a basin is used for short term storage and may not provide biological treatment. Lagoon decomposition of manure is much greater than in a basin, since lagoons maintain bacterial populations to aid in the digestion of newly added manure while basins do not. In addition, characteristics of swine and dairy manure are significantly different. A combination of these two datasets would overlook the basic differences in microbial processes and waste characteristics and undermine the credibility of conclusions drawn from such analyses.

Furthermore, it is not appropriate to combine the data from different lagoons/basins within species if there are no predictor variables describing the chemical, physical, and biological characteristics of the lagoons in the model. For example variations in the chemical composition of dairy lagoons across the country, driven by differences in manure handling systems, lead to differences in the processes that control ammonia (or other compound) emissions. Separating the swine and dairy lagoon data while still using the predictor variables selected in the current EEMs (i.e., ambient temperature, relative humidity, solar radiation and wind speed) will only provide an estimate for the specific lagoons included in the dataset.

Charge Question 3: Use of Static Predictor Variables

Please comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA consider specific alternative approaches for statistically analyzing the data that would allow for the site-specific lagoon liquid characteristics to be used as predictor variables?

To maximize the number of NH_3 emissions measurements used to develop the draft EEM, the EPA used static predictor variables as surrogates for data on lagoon/basin conditions (i.e., nitrogen content of lagoon liquid, lagoon pH, oxidation reduction potential and temperature). The EPA used the static variables of animal type, total live mass of animal capacity on the farm, and the surface area of the lagoon to represent total nitrogen loading rates and the potential for release to the air. There are significant problems with using static predictor variables as surrogates for data on lagoon/basin conditions. Such an approach obscures key emission processes and variable interactions and does not account for regional and inter-species variability among the fundamental drivers of emission processes. It would be inappropriate to extrapolate this approach to operations not represented by the study locations.

Several of EPA's static predictor variables are also individually deficient. For example, the lagoon/basin surface area is generally highly variable at swine and dairy facilities, particularly in situations where lagoons/basins have sloping sides, where small changes in water depth can translate into large changes in surface area. Also, animal numbers represent a fundamental variable that drives nitrogen loading and, subsequently, NH_3 emissions. In addition, the range of climatic, management, feeding, and animal-performance conditions represented by the AFOs in the NAEMS is too narrow to provide reliable emission estimates across the full range of conditions in which dairy and swine producers operate in the United States. (e.g., moderate winters or extended, hot summers are not represented).

As discussed in more detail under the response under Charge Question 1, the SAB recommends that the EPA develop a process-based approach that uses appropriate, biologically-, physically-, and chemically-based, region- and species-specific variables. Functional relationships in any statistical model should be based on the key drivers of emission processes.

Charge Question 4: Alternative Approaches for Statistically Developing the NH_3 EEM

Does the SAB recommend that EPA consider alternative approaches for developing the draft NH_3 EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions. If so, what specific alternative approaches would be appropriate to consider?

The SAB concludes that the EPA should consider the following alternative approaches for statistically developing a draft lagoon NH_3 EEM, since there are limited data and the EEM needs to be broadly applicable across the United States for determining emissions from lagoons:

- <u>Expand Data Completeness Methodology:</u> The EPA's data completeness methodology assumes that a valid monitoring hour is one in which 75 percent of the data recorded during that hour were valid. EPA should expand its data completeness criteria in order to increase the amount of data available to develop an NH_3 EEM. SAB finds that the EPA should include data with less than 75 percent completeness for any given hour, since there are already many gaps in the data used for the development of these EEMs. In addition, the EPA should examine the 75 percent completeness criteria for daily averages (A valid monitoring day is one in which 75 percent of the hourly average data values used were valid). EPA should consider whether the missing hourly values are random or whether they occurred in some discernible pattern, and consider using methods to "gap fill" missing data.

- Use Backward Lagrangian Stochastic (bLS) Data Instead of Radial Plume Mapping (RPM Data) or in Conjunction with RPM Data: EPA's calculated daily lagoon emissions were developed based on measurements obtained using the RPM model rather than the bLS model. The EPA should consider using the emissions estimated with the bLS method, since there is such a paucity of data in the current RPM dataset. Since the drivers of emissions (i.e., lagoon chemistry and biology) are changing slowly (more in terms of weeks or months, not minutes), it may be preferable to use daily average data values rather than hourly values. If daily values are used, the bLS dataset has 285 valid days as opposed to only 69 valid days using the RPM model. These daily averages could be used in conjunction with measured lagoon characteristics in order to develop a more robust model. In addition, published validation studies indicate that the bLS model has performed very well for open area sources.

- Revise Units for Emissions Estimates: The EPA's unit for emissions is kg/30-min. SAB finds that EEMs that use kg/ha or kg/live wt or some other denominator that captures the physical differences of the operations would more appropriately account for actual emissions that are released at dairy and swine facilities.

- Use Appropriate Predictor Variables to Estimate Emissions: The EPA should apply both the environmental factors (manure temperature, air temperature, wind speed, and solar radiation) and predictor factors/variables that actually drive emissions. These variables include available lagoon chemistry data such as nitrogen content and pH of the lagoon, and the manure management system. The potential effects of surface crust on reducing emissions should also be considered. The EPA's predictor factors/variables should have realistic biological thresholds and boundaries to ensure that the methodology does not result in an estimated emission rate that is not feasible. The EPA should compare the results of the EEMs that it develops with emissions reported in the literature.

Charge Questions 5 and 6: Approaches for Handling Negative and Zero Data

Please comment on the EPA's approach for handling negative or zero emission measurements. In the interest of maximizing the number of available data values for development of the draft H2S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero data other than the approach used by the agency.

Some NAEMS emissions measurements were reported as either negative or zero emissions values. The EPA considered whether to include these negative and zero emissions values in the data used to develop the EEMs. The agency evaluated whether the negative or zero values represented variability in emissions measurements due to instrument/equipment performance and concluded that all negative values should not be considered in the development of the EEMs. The EPA also reviewed the data to see if the data quality measures were properly performed according to the Quality Assurance Project Plan.

The SAB has several recommendations regarding the EPA's handling of negative and zero values for both direct concentration measurement and calculated emission values. In general, a zero or negative direct concentration measurement value can occur due to a true value that is at or below the Minimum Detection Level (MDL), instrument measurement error, a measurement value that is adjusted by the equipment calibration offset procedure, and instrument fluctuation due to influence by ambient conditions. Each of these cases is considered individually and recommendations are provided in the full report. In some cases the SAB recommends that zero and negative direct concentration values be included in the development of EEMs.

Negative and zero calculated emission data should be generally included when calculating EEMs. If the measured concentration data are considered valid and included in the dataset, then the emission value calculated from that dataset should also be considered valid, whether it is negative, zero or positive. If the calculated value is negative, The EPA should consult the raw data to assess whether the value was due to calculation, instrument results, ambient conditions, or some other effect.

Outliers (observations that appear to be different from the other observations in the sample set) should be first treated per the quality assurance/quality control process to determine (if possible) their origin and then included or not in EPA's analyses with a clear explanation for the decisions made.

Charge Question 7: Broiler VOC EEM

Please comment on the approach EPA used to develop the draft broiler VOC EEM.

The EPA reviewed the VOC data submitted for the California and Kentucky broiler sites. The two sites used different VOC measurement techniques. Based on analysis of the measurement and analytical techniques and the VOC data, EPA used only the VOC data from the Kentucky sites when developing the draft VOC EEM.

There are significant uncertainties associated with the broiler VOC data collected as part of the NAEMS, and the SAB therefore concludes that the broiler VOC data cannot support the development of a broiler VOC EEM at this time. Although the NAEMS dataset is too limited to produce an EEM, there are valuable components of the VOC data that should be reported. The KY1B VOC data may generally be valid and usable if the EPA extensively and clearly documents the methods that were used to collect VOC data. The EPA should also provide information on the total and speciated VOC concentrations at the sites where data were collected. SAB recommends that the EPA investigate the factors that drive generation of VOC emissions from broiler facilities and develop a process-based modeling approach to estimate VOC emissions from these operations.

General Comments on the Draft Broiler and Lagoon Reports

In addition to evaluating the technical content of the reports, the SAB considered whether the draft Broiler and Lagoon Reports were presented in a clear, comprehensive, and scientifically sound manner. This SAB report suggests alternative analyses or presentation that should be conducted. Overall, many areas of the draft reports should be enhanced to strengthen the clarity and scientific basis of the EPA's analyses. Both reports should be updated to set a long-term goal for producing process-based models and to indicate additional data received by the agency from Dr. Al Heber of Purdue University, the NAEMS science advisor, since the time of the initial publication of the NAEMS dataset. The SAB also concludes that the reports should more comprehensively describe data completeness, representativeness, and limitations, and whether there are sufficient data to begin a process-based modeling approach. Various suggestions are included for improving the EPA's statistical approach. Furthermore, SAB recommends that the reports more fully explain why any of the NAEMS data were excluded from EEM development. Since NAEMS data have significant limitations, the reports should include an assessment that considers use of data that were not collected as part of the NAEMS data collection effort.

2. INTRODUCTION

2.1. Background

In 2011, the EPA's Office of Air and Radiation (OAR) initiated development of draft emissions-estimating methodologies (EEMs) for animal feeding operations (AFOs) at broiler confinement facilities and for open lagoons and basins at swine and dairy AFOs. EEMs are tools for estimating emissions from AFOs and are commonly used to estimate emissions from industries where site-specific emissions data are not available. The EPA developed EEMs for confinement structures (e.g., barns or buildings at broiler facilities) and for open area sources (i.e., lagoons and basins at swine and dairy facilities).

The EPA developed the EEMs for broiler confinement facilities and for open lagoons and basins at swine and dairy AFOs to address requirements of a voluntary air compliance consent agreement signed in 2005 between the EPA and nearly 14,000 broiler, dairy, egg layer and swine AFOs. The goals of the agreement are to reduce air pollution, monitor AFO emissions, promote a national consensus on methodologies for estimating emissions from AFOs, and ensure compliance with the requirements of the Clean Air Act (CAA), the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Emergency Planning and Community Right-to-Know Act (EPCRA). The EEMs will be used by the AFO industry to estimate daily and annual emissions for use in determining their responsibilities under these regulatory programs. The pollutants monitored under the agreement include: ammonia, hydrogen sulfide, particulate matter, and VOCs. As part of the agreement, EPA is charged with developing EEMs for broiler, dairy, egg layer and swine AFO sectors. There is a provision in the Consent Agreement that, if the SAB decides that the available data are not adequate to support development of the EEMs, the EPA can delay development of the EEMs until adequate data are available[8].

At broiler confinement facilities, young chickens between 28 to 63 days old are raised for meat. The most common type of housing for broilers is enclosed housing with a compacted soil floor covered with dry bedding such as sawdust, wood shavings, or chopped straw. Mechanical ventilation is typically provided using a negative-pressure system, with exhaust fans drawing air out of the house, and fresh air returning through ducts around the perimeter of the roof.

Swine AFOs involve the breeding and growth of pigs for meat. Dairy AFOs produce milk. At many swine and dairy AFOs, manure handled as a slurry or liquid is stored in external earthen impoundments such as anaerobic lagoons. Lagoons are designed to hold the total volume of manure and process wastewater generated in addition to precipitation runoff. In the dairy industry, liquid-solid separation may be used to remove solids collected from runoff from dry lots and/or flushed manure from barns and milking centers. The liquid wastes separated from solid wastes are sent to an external storage pond or anaerobic lagoon, usually constructed as an earthen basin.

The EPA developed EEMs for broiler confinement facilities and for open lagoons and basins at swine and dairy AFOs after reviewing data on emissions from two key sources: a) the National Air Emissions

[8] See *Federal Register Notice* Volume 70, Number 60, Pages 4958-4977, published on January 31, 2005.

Monitoring Study (NAEMS) and b) data that the EPA received in response to its Call for Information[9] seeking additional data on AFOs and emissions to ensure that the agency reviewed the broadest range of available scientific data. The NAEMS was a two-year study of emissions from AFOs that raise pigs and broiler chickens, and from egg-laying operations and dairies. The study was funded by the AFO industry as part of the 2005 voluntary air compliance agreement with the EPA.

2.2. SAB Review

During the summer of 2011, the EPA requested the Science Advisory Board (SAB) to provide advice on scientific issues associated with the EPA's development of the EEMs. In February 2012, the EPA developed two draft documents (''Development of Emissions-Estimating Methodologies for Broiler Animal Feeding Operations '' and ''Development of Emissions-Estimating Methodologies for Lagoons and Basins at Swine and Dairy Animal Feeding Operations''). The documents provided to the SAB describe the sites monitored, the data submitted to the EPA, and a detailed discussion of the statistical methodology used to develop the draft EEMs. After addressing SAB advice in the Broiler and Lagoon Reports, the EPA intends to use the updated overall approach to develop draft EEMs that was used in the Broiler and Lagoon Reports for egg-layer AFO facilities and swine and dairy AFO confinement facilities.

The EPA asked the SAB to provide advice on the agency's overall approach for developing the EEMs. The EPA also requested advice on whether it should combine lagoon and basin data, whether it should use static or dynamic predictor variables for its model and how to handle data that were reported as negative or zero results. In addition, the EPA requested advice on alternative approaches for developing the NH_3 EEM for swine and dairy facilities and on whether it should develop an EEM for VOCs.

The SAB Animal Feeding Operations Air Emissions Review Panel (AFO Panel) reviewed the draft EPA documents, considered public comments that were received on the draft documents, and held a public meeting on March 14, 15 and 16, 2012 to provide advice to EPA on the scientific adequacy, suitability and appropriateness of EPA's draft documents. The AFO Panel considered oral statements that were received from the public during the public meeting and written public comments that were received on the draft EPA documents. At the March 2012 public meeting, the AFO Panel raised several questions and requested additional data. The EPA responded to these requests and provided information to the AFO Panel in July and August 2012. The SAB AFO Panel held a follow-up public teleconference call on August 13, 2012 to review the agency's additional information and to consider whether the EPA's supplemental responses changed any of the AFO Panel's preliminary findings and recommendations identified at the March 2012 public meeting. The AFO Panel held a public teleconference on October 24, 2012, to discuss substantive comments from Panel members on this draft SAB report.

The EPA plans to consider SAB advice on the draft Broiler and Lagoons Reports as it finalizes those documents. SAB recommends that after the EPA updates its approaches for developing EEMs for broiler confinement facilities and swine and dairy lagoons/basins consistent with SAB's advice, the agency should use these updated approaches to develop draft EEMs for egg-layers, swine and dairy confinement facilities.

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[9] See *Federal Register Notice* Volume 76, Number 12, Pages 3060-3062, published on January 19, 2011.

The Executive Summary highlights the SAB's major findings and recommendations. The SAB's full responses to the charge questions are detailed in Section 3. Section 4 provides recommendations to guide the EPA in revising the Broiler and Lagoon Reports.

3. RESPONSES TO THE EPA'S CHARGE QUESTIONS

3.1. THE EPA'S Approach for Developing the EEMS

Question 1: Please comment on the statistical approach used by the EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition please comment on the approach for developing draft EEMs for egg-layers, swine and dairy confinement houses.

3.1.1. Background

The EPA developed separate broiler confinement facility EEMs for NH_3, PM_{10}, $PM_{2.5}$, TSP, VOC and H_2S using NAEMS emissions and process information collected from one broiler operation in California and from two broiler operations in Kentucky. EPA applied Statistical Analysis Software (SAS) to evaluate parameters statistically to determine if they were predictor variables appropriate to use to develop the EEMs. Based on the results of the predictor analysis, EPA developed broiler EEMs using the following input parameters: bird inventory; ambient meteorological parameters (i.e., temperature, relative humidity, and barometric pressure) and confinement parameters (i.e., house temperature and relative humidity).

The EPA developed a swine and dairy lagoon open source EEM for NH_3 using NAEMS emissions and process information collected from three dairies, three breeding and gestation swine farms and three swine growing and finishing farms. The EPA applied SAS to evaluate the parameters statistically and determined input parameters in a manner similar to that used to develop the broiler EEMs. The EPA developed its swine and dairy lagoon NH_3 EEM using the following input parameters: ambient temperature, relative humidity, solar radiation and wind speed.

The EPA evaluated the parameters statistically using a mean trend function that provided a point prediction of emissions under a given set of conditions. The agency chose a mean trend function to quantify the relationship between predictor variables and pollutant emissions by analyzing the emissions data. The EPA also chose a probability distribution and covariance function to quantify other contributions to variability in emissions and to provide estimates of uncertainty.

3.1.2. Response

A small number of broiler, swine and dairy facilities were used to develop the EEMs, and the EEMs developed from this limited sample are intended to be applied to AFOs throughout the country. The methods used in developing the EEMs are not well suited for extrapolation to conditions beyond those represented in the data set and therefore the EEMs may not be assumed to be accurate predictors of emissions from other farms in the United States. The SAB concludes that the EPA should not apply the current versions of the models for estimating emissions beyond the farms in the data set.

The SAB strongly recommends that the EPA develop process-based models of air emissions from AFOs of all types (e.g., broiler, dairy, egg layers, swine, etc.). This approach was recommended previously and described in detail by the National Research Council (NRC 2003). A process-based model would quantify the flows of materials from one process on a farm to the next (e.g., flows from feed through the animal housing to manure storage to field application and crop production). Rigorous process-based models would require consideration of emissions from each component of the farm system based on the concentrations and amount of reactants that lead to the emission from that component.

Statistical Approach:

The SAB reviewed the statistical approach taken by the EPA for estimation of air emissions from broiler confinement operations and dairy and swine lagoons.

The SAB recommends that the EPA should not apply the current versions of the statistical and modeling tools for estimating emissions beyond the farms in the data set, since it may not be possible to use the EEM broiler and lagoon/basin models developed by the EPA to extrapolate to other farms with reasonable accuracy. While the statistical approach to analysis of the data may be acceptable for the small number of locations and limited range of conditions represented in the dataset, the EEMs are not well suited for extrapolation to conditions beyond those represented in that dataset. Such extrapolations will be necessary if the EEMs are applied nationally. Further, some of the variables used for the model predictions do not make mechanistic sense. It would be more plausible and more credible to use variables known to be logically or experimentally linked to emissions (e.g., nitrogen content of litter to predict ammonia emissions). Such variables would be more likely to perform well across a broader collection of facilities than the variables used by the EPA in the draft EEMs.

To make accurate predictions across farms, measurements of a larger number of farms that adequately represent conditions at farms across the U.S. are required. Only two sites were evaluated for broiler operations, and this limited number of sites is unlikely to represent the industry as a whole. Only one site was used to estimate VOC emissions from broiler houses, and this was clearly not adequate to derive meaningful conclusions for the entire industry nationwide. In addition, the six swine and three dairy lagoons sampled cannot represent all lagoons across both industries. The SAB cautions against the use of polynomial models when the use of the model is likely to extend beyond the range of data measured to develop the relationships since such models can lead to clearly erroneous predictions under certain production regimes employed in the United States. (e.g., negative emissions or “near zero” emissions from large birds).

The SAB finds that most emission measures were over-weighted for periods of higher emissions such as during warmer weather, and the range in weather parameters for the dataset may not reflect the range in measurements across the country. The SAB recommends that the EPA evaluate the effects of weather on emissions and evaluate the ranges in weather patterns within the dataset, relative to the industry across the United States, to determine how much of the data collected can be extrapolated to farms in different climatic regions. In general, ranges of data should be explained in the reports and extrapolation beyond those limits should be counter indicated.

In addition, the EPA should create a modeling approach that relies on default parameters that can be attained by most farms within a reasonable budget. The modeling approach should allow opportunity to add data if new data are available that would reflect the heterogeneity of AFOs. The EPA should estimate and evaluate uncertainty associated with different modeling approaches during the model building exercise to determine the degree to which different models might be required.

In descriptions of the methodology supporting the EEM, the EPA should describe methods for calculating confidence values to present variability of data, include quantitative statistical analyses that compare the confinement buildings (i.e., house) for the animals, consider additional approaches besides the cross-validation method used to evaluate the model, and more comprehensively describe data completeness, representativeness, and limitations.

Process-Based Models

The SAB strongly recommends that the EPA develop process-based models of air emissions from AFOs of all types (e.g., broiler, dairy, egg layers, swine, etc.). This approach was recommended previously and described in detail by the National Research Council (NRC 2003). A process-based model would quantify the flows of materials from one process on a farm to the next (e.g., flows from feed through the animal housing to manure storage to field application and crop production). Rigorous process-based models would require consideration of emissions from each component of the farm system based on the concentrations and amount of reactants that lead to the emission from that component.

A process-based model would quantify the flows of materials from one process on a farm to the next (e.g., process flows from feed through the animal housing to manure). Process-based models would require consideration of emissions from each component of the farm system based on the concentrations and amount of reactants that lead to the emissions from that component. In process-based emission modeling, system processes are mathematically represented at an appropriate level of detail to capture the important dynamics and interactions among components. In the most rigorous form, a process-based model is developed from the scientific understanding of the physical, chemical, biological, and other processes that control emissions. Although empirical data may be used to help establish certain model coefficients[10] or relationships, the primary need for empirical data is for evaluation or verification of the mechanistic models used to describe system processes. This is different from an empirical approach where regression techniques are used to formulate models from experimental data and independent datasets are needed for validation. Process-based modeling provides a robust emission estimation approach, since the mechanistic models are designed to be valid beyond the datasets used to establish model coefficients.

By representing the chemical, biological and physical processes and constraints in an EEM, the SAB concludes that process-based models are more likely than the current statistical models to be successful in representing a broad range of conditions. In their most rigorous forms, process-based models are data intensive; however, process considerations can be incorporated into models at a variety of levels of complexity. The EPA should consider developing EEMs at a variety of levels of complexity to provide options for producers with different levels of data availability. While the NAEMS does not provide sufficient data to implement a rigorous process-based modeling approach, it is sufficient to start the development of a modeling approach for estimating emissions. The EPA should create a modeling approach that can be defined using default parameters[11] that can be simply attained and that would reflect the heterogeneity of AFOs.

[10] For purposes of this report, the term "coefficient" refers to unknown constants (regression coefficients, the variance, and the auto-correlation coefficient) whose values give the EEMs their shape.

[11] For purposes of this report, the term "parameter" refers to the data and data collection methods used to support the modeling approach.

For example, emissions from manure lagoons would be based on the composition of manure, which would in turn depend on flows into and out of the manure lagoon. The flows into the manure lagoon would be derived from the manure production from the animal housing in the form of excreted feces and urine and bedding. Flows into a lagoon would need to consider inputs from the milking parlors and account for clean water collection from slabs and surfaces that may change the volume and solids ratios. Flows out of the lagoon would be equivalent to the flows into the lagoon minus compounds emitted into the air, leached, or mineralized in the soil. Furthermore, mass flows in the manure lagoon would be quantified for each air species of interest (e.g., NH_3, CH_4) based on the nutrient loading rates and concentrations of the nutrients that lead to those species (e.g., urea, NH_4, organic nitrogen and organic carbon).

Developing a rigorous process-based EEM will require extensive data beyond the range of values, conditions, and types of farms available in the NAEMS data set. To address this data gap the EPA should consider using data collected through mechanisms outside the consent agreement, including data published in peer-reviewed literature, raw data from key studies, data that support key literature, and additional data that the EPA has collected since receiving data in response to the Call for Information[12] that the EPA released that sought additional data on AFOs and emissions. These data would need to measure the emissions from various components for the farm enterprise as a function of variables that should matter based on a mechanistic understanding of the emissions. For example, nutrients in animal manure could be estimated based on nutrient intake and production rates or at least expected intake for a level of production. Nitrogen flows would be especially relevant to ammonia emissions. The amount of urine and fecal nitrogen could be used to estimate emissions from the barn floor or subsequent manure storage and application. The NAEMS data could be used to some extent to evaluate the accuracy of process-based models.

Rigorous process-based models are data intensive, but process concepts, such as limiting predicted releases of nitrogen in emissions to be less than nitrogen inputs, can be used in simplified models. Models of varying complexity should be developed based on the level of input provided by a given producer (e.g., one model may be developed considering the composition of a feed ration, while a less complex model using default industry values could be used if a producer does not wish to or cannot disclose information regarding feed rations).

The advantages of using a process-based model include the following:

- More existing data could be used, such as data for estimated emissions from a certain component of the farm under certain conditions.
- Estimates derived would be more robust across different farm types.
- Control strategies could be developed for reducing emissions from farms based on implementing technology standards or performance standards, wherein the standards would predict specific impacts using the process-based models.

[12] See *Federal Register Notice* Volume 76, Number 12, Pages 3060-3062, published on January 19, 2011.

These advantages would enhance the robustness of EEMs and ensure their applicability into the future rather than representing only a snapshot in time. Regardless of the approach that is used, uncertainty associated with the prediction at new farms should be evaluated.

The SAB has identified several key factors and parameters that the EPA should consider within process-based modeling approaches. Key factors and parameters that impact broiler emissions may include, but are not limited to: animal activity (perhaps assessed through lighting program hours for light and dark periods); key diet ingredients (that result in releases of gaseous pollutants, such as total nitrogen); water management; manure composition (moisture, mass, and nitrogen); total number of animal units; temperature in the house; and ventilation rate. Key factors and parameters that affect dairy and swine lagoon emissions may include but are not limited to: sulfur; nitrogen and carbon content of feed; conversion of feed nutrients to animal product (milk and meat); nutrients fed, climate variables such as temperature and wind speed; the lagoon sulfur; nitrogen and carbon content; surface area; depth; manure residence time; volume; temperature; pH;, oxidation-reduction potential; and presence or absence of a surface crust. The NAEMS does not provide sufficient data to evaluate and estimate parameters for a modeling approach for estimating emissions incorporating all of these key factors and parameters. In particular, the NAEMS data set does not include sufficient information for the steps from feed development to manure collection. The NAEMS swine and dairy lagoons/basins data are particularly limited regarding feed input data, nutrient and chemical loading inputs into lagoons, and the chemical and physical composition and pH of lagoons. The references provided in this SAB report include citations for process-based models that the EPA should consider in its development of process-based models.

The SAB recognizes that there are potential drawbacks with developing and applying process-based models to assess emissions at AFO facilities. Since a single set of processes may not determine emissions for all farms across the nation in a particular AFO sector, a large number of parameters and static variables may be required to address the variety of factors that affect emissions on a number of farms within a sector. Also, interactions between the parameters may need to be assessed and incorporated into the modeling approach. Since different farms may have different processes that control emissions, process based models should be robust enough so that input variables would discriminate between these different regimes of estimation. The EPA should estimate and evaluate uncertainty associated with different modeling approaches during the model building exercise to determine the degree to which different models might be required.

In addition, the SAB recommends that after the EPA updates its approaches for developing EEMs for broiler confinement facilities and swine and dairy lagoons/basins consistent with SAB's advice, the EPA should use these updated approaches to develop draft EEMs for egg-layers, swine and dairy confinement facilities. The SAB also recommends that the EPA should develop a process-based modeling approach to predict air emissions from these sectors. The EPA should consider developing EEMs at a variety of levels of complexity to provide options for producers with different levels of data availability. The EPA should also identify critical data gaps associated with development of such modeling approaches and begin the process for identifying which key parameters should be included within the process-based models. The EPA should consider conducting a full mass balance analysis to help in the assessment of key parameters that would be used in a process-based modeling approach.

3.2. Combination of Lagoon and Basin Data

Question 2: Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.

3.2.1. Background

After conducting an initial analysis of the NAEMS data submitted for swine and dairy lagoons/basins, the EPA began developing a draft EEM for NH_3. The EPA's review of literature indicated that lagoon/basin emissions were influenced by several factors, including lagoon/basin temperature. To ensure that the dataset used to develop the draft EEM represented all seasonal meteorological conditions for the entire two-year monitoring period, EPA decided to combine the swine and dairy data that the EPA relied on to develop the draft NH_3 EEM.

3.2.2. Response

The SAB recommends against combining swine and dairy datasets. The EPA justifies combining the swine and dairy data to ensure that multiple seasonal meteorological conditions are represented and a sufficiently large data set is available for analysis. Initial site selection for dairy lagoons in this study did not provide representation for measurements of all seasonal meteorological conditions. Neither moderate winters nor extended hot conditions in summer were represented. Although combining datasets attempts to resolve problems associated with inadequate sample design by combining data from separate species, it should not be done, and it is not clear what inferences could be made from any models resulting from combined datasets.

Lagoons and basins are not the same and operate very differently. Treatment lagoons rely upon microbial populations to digest organic fractions of manure. Intermediary compounds are consumed by other populations of microbes. The net result is digestion and decomposition of organic matter. This process occurs more rapidly in lagoons than in basins. Differences in chemical composition and concentration between swine and dairy lagoons make it difficult (if not erroneous) to combine the data from these two sources. Combining species data without correcting for nutrient loading rates and chemical differences overlooks the basic differences in microbial processes and waste characteristics and undermines the credibility of conclusions drawn from such analyses.

Although the current EEM approach represents multiple seasons, little attention is paid to many relevant factors including: chemical, physical, and biological differences in the contents and functionality of the various lagoons and basins; difference in species; production efficiency; diets; feed intake; animal stocking densities; injection of fresh water; and lagoon loading. Inputs into lagoons/basins (loading rates for nutrients and chemical constituents) vary by facility and must be considered as such inputs are feedstocks for microbial populations present in containment structures. More rapidly fermentable carbohydrates will be present in the swine manure. Different compositions of nitrogen and sulfur are also expected. Combined, these differences in influent concentrations translate to differences in microbial decomposition activities, rates and intermediary compounds, all influencing potential conversion to methane or non-conversion and potential release of emissions to the atmosphere. Nitrogen quantity and composition in waste streams, pH, temperature at the interface between the water surface and the atmosphere and wind speed are known to play key roles in volatilization of nitrogen as ammonia, yet none of these factors is considered in EPA's EEM.

It is not appropriate to combine both sites to compensate for flows in the study design. The EPA informed the SAB that the EPA combined the basin and lagoon data collected through the NAEMS effort to allow the estimation of basin NH_3 emissions in high temperature ranges only measured in lagoons. Extrapolating basin NH_3 emissions to higher temperatures based upon lagoon NH_3 emissions measured at higher temperatures is an example of erroneous analytical practice. This extrapolation assumes that basin and lagoon NH_3 emission dependency on temperature is the same. Such an assumption is not known to be true. The EPA should identify any other modeling assumptions or data use used to estimate NH_3 emissions that might differ for lagoons and basins. The SAB requests, for example, that the EPA clarify:

- Whether the basins developed any crusts or other solids on the surface which might obstruct diffusion of NH_3 across the liquid/atmosphere interface;
- Dimensions of the basins and lagoons;
- Whether there are significant differences between lagoons and basins that would affect the wind fetch and hence gas stripping effects of flow across the liquid/atmosphere interface;
- Whether there are pH differences;
- Whether redox potentials are similar; and
- Whether any basins have anoxic surface layers.

The NRC report on AFO emissions concluded that emissions should be estimated based upon a process-based model. A process-based approach will require special attention if different treatment systems are to be combined. The microbial processes must be shown to be sufficiently similar. Once this is established, then it might be possible for the EPA to identify lagoon and basin characteristics such as: nitrogen, sulfur, and carbon concentrations; residence time; temperature; pH; and other characteristics, and identify the range of data needed to develop a nationally-applicable process-based emission model. Such an approach would require taking into account how the microbial processes and the chemical and physical processes are controlled by dominant characteristics in each system. As discussed in more detail in section 3.1.2 of this report, the SAB notes that developing a rigorous process-based EEM will require extensive data beyond those available in the NAEMS data set.

3.3. <u>Use of Static Predictor Variables</u>

Question 3: Please comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA consider specific alternative approaches for statistically analyzing the data that would allow for the site-specific lagoon liquid characteristics to be used as predictor variables?

3.3.1. Background

To maximize the number of NH_3 emissions measurements used to develop the draft EEM, the EPA used static predictor variables (SPVs) as surrogates for data on lagoon/basin conditions (i.e., nitrogen content of lagoon liquid, lagoon pH, oxidation reduction potential and temperature). The EPA used the static variables of animal type, total live mass of animal capacity on the farm and the surface area of the lagoon to represent NH_3 precursor loading and the potential for release to the air.

3.3.2. Response

There are significant problems in using SPVs as surrogates for data on lagoon/basin conditions. Such an approach obscures key emission processes and variable interactions and does not account for regional and inter-species variability among the fundamental drivers of emission processes. It would be inappropriate to extrapolate this approach to types of operations not represented by the study locations. The SAB recommends that the functional relationships in any EEM should be based on the key drivers of emission processes.

Use of static predictor variables as surrogates for data on lagoon/basin conditions
To develop an EEM for NH_3 emissions from lagoons and basins at dairy and swine operations, the EPA proposes to use SPVs such as total animal live weight and lagoon surface area, in *lieu* of time-varying, lagoon- or basin-characterization data. Examples of the latter would include lagoon nitrogen loading, feed-to-gain performance (for feeder pigs), and milk production (for milking herds).

The EPA model uses a combination of static (e.g., farm characteristics) and dynamic (e.g., meteorological) variables and interactions in the models they develop. In the EPA's formulation, the SPVs may be either raw or transformed measurement data, depending on the individual variables' distributions. Because of the small number of farms relative to the number of static variables, all SPVs could not be considered. Instead, the EPA developed several models using subsets of potential static variables. Implicit in the modeling approach is the assumption that processes associated with NH_3 generation are able to be adequately modeled through linear statistical models.

As noted in the response to Charge Question 1, the SAB has identified several key factors and parameters that the EPA should consider within process-based modeling approaches. Please refer to that response for a discussion on those key factors and parameters that impact broiler emissions and dairy and swine lagoon emissions.

As presented in the draft EPA document, the SPV approach is problematic for a number of interrelated reasons:

- To the extent that a given SPV is not clearly, unambiguously and fundamentally related to the emission rate through a well-established emissions mechanism – the resulting EEM cannot be reasonably extrapolated to other AFOs. Given the EPA's desire to use the EEM on facilities across the United States, the model should account for the wide variation in design, climate, and management factors across the United States.
- Several of the SPVs that the EPA selected for its EEM are individually deficient. For example:
    - *Lagoon surface area*

In the case of storages that are managed as anaerobic lagoons and that therefore maintain a relatively constant depth over time, liquid surface area would be a reasonable SPV. However, design and management factors, both of which are site-specific, determine whether or not a given storage actually maintains a constant depth. In the general case, particularly where storages have sloping sides, small changes in depth can translate into large changes in surface area, even within a span of hours to days.

  - *Animal numbers*
    It is reasonable to suppose that nitrogen loading to a basin scales by animal numbers, provided that all other feed-intake, retention/milk production, and management variables remain static. But that (highly contingent) scalability ought not to be taken to mean that animal numbers represent a fundamental variable driving NH_3 emissions. In the case of dairies, for example, milking herds may be managed according to productivity, feeding higher-energy, higher-protein diets to higher-producing cows, and vice-versa. Simply doubling herd size, without knowledge of the feed intake, performance, management factors associated with the additional animals, and the degree of solids separation does not necessarily double the emissions attributable to the per-animal emissions processes; but that is what the SPV approach implicitly assumes.

- Dairies and swine operations differ substantially and in ways that cannot reasonably be collapsed into a single pseudo-species. Because nitrogen loading to a lagoon or basin, a key driver of NH_3 emissions, is driven in large measure by feed composition, feed intake, nitrogen retention (for swine operations), and milk production (for dairies), among other key variables, inter-species effects on diet and the manure produced must be taken into account in SPV evaluation. Swine and dairy EEMs should be individually formulated.
- The range of climatic, management, feeding, and animal-performance conditions represented by the livestock operations in the NAEMS study is too narrow to provide reliable emissions estimates across the full range of conditions in which dairy and swine producers operate in the United States. For example, the datasets used in the NAEMS study do not represent moderate winters or extended, hot summers.

In summary, the EPA has attempted to overcome serious deficiencies in the NAEMS datasets by appealing to a statistical analysis that obscures key emission processes and variable interactions, that fails to account for regional and inter-species variability among the fundamental drivers of emission processes, and that cannot reasonably be extrapolated to types of operations not represented by the study locations. The SAB recommends that the EPA consider a process-based approach that uses appropriate, physically-based, region- and species-specific variables.

Alternative approach for statistically analyzing the data

A statistical model developed from limited data will not provide a satisfactory EEM for use beyond the range of values, conditions, and types of farms in the data set from which it was created. An alternative to the statistical approach proposed by the EPA is to develop functional relationships based upon a scientific understanding of the principles involved in the emission process and use a statistical procedure to quantify the required parameters. This process-based approach must begin by identifying the appropriate dependent and independent variables. For ammonia emission from a manure lagoon or basin, for example, the predicted variable should be the emission per unit surface area of the lagoon or basin. The independent variables must include both weather conditions and manure characteristics. Important weather variables that must be included are ambient temperature and wind speed. Solar radiation and precipitation may also contribute and should be used if the data are available. Important manure characteristics include dry matter and nitrogen concentrations. The organic and inorganic nitrogen contents would also be helpful if that information is available. Other important manure characteristics include pH and temperature (if it is different from ambient temperature). Management can affect the amount of crusting that occurs on the manure surface, and a surface crust can reduce emissions from 20 to 80 percent depending upon the thickness and uniformity of the crust across the surface. If the appropriate manure characteristics are defined and used, the manure source (e.g., dairy, swine, and poultry) would not be important. For all of these variables, the temporal resolution of the data should be consistent with the time scales on which the variables are changing. For example, manure characteristics will not change rapidly, so hourly or daily data are not needed for these variables.

The functional form of the predictive relationship must be established based upon the biological, chemical and physical processes driving emissions; most often this will require nonlinear relationships. As the independent variables approach maximum and minimum potential values, predicted emissions must also approach appropriate values (i.e., emission predictions must approach zero under the appropriate conditions and approach some maximum value at the outer extremes). Unreasonable predictions such as negative or infinite values cannot occur. The functional relationship must allow an appropriate prediction across the full possible range of each independent variable and combination of variables that might be used. Only this type of relationship can be used to extrapolate to conditions outside the original dataset. An EEM that is applied to all manure storages throughout the country must be satisfactorily applied to conditions beyond the limited data from which it was developed.

After the functional form of the relationship is established and the appropriate independent and dependent variables are included in that function, a statistical approach can be used to help quantify parameters along with scientific understanding. Somewhat limited data can be used to determine parameters that should be appropriate beyond the bounds of the original data. Extensive verification is required across the full range of possible conditions and some parameter adjustment may be needed to avoid inappropriate predictions outside the bounds of the original data. Therefore, statistical accuracy relative to the original data may be sacrificed to assure a full range of appropriate predictions. The NAEMS data should provide an appropriate dataset for model parameterization, but other data and published information should be used for establishing the structure and parameters of the EEM and evaluating that EEM for more diverse conditions. This level of rigor in EEM development and evaluation is necessary to develop a nationally-applicable EEM.

3.4. Alternative Approaches for Ammonia Emissions-Estimation Methodologies

Question 4: Does the SAB recommend that EPA consider alternative approaches for developing the draft NH_3 EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions. If so, what specific alternative approaches would be appropriate to consider?

3.4.1. Background

The EPA requested SAB advice on alternative approaches for developing an NH_3 EEM that would balance the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions.

3.4.2. Response

The SAB recommends that the EPA consider alternative approaches for developing a NH_3 EEM, since the NAEMS data are limited, and since EPA's goal is to develop an EEM that would be broadly applicable across the United States for determining emissions from lagoons. The SAB has several recommendations that the agency should consider to enhance its ability to develop a better EEM:

Completeness goals for data

Section 3.1.2 of EPA's draft Lagoon Report notes that: "A valid monitoring day is one in which 75 percent of the hourly average data values used to calculate the daily value were valid measurements. An hourly average is considered valid if 75 percent of the data recorded during that hour were valid." The EPA should clarify why the completeness goal of 75 percent was deemed critical for determining an hourly average and whether it limited this criterion to 75 percent of the raw data or to 75 percent of the two 30-minute averages. The EPA should consider whether or not this criterion is too stringent, given the data limitations. If collected data were of good quality during a particular hour interval, EPA should include these data as there are already many gaps in the data used for the development of these EEMs.

The requirement for valid monitoring days to have 75 percent of the hourly averages may bias and limit the dataset. A 75 percent completeness goal means that as many as six hours of data could be missing in a day, and it is important to know when data are missing and whether the missing data would bias the daily average. For example, if data were consistently missing at a time period when the emissions might be high or low, then the overall average may be biased in one direction or the other. It is important to note if the missing hourly values were random or if they occurred in some discernible pattern. In addition, the EPA should consider using methods to fill missing data gaps. In many cases, emissions follow very distinct patterns and it is possible to fill in missing data using interpolation or other algorithms that would increase the number of valid days available for analysis.

Emissions estimated using the Backward Lagrangian Stochastic Model (bLS) method

As discussed in Section 5.1 of the Lagoon Report, EPA's calculated daily lagoon emissions were developed based on measurements obtained using the Radial Plume Mapping (RPM) model rather than the Backward Lagrangian Stochastic (bLS) model. The SAB recommends that the EPA consider using the bLS data either instead of the RPM data or in conjunction with the RPM data, since there is a paucity of data in the current dataset,. There are two points to consider here. The first point is the decision to use 30-minute emission values, as opposed to using daily values. While doing this does result in a greater number of data points, the use of daily averages may better capture emission trends. As there are large diurnal emission patterns in any given day, this may overshadow predictor variable effects or add more "noise" in the analysis. As stated above, if the 30-minute averages are from time periods when the lagoon emissions are typically high or low, this could affect the overall EEM estimate, whereas using a daily emission value may eliminate that potential problem. Additionally, the real drivers of emissions (i.e., lagoon chemistry and biology) change slowly (more in terms of weeks or months, not minutes), therefore it might be better to use daily values in conjunction with the available lagoon chemistry data to build more powerful models (more on this point below).

As stated in Section 5.1 of the Lagoon Report:

> The EPA used the RPM data because these measurements were obtained using instrumentation and procedures that were similar to EPA's developmental test method OTM-10. The EPA did not use the bLS emissions measurements because these data were collected under the NAEMS to conduct a validation study of the bLS model performance relative to the RPM model. Furthermore, because the RPM emissions dataset is much larger than the bLS dataset, including the bLS measurement in the EEM development dataset would not provide any additional information on lagoon emissions.

If daily values are used, then the bLS dataset has 285 valid days as opposed to only 69 valid days using the RPM model. To conduct a validation study, the true emission values from the source should be known. Because the true emissions are not known from any of the open area sources, it would not be possible to establish which model performed better and which model produced an emission rate closest to the true rate. Therefore, one cannot draw conclusions as to which model more closely estimated the true emissions from the source. Based on the few published validation studies available, the bLS model has performed very well for open area sources. Ro et al. (2011, 2012) found that the bLS model more accurately predicted emissions from open sources than the RPM model. The RPM and bLS emissions estimates were very close in several of the datasets collected in the NAEMS study. It might therefore be possible to fill in missing days by combining the two datasets and eliminating the overlap. This would result in more available days for use in the development of the model.

Units of emissions estimate

Use of proper units to express the emissions estimates is also a concern. The draft EEMs use kg/30-minutes as the unit of emissions, but perhaps better relationships could be developed if the EPA used kilograms per hectare (kg/ha), kilograms of live weight of animal (kg/live-wt), or some other denominator that captured the physical differences between operations. These variables (lagoon size and animal weight) were included as predictor variables, but it would potentially be better to account for these in the emission unit, therefore eliminating the need to have them as a predictor variable.

Use of available lagoon chemistry data

In the draft EEMs, the predictor variables chosen to estimate emissions are inadequate. The factors that actually drive the emissions (i.e., lagoon characteristics) were not included in any of the analyses. It seems highly unlikely that a suitable methodology could be developed to predict NH_3 emissions across the country when (at a minimum) the nitrogen content and pH of the lagoon have not been included as variables in the model. The model should also consider the potential effects of surface crust on emissions. Some of the predictors chosen such as temperature, day of year, and wind speed would certainly have an impact on emissions, but due to differences in lagoon composition and chemistry, the effects would be farm-specific and would not translate to other farms. For instance, it is possible for two farms in the same area, with the same number of animals and same meteorological conditions to have greatly different emissions due to differences in the pH and nitrogen content of their lagoons. There does seem to be both nitrogen and pH data available for four of the farms, representing approximately 46 percent of the 30-minute emissions estimates used in the models. If daily emissions estimates were used and the lagoon chemistry data were extrapolated to other days, there may be a suitable dataset that could be used to develop a more robust EEM using both the lagoon characteristics as well as meteorological data. The SAB finds that developing an EEM that incorporates lagoon chemistry, meteorological and farm data would be much more valid than relying on weather data and static predictor variables alone, even though the dataset would be smaller.

Biological thresholds

One other concern related to the development of the EEMs using the current technique is that there is no recognition of realistic biological thresholds. Estimates from any model should not violate biological boundaries (e.g., one cannot emit more nitrogen than is present). There should be some upper and lower threshold limits to ensure that the methodology would not result in an estimated emission rate that is not realistic. SAB also recommends that the EPA compare the results of the EEMs that it develops with emissions documented in available literature. There are a number of models available that are used to estimate NH_3 emissions. One could use the nitrogen and weather information available for the lagoons, attempt to calculate emission rates and compare those with published emission estimates from the literature.

Primary and secondary units

Selection of appropriate units to express emissions is influenced by the type of facility and final use of the data. Primary emission units are directly from the measurements on-farm with secondary units available based on parameters collected to allow conversion from one emission expression to another. The uncertainty associated with the measurements needs to be reported (Wheeler et al. 2010, Xin et al. 2010). The following are five potential expressions of Emission Rate (ER), defined as contaminant mass per unit time for types of source. Some examples are provided for situations in which they are most useful.

1. Per Farm (e.g., ER/500-cow-dairy)
   Not commonly used due to complexity of accounting for all emission sources under various management options, weather, and geographical differences.
2. Per Unit of Area (e.g., ER/m^2) for animal housing, open lots, manure storage, and feed storage.
   Most common for emissions that do not originate from a fully enclosed building.
3. Per Animal Unit (e.g., ER/bird) for animal, place (i.e., # stalls), body weight, productive animal [“per milking cow” = lactating/dry cow + her replacements]
   Very commonly used for enclosed buildings or where the animal population is relatively stable in both number and body weight.
4. Per Unit of Food Product (e.g., ER/lb pork, gallon of milk, dozen eggs, or weaned piglet) for final food product or animals marketed.
   Increasing in use as animal agriculture has become more efficient in product produced with reduced animal population.
5. Per Inputs (e.g., ER/kg nitrogen fed)
   Best use in models and pollutant mitigation where the biological, chemical, and management influences can be fairly evaluated.

3.5. <u>Comments on Approach for Handling Negative and Zero Data</u>

Question 5: Please comment on the EPA's approach for handling negative or zero emission measurements.

3.5.1. Background

Some NAEMS emissions measurements were reported as either negative or zero emissions values. The EPA considered whether to include these negative and zero emissions values in the data used to develop the EEMs. The agency evaluated whether the negative or zero values represented variability in emissions measurements due to instrument/equipment performance. The EPA also reviewed the data to see if the data quality measures were properly performed according to the Quality Assurance Project Plan. The EPA concluded that all negative values should not be considered in the development of the EEMs.

3.5.2. Response

Overview
There are two types of data assessed in the EPA's documents: directly measured air pollutant concentrations and calculated air emission rate values. In both cases, the EPA must address negative and zero values. In the draft EEMs, the EPA has not included negative values in the EEM development process and kept the zero values. The SAB has reviewed the EPA's treatment of these values and provides the following suggestions for the handling of negative and zero data for both direct concentration measurement and calculated emission values.

Negative values
There was a relatively small number (<1.7 percent for broiler and <2 percent for swine and dairy lagoon data) of negative data points, but their inclusion in the model is important. Negative values appear in both direct concentration measurements and calculated air emission rates. The SAB suggests several approaches for handling the negative values..

Direct Air Pollutant Concentration Measurement Values
Except in a few possible situations, negative measures of concentrations are problematic. Since a rigorous Quality Assurance/Quality Control (QA/QC) protocol was implemented for the NAEMS data, and the raw data subjected to a flagging/validation process based on the QA/QC, EPA should remove negative concentration values due to instrument malfunction or any other obvious errors. Therefore, in the submitted dataset, a negative concentration measurement value would occur due to a true value that is at or below the minimum detection level (MDL), a measurement value that is adjusted by the equipment calibration offset procedure, or instrument fluctuation due to influence by ambient conditions. Each of these cases is considered individually.

- *Minimum Detection Level*
  From a statistical point of view, the correct approach for dealing with negative values due to MDL is to recognize that those values are censored. That is, it is known that the measured value is below the instrument's minimum limits of detection, but above zero (a true concentration can never be below zero). These censored values should be included in all statistical analyses. Suggestions for the treatment of this type of negative value are as follows:
  - Use the negative value produced as it is.
  - Employ the EPA procedure of using half of the MDL when the observed value is below the MDL. (Theoretically this method is better, but it is also very difficult to differentiate the negative values that are due to MDL).
- *Calibration Offset*.
  Negative values can arise due to instrument "noise" or adjustment of calibration offset, which is calculated based on the average zero and span values over a period of time. The negative gas concentration values attained during offset correction should generally be very small in comparison with the mean measurement values. Due to the nature of equipment noise, the resulting measurement values can be positive, zero or negative. Since there is no way to identify and adjust for positive noise, the negative noise measurement should be kept to ensure unbiased statistical analysis.
- *Ambient Influence*
  Variability in instrument measurements can result from variations in ambient conditions (e.g., atmospheric stability) resulting in overestimated positive or negative values. The bias, either positive or negative, will depend on the instrument type (particulate matter or gas) and ambient condition. For example, in the measurement of PM from broiler confinement housing, negative PM concentrations can occur due to short term fluctuations in relative humidity which causes fluctuation in the real-time Tapered Element Oscillating MicroBalance (TEOM) PM concentration measurement process. When the air humidity increases, the TEOM measurement will have an increased bias. If the air humidity decreases, then the TEOM measurement bias will decrease, and a negative PM concentration can possibly occur. Since it is very difficult to identify and quantify the positive bias, the negative bias measurement should be kept for non-biased statistical analysis. In cases such as these, the negative values that are produced from these situations will introduce a bias (that is likely small) to the data. If excluded from the dataset, standard errors of estimated model coefficients will be underestimated and, consequently, confidence intervals around, predicted concentrations, for example, will be too narrow, indicating a precision that is higher than what it should be.

Overall, it is important to qualify unexpected observations individually and to understand and document why an observation is negative. In some cases, it will be decided that the measurement is the result of operator error, instrument failure, instrument drift or some other factor. In these cases, and absent additional information that might permit correcting the measurement, observations should be discarded.

Calculated Emission Rate Data

Air emission rates were calculated by subtracting the measured background concentration value from the directly measured concentration value, and multiplying by the airflow rate. Where the calculated value was negative, the EPA decided not to include the negative value in the model because the agency concluded that it suggested that the area in question (i.e., confinement houses, lagoon), was acting as a sink (EPA, 2012, pg 3). The SAB, however, recommends that negative calculated emission data be included in the model under certain conditions.

Negative calculated emission values can arise from the following scenarios:

- In this study, the background and source measurements were measured either intermittently (twice a day for gas), or continuously without correction for lag time in the barn (PM data), thus leading to a bias either up or down, introducing the potential for negative emission values. Because bias could occur in either the positive or negative direction, negative calculated emission values should be retained in the dataset, as long as their individual measured value was already validated. Omitting these data would bias the model in the upward direction. The true estimated value is more accurate if all calculated values are included.
- A calculation bias may also occur when the measured values are at or near the detection limit, or negative. Calculation of negative emission rates due to small or negative values should be very small, and should be kept.
- In some scenarios, outdoor events may affect the background concentration. For example, if there was activity outside the poultry barn which resulted in increased pollutant concentration (e.g., other barn cleanout and manure movement), the measured background values would be biased upwards, and subsequently, the calculated emission value may become negative. Alternatively, a positive bias could occur if meteorological conditions caused the exhaust air to come back into the barn, thus influencing the measured concentration. In these situations, errors caused by special abnormal outdoor events should be identified and removed from the study results if appropriate.

Negative emission rates can be used to develop a model that never predicts negative emissions. In some cases, these negative emission rates may be necessary to appropriately describe the uncertainty of the model.

Overall, if the measured concentration data are validated and included in the dataset, then the emission value calculated from that dataset is also valid, whether it is negative or positive.

Zero values

Zero values are present in the direct measurement data as well as in the calculated emissions dataset. If during measurement of direct air pollutant concentrations, or after instrument calibration, the resulting measurement is zero, the SAB recommends that the value ought to be used in statistical analyses. However, few instruments have the precision needed to distinguish a true zero from a small value. Consequently, zero measurements will often correspond to censored observations and thus should be treated as such. The use of zero values in the model is likely to produce small biases in both the estimated regression coefficients and their standard errors.

After elimination of invalid data, if a calculated emission value is zero, it should be included in the dataset. There are many cases in which emissions of a given pollutant may be zero from a particular source and should be included in any analysis. Overall, if the emission value, calculated from valid data, is zero, then that value should always be included in the model.

Outliers
The EPA did not apply formal statistical outlier tests as part of the modeling process. Instead, the, EPA applied standard procedures (control charts and custom software) to flag data believed to be outliers (See Page 2, Attachment A, of EPA's July 2012 Supplemental Data[13]) as part of the data verification process. The SAB suggests that outlier analysis procedures be conducted as part of the model building process.

3.6. Alternative Approaches for Negative and Zero Data

Question 6: In the interest of maximizing the number of available data values for development of the draft H_2S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero data other than the approach used by the agency.

Response

It is understood that the dataset for hydrogen sulfide (H_2S) for swine and dairy lagoons/basins was small due to data summary methods and/or instrument deficiency in being able to record concentration/emission values. Instrument deficiency was due to changes in wind direction, inadequate wind speeds or other unknown variables. This cannot be corrected after the fact. The Broiler and Lagoon Reports should fully discuss the occurrence and reasons for the lack of sufficient data and large amount of poor quality data.

The summary methods used by the EPA excluded data if the 75 percent completeness level for various time periods (i.e., hourly, daily, and total) was not met. The 75 percent completeness criterion is too stringent and unnecessary in this case. The SAB suggests that the criterion be evaluated so that more data can be included. To maximize the dataset, it is recommended that all data meeting the criteria outlined in Charge Question #5 be included for analysis, regardless of the 75% completeness criterion.

See the SAB response to Charge Question 5 for general recommendations for handling negative and zero data for any dataset.

3.7. Broiler Volatile Organic Compound (VOC) Emissions-Estimation Methodologies

Question 7: Please comment on the approach EPA used to develop the draft broiler VOC EEM.

[13] See EPA's July 2012 Report, "Additional Data for SAB Review: EPA's Emissions Estimating Methodologies for Animal Feeding Operations for Broiler Sector and for Swine and Dairy Lagoons and Basins", available at http://yosemite.epa.gov/sab/sabproduct.nsf/B69FE142E3285B6385257A390047842C/$File/Additional+Data-EPA+Emissions+Estimating+Methods+for+AFOs-Broiler+Sector+and+Swine+&+Dairy+Lagoons+&+Basins-July+2012.pdf.

3.7.1. Background

The EPA reviewed the VOC data submitted for the California and Kentucky broiler sites. The two sites used different VOC measurement techniques. Based on analysis of the measurement and analytical techniques and the VOC data, the EPA used only the VOC data from the Kentucky sites when developing the draft VOC EEM.

3.7.2. Response

The SAB has identified significant limitations with the broiler VOC data and concluded that the broiler VOC data cannot support the development of a broiler VOC EEM at this time.

Under the Consent Agreement, the EPA is required to set an EEM for daily and annual VOC emissions. However, there is a provision in the Consent Agreement that, if the SAB decides that the available data are not adequate to support development of the EEMs, the EPA can delay development of the EEMs until adequate data are available[14]. Limitations of the broiler VOC data include:

- The procedures used to collect VOC data at Site CA1B (i.e., Trihalomethane analyzer with photobooster) did not produce useful data for model development and evaluation and should not be used in development of an EEM. Therefore, data from only two farms in one geographic region (KY1B-1 and KY1B-2) are available to the EPA through the NAEMS study.
- Canisters, which can only be used to assess a limited suite of compounds, were used to sample VOCs. Other sampling techniques are required to gather other VOCs that cannot be analyzed using canister analysis.
- From Site KY1B, VOC recovery rates from the canister are unknown as not all compounds are able to be extracted from electropolished canisters onto sorbent tubes, and sorbent tubes were not utilized for direct collection of VOCs.
- Sampling at Site KY1B was conducted quarterly over a 21-month period (i.e., seven collection events), during which time two samplers were placed at the exhaust fans of each of two facilities. However, background samples were not collected at the inlet of the barns, so no data were available from which to determine the net increases in VOC concentrations attributable to the housing facilities.
- VOC concentration data from Site KY1B are limited to the specific climate and management conditions of the site and cannot be applied to all production facilities across the United States with a reasonable degree of confidence regarding their representativeness.

Based on these concerns, the SAB recommends that the EPA not generate an EEM for VOCs from broiler operations at this time.

Although the NAEMS dataset is too limited to produce an EEM, valuable components of the VOC data should be reported. Based on the EPA's presentation of KY1B VOC data, those data appear generally

[14] See *Federal Register Notice* Volume 70, Number 60, Pages 4958-4977, published on January 31, 2005.

valid and usable if (and only if) the methods used to collect VOC data are more extensively and clearly documented than in the EPA's first draft Broiler Report. In the draft, the agency reported in detail how data were *supposed* to be collected at both sites, but details of how and what data were *actually* collected were incomplete and unclear. The EPA should state unambiguously what data were actually collected from each site, how they were collected and analyzed and what data passed QA/QC criteria checks. Data collected absent strict adherence to SOP and Quality Assurance Project Plans (QAPP), including equipment calibration methods, are not valid and should be identified as such.

Data reported by the EPA should include total and speciated VOC concentrations to provide general information on broiler emissions from the sites where data were collected. Moreover, "Total VOCs" should be explicitly defined to clarify whether reported values represent the sum of all VOCs analyzed or the total VOCs quantified by the analyzer, which will capture only a portion of all VOCs present in a sample. These data may help identify important compounds emitted from broiler facilities, which can help guide future data collection efforts. An indication of the magnitude of VOC concentrations relative to any reports of background VOC concentrations reported for this region would help, qualitatively, to identify those compounds that appear to be emitted in substantial quantities from the CAFOs. One challenge with the incomplete data collection is how the EPA determines if "substantial quantities of compounds are emitted" when the entire VOC suite emitted is not quantified. When such quantification does not occur, it is not possible to identify if one compound or another is a substantial component of the VOCs emitted. Also, the determination of what is "substantial" is subjective without a numeric qualifier. After reporting the available data, the EPA should defend the decision to not develop an EEM given the limited information available and the uncertainty of the data collected in the NAEMS. To develop an EEM for VOCs EPA must lay the foundation for development of a process-based model for estimating emissions from these operations. This foundation requires a comprehensive investigation of existing scientific literature and future research regarding factors driving generation of VOC emissions from broiler facilities.

4. SPECIFIC RECOMMENDATIONS FOR THE DRAFT BROILER AND LAGOON REPORTS

The SAB provides the following general comments on EPA's draft Broiler Report and Lagoon Report. The SAB considered whether the draft Broiler and Lagoon Reports were presented in a clear, comprehensive, and scientifically sound manner.

Overall, SAB finds that both reports should be updated to describe the importance of retaining a long-term goal for producing process-based models. The SAB also concludes that the reports should more comprehensively describe data completeness, representativeness, limitations and whether there are sufficient data to begin a process-based modeling approach. The SAB recommends that the discussions of mechanisms of data collection, including pollutant concentrations, ventilation rates within barns, and feed composition and quantity should be enhanced in the reports. Furthermore, the reports should more fully explain why any of the NAEMS data were excluded from EEM development. Since NAEMS data have significant limitations, the reports should include an assessment of additional data that the EPA has collected through EPA's Call for Information[15].

Specific SAB recommendations for each EPA draft report, beyond those made in response to the charge questions in section of this SAB report, are noted below. The SAB recommends that the EPA consider the references provided in this SAB report to improve the literature base for the Broiler and Lagoon Reports and to help ensure a more comprehensive understanding of AFO broiler and/or swine and dairy lagoon/basin operations:

4.1. Recommendations for Revising the Draft EPA Broiler Report

The SAB recommends that the EPA reorganize the report and rewrite several sections to address various concerns of the SAB. The EPA should develop a process-based modeling approach to predict air emissions from broiler farms and incorporate that approach into the report. The EPA should also make a number of improvements to the statistical approach for developing EEMs. In particular, the agency should describe methods for calculating confidence values to present variability of data, include quantitative statistical analyses that compare houses, consider approaches in addition to the cross-validation method used to evaluate the model, and more comprehensively describe data completeness, representativeness, and limitations.

Section 1 should describe the importance of pursuing a long-term goal of producing process-based models and refer to the NRC recommendations (NRC 2003) on this topic. This section should also note that the developed models are considered short-term tools with limited application for estimating emissions.

The limitations of the data set and the various data measurement problems that occurred as part of the NAEMS data collection efforts should be more comprehensively described and summarized in Section 1. For example, data from poultry sites were collected for typical bird grow-out periods, but there are

[15] See *Federal Register Notice* Volume 76, Number 12, Pages 3060-3062, published on January 19, 2011.

birds that are grown for much shorter periods (e.g., Cornish hens) and those that are grown for much longer periods (e.g., large roasters). These limitations should be clearly stated because the current EEMs for ammonia would not fit some of the situations well (i.e., emissions would be estimated to go to zero for some of the largest birds and would be negative for some of the smallest birds). The discussion of mechanisms for data collection, ventilation rates within barns and feed nutrients consumed should also be enhanced.

The introduction section should also clearly acknowledge that the broiler data were collected at an extremely limited number of study sites (four broiler barns on three farms, including two farms at the Kentucky site). The EPA should consider clarifying the text to note that the 2,600 industrial participants in the Consent Agreement are a very small fraction of the one-half million AFOs in the country. EPA should also consider clarifying the percentage of total confinement animal production represented by these industrial respondents.

The text in Sections 1 and 2 would be strengthened by referral to the mechanistic processes that drive the emissions that the developed EEMs are estimating. The primary physical/biological/chemical mechanisms that lead to emissions of each regulated parameter should be described in relation to the surrogate statistical parameter. This would strengthen the validity of the statistical model employed. For example, the product of bird number and mass is considered a surrogate for fresh manure production that impacts ammonia emissions.

The text should note that the EPA planned to measure several key parameters that affect emissions generation, such as animal activity, diets, feed rate and composition, water management, and manure composition (moisture and nitrogen), total number of animals, and ventilation rate. The text should note that the EPA did not utilize these parameters during EEM development because the EPA judged that data for these variables were insufficient in quantity and/or quality. EPA should describe data that were collected but not yet transmitted to the agency as of the development of the EEMs.

The accurate determination of ventilation rate (VR) is a very important aspect of the NAEMS data collection and is necessary to achieve representative emission data. The determination of accurate ventilation rate should be given more prominence in the report with a concise description of how this was achieved. The description of ventilation systems and control operations for each barn also should be clarified, particularly regarding inlet description and function.

The EPA should also clarify the range of conditions under which the NAEMS-based EEMs can be used. For example, the EPA should describe the ambient temperature range during grow-out or litter management period between flocks within which the EEMs can be applied. The EPA should also add cautionary notes regarding the use of EEMs outside of the studied range.

The report should note that that broiler confinement facilities are commonly managed as both bird production facilities and as dry manure storage if litter is not completely cleaned out between flocks. The report should discuss the importance of stockpiled litter storage emission measurements (litter being the combination of bedding and manure) and the link of such emissions to the process-based model development and evaluation. The microbial degradation and natural chemical interactions associated with all the parameters measured should be described. Throughout the report, the emissions from populated houses during grow-out and empty houses during litter management should be presented separately since the house is managed very differently during these two time periods. In addition, the differential in emissions observed from fully cleaned out houses versus de-caked, built-up litter houses should be presented separately.

The EPA should improve the clarity of the discussions on the NAEMS monitoring sites and on the data available for EEM development. The report should discuss why the data sets used are representative of the industry and the literature. For example, it is unclear how well California farm CA1B, a 16-house broiler ranch in Stanislaus County, California, built in the 1960s, represents modern industry practices. Also, pancake brooders (used in Kentucky) are primarily used by one parent company (i.e., integrator, who typically operates or contracts every aspect of the broiler production process), so emissions from houses employing such equipment during the brooding period are not likely to represent emissions from facilities operated by other integrators. EPA should develop criteria for considering additional data and how to use such data.

EPA describes many parameters that were not used in its analysis. EPA should clarify which parameters were used for developing EEMs and discuss the reasons for, and the importance of, not including other parameters for which data were collected in the analysis.

The EPA should take the following steps to provide additional information regarding the data used in developing EEMs:

- Identify the number of samples collected during each sampling event and the periods that data were collected;
- Clarify the VOC discussions regarding Kentucky and California VOC analyses. This discussion is poorly written and very confusing (the EPA should note that the California VOC data were not used and why these data were not used);.
- Describe fan calibration procedures and frequency;
- Clarify how the change in purge time for first 4 months of gas sampling in California was addressed;
- Describe the sampling schedule for PM10, PM2.5 and TSP samples;
- Explain the data to be collected in the sampling plan and why data that were specified in the sampling plan were not collected;
- Describe sampler inlet systems used for measurement and address associated issues with use of these inlets in some applications (e.g., aspiration of PM by low volume inlets);
- Describe ventilation rate which includes discussion on the FANS system and repeated calibrations; and
- Clarify a potential discrepancy associated with the KY1B data-set, available at http://www.epa.gov/airquality/agmonitoring/data.html. The report does not indicate that ambient weather data and confinement data are available for the Kentucky site, although the data posted on the website spreadsheet are described as containing "daily mean concentrations of pollutants, weather and barn conditions." The report should clarify this potential discrepancy.

The EPA should clearly specify criteria for data completeness, use of data, eliminating data, collection of background concentration data, and use of data available in the literature for modeling verification.

EPA should also discuss why a 75 percent completeness value was used as a threshold for using data, why there are missing data days and why some data were collected in some seasons and not in others. The EPA should also clarify how the agency identified outliers in the data and the reasons for their inclusion or omission. The discussion on seasonal influences should be improved to discuss whether such influences should be incorporated into the model. The text should also describe how anomalies are defined and applied in the data set.

4.2. Recommendations for Revising the Draft EPA Lagoon Report

The SAB recommends that the EPA reorganize the report and rewrite several sections to address various concerns of the SAB. Various recommendations are provided to more comprehensively describe data completeness, representativeness and limitations. Many comments that the SAB provides to strengthen the Broiler Report also apply to the Lagoon Report (e.g., comments on data completeness, use of data, and statistical and process-based model approaches). The EPA should review the Lagoon Report in light of these comments and incorporate such comments as appropriate.

Section 1 should describe the importance of pursuing a long-term goal for developing process-based models, and refer to the NRC recommendations (NRC 2003) on this topic. This section should also note that the development of empirical models is considered a short-term tool for estimating emissions.

The discussion of the U.S. dairy and swine industries should be rewritten. Additional details should be provided on the overall operations at the dairy and swine industry facilities, particularly the facility waste handling techniques and manure management systems. The EPA should consider conducting a nitrogen balance analysis to better understand the mass of nitrogen that may be emitted. Additional information on the lagoons where data were collected should be provided, as well as information on what constitutes a standard lagoon throughout the industry. Section 1 notes that due to the limited amount of data for nitrogen content, solid content and pH of the lagoon liquid, these data were not included in the EEM. Section 2 also notes that data on manure residence time, amount of sulfur ingested by an animal and amount of carbon in feed were not collected. The EPA should summarize the limitations of the data set and the various data measurement problems that occurred as part of the NAEMS data collection efforts.

The discussion of manure management, storage and stabilization should be revised. Discussion of the design difference between storage and treatment ponds (i.e., basins and lagoons, respectively) should be corrected to indicate that treatment ponds are designed specifically for biological treatment and storage ponds are not designed for biological treatment. In addition, the report should indicate that waste characteristics for swine and dairy animals are significantly different. Standardized definitions exist for manure treatment/storage structures. The EPA's report should use American Society of Agricultural Engineers/American Society of Agricultural and Biological Engineers (ASAE/ASABE) Standard: Uniform Terminology for Rural Waste Management (ASABE S292.5). The text should describe the processes that generate ammonia from nitrogen and cause volatilization of that nitrogen. The text should also describe the microbial degradation and natural chemical interactions for all parameters measured.

The report should be rewritten to include additional details on the dairy and swine industry, in particular the waste handling techniques and manure characteristics. Additional details on hydrocarbon and VOC sampling results, average dairy cow weight and manure management systems should be provided. The EPA report should provide additional information on the lagoons where data were collected, and a definition of a standard. In addition, it should be noted that the EPA's analysis used data from a wash water dairy lagoon, not a manure storage lagoon, which may affect the EEM estimation efforts. Finally, the appendices reference several pre-study validation studies. The results from these validation studies should be included in the report so that it would be possible to evaluate the data quality that may have been generated using these tested techniques.

The EPA should clearly specify criteria for data completeness, use of data, eliminating data, collection of background concentration data, and use of data available in the literature for modeling verification. EPA should also clarify how outliers were identified and the reasons for their inclusion or omission.

Appendices:

The Appendices reference several pre-study validation studies. The results from these validation studies should be included in the Report so that it is possible to evaluate the data quality that may have been generated using these tested techniques.

REFERENCES

SAB suggests that the EPA consider the following additional references to improve the literature base for the draft EPA Reports and help ensure a more comprehensive understanding of AFO broiler and/or swine and dairy lagoon/basin operations:

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South Coast Air Management District has had emissions estimates for dairy in poultry for years. SCAQMD Poultry and Dairy Emission factors and guidelines for using the online 'calculator' can be found here: www.aqmd.gov/aer/Updates/GuideCalcEmisDairyPoultry.pdf (January 2009).

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APPENDIX A–EPA'S CHARGE QUESTIONS

February 17, 2012

MEMORANDUM

SUBJECT: Animal Feeding Operations Air Emissions Estimating Methodologies from the National Air Emissions Monitoring Study

FROM: Stephen D. Page, Director
Office of Air Quality Planning and Standards (C404-04)

TO: Ed Hanlon
Designated Federal Officer
Animal Feeding Operations Emission Review Panel
EPA Science Advisory Board Staff Office (1400R)

This memorandum requests that the Science Advisory Board (SAB) review and comment on the draft emissions estimating methodologies (EEMs) for animal feeding operations (AFOs). In preparation for this review, the SAB has formed the *Animal Feeding Operations Emission Review Panel*. We envision conducting multiple meetings of this panel to cover the material we are requesting to be reviewed. This memorandum contains background material and charge questions for review by the expert SAB Panel at the initial meeting. We request that these materials be forwarded to the SAB Panel for their review.

As the attachment and associated documents illustrate, the EPA staff has carefully considered the data collected as part of the National Air Emissions Monitoring Study (NAEMS) and now ask the Panel to refine and comment upon our work thus far to create EEMs. To bound and define the discussion, the attachment offers charge questions for the Panel to consider.

By way of background, in 2005, the EPA entered a voluntary consent agreement with the AFO industry in which AFOs that chose to sign the Air Compliance Agreement (Agreement) shared responsibility for funding a nationwide emissions monitoring study. The NAEMS monitoring protocol was developed through a collaborative effort of AFO industry experts, university scientists, U.S. Department of Agriculture and EPA scientists and other stakeholders. The monitoring study was designed to gather data for developing methodologies for estimating emissions from AFOs and to help AFOs determine and comply with their regulatory responsibilities under the Clean Air Act (CAA), the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and the Emergency Planning and Community Right-To-Know Act (EPCRA). Once the EPA publishes the applicable EEMs, the Agreement requires each participating AFO to certify that it is in compliance with all relevant requirements of the CAA, CERCLA and EPCRA.

We appreciate your efforts and those of the Panel to prepare for the upcoming meeting and look forward to discussing this project in detail. Questions regarding the attached materials should be directed to Ms. Robin Dunkins, EPA-OAQPS (telephone: 919-541-5335; email: dunkins.robin@epa.gov).

Attachment

cc: Bill Harnett
Robin Dunkins
Larry Elmore
Lawrence Elworth
Allison Mayer
Janet McCabe
Peter Tsirigotis

ATTACHMENT

Regulatory Background

In 2005, the EPA entered a voluntary consent agreement with the animal feeding operations (AFO) industry in which AFOs that chose to sign the Air Compliance Agreement (Agreement) shared responsibility for funding the National Air Emissions Monitoring Study (NAEMS). Approximately 2,600 AFOs, representing nearly 14,000 facilities that include broiler, dairy, egg layer and swine operations, received the EPA's approval to participate in the Agreement.

To provide a framework for the NAEMS, AFO industry experts, university and government scientists and other stakeholders collaborated to develop a comprehensive monitoring plan. The study was designed to generate scientifically credible data to characterize emissions from the participating animal sectors.

Consistent with the Agreement, the Agriculture Air Research Council (AARC), a nonprofit entity comprised of participating AFO industry representatives, administered the monitoring study. The AARC was responsible for selecting the Independent Monitoring Contractor (IMC) and the study's Science Advisor with EPA approval. The Agreement outlined the roles and responsibilities of the AARC, the IMC and the Science Advisor.

The monitoring plan specified the general geographic location of the farms to be monitored, animal production phase, ventilation type, manure management/handling system and other pertinent information for each animal sector.

- For broilers, two sites were to be monitored - one on the West Coast and the other in the Southeast. Both were to be mechanically ventilated and have litter on the floor.
- For the swine industry, the sites were to be located in the Southeast (sow and finisher), Midwest (sow and finisher), and West (sow). Mechanically-ventilated buildings, a deep pit building, lagoons and basin manure storage types were to be monitored.
- For dairy, both naturally- and mechanically-ventilated buildings, lagoons and basins were monitored. Five dairies were monitored, one dairy in each of the following geographical areas: Northeast, Midwest, Northwest, West and South.

For confinement sources, the IMC monitored for ammonia (NH_3), particulate matter (PM_{10}, $PM_{2.5}$, TSP), volatile organic compounds (VOCs) and hydrogen sulfide (H_2S). For lagoons and basins, H_2S, NH_3 and VOC were to be monitored. Accordingly, the EPA is then responsible for developing EEMs for each of these pollutants.

Charge to the Science Advisory Board (SAB) AFO Air Emissions Review Panel

In preparation for the first and second meeting, the EPA has analyzed the NAEMS data for two broiler sites and nine swine and dairy lagoons/basins. For the purpose of this study, the EPA used the description of a lagoon and basin as provided in the MidWest Plan Service "Manure Storages" (MWPS-18 Section 2) document. According to MWPS, "A lagoon is a biological treatment system designed and operated for biodegradation of organic matter in animal manure to a more stable end product. A basin, while similar to but smaller than a lagoon, is designed to store manure only and is not a treatment system."

For a broiler confinement house, the EPA has developed draft EEMs for NH_3, PM_{10}, $PM_{2.5}$, TSP, VOC and H_2S. For swine and dairy lagoons/basins, the EPA has only developed a draft EEM for NH_3. The documents provided to the SAB describe the sites monitored; the data submitted to the EPA; and a detailed discussion of the statistical methodology used to develop the draft EEMs. This material is provided to inform the SAB panel of the EEM development process used by the agency. In subsequent meetings, the EPA will address draft EEMs for egg-layers, swine and dairy confinement houses and other pollutants for swine and dairy lagoons/basins.

Issue 1: Statistical Methodology used to develop draft EEMs

The EPA seeks the SAB's input on the statistical methodology used by the EPA to develop the draft EEMs. Section 7.0 and 8.0 of the broiler document and section 5.0 of the swine and dairy lagoon/basin document provide an overview of the statistical methodology used to develop the draft EEMs. A flow diagram of the statistical methodology is provided in Figure 7-1 in the broiler document and Figure 5-1 in the swine and dairy lagoon/basin document. The EPA considers this statistical methodology to be the best approach for analyzing the data and intends to use this same approach to develop draft EEMs for the egg-layers, swine and dairy confinement houses.

Using the process described in the sections listed above, we developed a mean trend function that provides a point prediction of emissions under a given set of conditions. We chose an appropriate mean trend function to quantify the relationship between predictor variables and pollutant emissions by analyzing the emissions data and incorporating knowledge of the emissions generating processes. The EEM development process also involves choosing a probability distribution and covariance function to appropriately quantify other contributions to variability in emissions, and thereby to accurately quantify methods at all stages. If necessary, we will adjust the statistical methodology based on our review of the SAB's input.

Question 1: Please comment on the statistical approach used by the EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition, please comment on using this approach for developing draft EEMs for egg-layers, swine and dairy confinement houses.

Issue 2: Statistical Methodology used to develop swine and dairy lagoon/basin draft EEMs

After conducting an initial analysis of the NAEMS data submitted for swine and dairy lagoons/basins, the EPA decided to focus on developing a draft EEM for NH_3. The EPA's review of current literature indicates that lagoon/basin emissions are influenced by several factors, one of these being lagoon/basin temperature. To ensure that the dataset used to develop the draft EEM represented all seasonal meteorological conditions for the entire two year monitoring period, the EPA decided to combine the swine and dairy data. Combining the swine and dairy lagoon/basin dataset also resulted in combining lagoon and basin emissions data.

To maximize the number of NH_3 emissions measurements used to develop the draft EEM, the EPA used static predictor variables (SPVs) as surrogates for data on lagoon/basin conditions (i.e., nitrogen content of lagoon liquid, lagoon pH, oxidation reduction potential and temperature). The static variables of animal type, total live mass of animal capacity on the farm and the surface area of the lagoon were used to represent NH_3 precursor loading and the potential for release to the air. Consistent with operating parameters associated with statistical degrees-of-freedom, we concluded that two degrees of freedom was the maximum that the data would credibly allow for inclusion in the developing the draft EEM. As a result, the EPA developed three sets of draft EEMs, using the paired combinations of these static variables (i.e., animal type, surface area, farm size) and the continuous variables representing meteorological conditions (i.e., temperature, atmospheric pressure, humidity, wind speed, solar radiation).

Question 2: Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.

Question 3: Please comment on the agency's decision to use SPVs as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that the EPA consider specific alternative approaches for statistically analyzing the data that would allow for the site-specific lagoon liquid characteristics to be used as predictor variables?

Question 4: Does the SAB recommend that EPA consider alternative approaches for developing the draft NH_3 EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions. If so, what specific alternative approaches would be appropriate to consider?

Issue 3: Negative and Zero Data

Some emissions measurements were reported to the EPA as either negative or zero emissions values. When developing the draft EEMs, the EPA used the following general approach regarding inclusion of negative and zero emissions values in the data.

- The EPA evaluated whether the negative or zero values represent the variability in emissions measurements due to the means of obtaining the measurements. For example, negative values for a pollutant concentration might result when the concentration of the pollutant falls below the minimum detection limit of a monitor. For all EEM datasets, the EPA included zero values because these values potentially represent instances where the emissions from the source were zero (e.g., a frozen lagoon), or the background and pollutant concentrations from the source were the same. Regarding negative values, in cases where the dataset available to develop draft EEMs was relatively large and the emissions were significantly greater than zero, the EPA excluded negative emissions values from the EEM datasets. The EPA used this approach to develop the entire broiler confinement house draft EEMs and swine and dairy lagoon/basin NH_3 draft EEMs.

- The EPA reviewed the data to see if the data quality measures were properly performed according to the Quality Assurance Project Plan.

- If the EPA identified data where the quality assurance measures were not followed, we contacted the science advisor to determine if the corrected data could be submitted to the EPA.

The EPA has conducted a preliminary analysis of the swine and dairy lagoon/basin H_2S emissions data. Our analysis indicates that we may need to modify our approach for handling negative and zero data in order to develop a draft H_2S EEM for swine and dairy lagoons/basins. A modification may be needed due to the limited number of H_2S emissions values, the presence of a greater percentage of negative emissions values and emissions values that are closer to zero than the NH_3 emissions for swine and dairy lagoons/basins. The EPA's concern is that failure to include the negative measurements in the dataset, or setting them equal to zero, would result in an EEM that fails to fully quantify uncertainty around the point prediction of emissions attributable to measurement error.

Question 5: Please comment on the EPA's approach for handling negative or zero emission measurements.
Question 6: In the interest of maximizing the number of available data values for development of the draft H_2S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero data other than the approach used by the agency.

Issue 4: Volatile Organic Compounds (VOC) Data

The EPA reviewed the VOC data submitted for the California and Kentucky broiler sites. The two sites used different VOC measurement techniques. Based on our analysis of the measurement and analytical techniques and the VOC data, the EPA decided to use only the VOC data from the Kentucky sites when developing the draft VOC EEM.

Question 7: Please comment on the approach EPA used to develop the draft broiler VOC EEM.