San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

APR 06 2018

Brandon Greer
Central Valley Eggs, LLC
13606 Gun Club Rd
Wasco, CA 93280

Re: Notice of Preliminary Decision - Authority to Construct
Facility Number: S-8841
Project Number: S-1180558

Dear Mr. Greer:

Enclosed for your review and comment is the District's analysis of Central Valley Eggs, LLC's application for an Authority to Construct for the installation of a 3,339,000 bird capacity poultry ranch consisting of ten poultry houses, at 13606 Gun Club Rd, Wasco, CA.

The notice of preliminary decision for this project will be published approximately three days from the date of this letter. After addressing all comments made during the 30-day public notice period, the District intends to issue the Authority to Construct. Please submit your written comments on this project within the 30-day public comment period, as specified in the enclosed public notice.

Thank you for your cooperation in this matter. If you have any questions regarding this matter, please contact Ms. Gurpreet Brar of Permit Services at (559) 230-5926.

Sincerely,

Arnaud Marjollet
Director of Permit Services

AM:gb

Enclosures

cc: Tung Le, CARB (w/ enclosure) via email
cc: Kathy Parker, Insight Environmental Consultants (w/ enclosure) via email

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San Joaquin Valley Air Pollution Control District
Authority to Construct Application Review
Poultry Ranch

Facility Name:	Central Valley Eggs, LLC	Date:	April 5, 2018
Mailing Address:	13606 Gun Club Rd Wasco, CA 93280	Engineer:	Gurpreet Brar
		Lead Engineer:	Jerry Sandhu
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Application #s:	S-8841-1-1 & -1-2		
Project #:	S-1180558		
Deemed Complete:	February 22, 2018		

I. Proposal

Central Valley Eggs has requested Authority to Construct (ATC) permits for a 3,339,000 bird capacity poultry ranch consisting of seven 327,000 bird capacity laying hen houses, and three 350,000 bird capacity pullet houses.

Central Valley Eggs previously received approval for the construction of this poultry ranch with ATC S-8841-1-0, which was evaluated under project S-1161654 and issued on November 7, 2017, and the facility has already completed construction of the 3,339,000 bird capacity poultry ranch. One of the conditions on the ATC permit requires each poultry house to be equipped with a belt manure aeration and removal system that continuously removes manure from the aviary section of the house. However, the facility has found that when the manure belts are operating continuously and the manure gets to the end of the house where it is transferred to the floor conveyor system, it contains too much moisture and sticks to the primary conveyor or to the scraper arms that are used to help transfer the manure between conveyors. Additionally, ATC S-8841-1-0 also requires a source test to be performed to demonstrate compliance with permitted emissions limits. The source test is required to be performed under conditions representative of normal operations or conditons specified in the ATC. As discussed above, because the facility has determined that continuous operation of the manure belts results in excessive moisture, the facility has indicated that they do not plan to operate with the manure belt operating continously. Therefore, the source test cannot be performed as required by ATC S-8841-1-0 and the ATC cannot be implemented. Since the facility cannot implement the original ATC issued, the equipment is being treated as new for the purposes of this project.

The proposed poultry ranch evaluated in this project is essentially identical to the one evaluated in project S-1161654. There is no change to the original number of birds or the number and capacity of poultry houses. However, the facility has proposed the following two changes.

- The facility is proposing to change the frequency that the belt manure aeration and removal system of each poultry house operates. As discussed above, the requirement in ATC S-8841-1-0 to have the belt manure system to operate continuously results in manure with an excessively high moisture content that disrupts the equipment and does not get properly removed. Therefore, rather than operating continuously, the facility is proposing that the manure belt in each house advance by a minimum of half the length of the belt during a 24-hour period so it completes one full rotation within two days. As a result, the moisture content of the manure is expected to be reduced from greater than 50% to approximately 30%. At 30% moisture content, the manure is still sufficiently moist and no increase in PM_{10} emissions are expected from this proposed change. A source test will be performed to demostrate compliance with the PM_{10} emission limits on the permit.

- ATC S-8841-1-0 requires the open end of each house to be equipped with water spray nozzles in order to minimize PM_{10} emissions from each house's exhaust fans. Thefacility has installed the required spray nozzles; however, when the facility performs the required source testing, they would like to verify if the permitted PM_{10} limits can be achieved without the use of these water sprays. In order to accommodate this request, the District will issue two ATCs for the poultry ranch, one requiring the installation of water sprays and the second ATC without water sprays, and the facility will have the option to choose which ATC they would like to implement.

The District will issue ATCs S-8841-1-1 and S-8841-1-2 to permit the poultry ranch, summarized as follows.

<u>ATC S-8841-1-1:</u>

- 3,339,000 bird capacity poultry ranch consisting of seven 327,000 bird capacity laying hen houses, and three 350,000 bird capacity pullet houses.
- Each poultry ranch will be equipped with a belt manure aeration and removal system that advances by a minimum of half the length of the belt every 24 hours so it completes one full rotation within two days.
- The open end of each house at the poultry ranch will be equipped with water sprays.

<u>ATC S-8841-1-2:</u>

This ATC will be identical to ATC S-8841-1-1 with the exception that water sprays will not be required for each poultry house.

Based on the above discussion, ATC S-8841-1-0 will not be implemented and will be cancelled upon issuance of ATCs S-8841-1-1 and -1-2. Therefore, the following condition will be placed on the ATCs:

- This Authority to Construct (ATC) cancels and supersedes ATC S-8841-1-0. [District Rule 2201]

Further in project S-1161654, the facility had originally proposed to construct a poultry facility with 4,320,000 birds in 13 new poultry houses (consisting of ten 327,000 bird capacity laying hen houses and three 350,000 bird capacity pullet houses). However, the Ambient Air Quality Analysis (AAQA) performed in project S-1161654 for the proposal for the 4,320,000 birds in 13 new poultry houses indicated that the increase in particulate matter (PM) emissions from the project would cause or make worse a violation of an Ambient Air Quality Standard and, therefore, would not comply with the requirements of District Rule 2201 - New and Modified Stationary Source Review Rule. Because of this, the facility modified the proposal during the previous ATC project to permit only ten new poultry houses so the AAQA for the proposed project could demonstrate that the emissions increase from the project will not cause or make worse a violation of an Ambient Air Quality Standard.

The facility will be performing source testing to measure emissions from at least one of the proposed poultry houses to demonstrate compliance with the permitted PM_{10} limit and to develop emissions factors that better represent the specific poultry house design. If the source test results show that the emissions factors used in this project have overstated the PM_{10} emissions from this facility, the applicant may come back and apply for the construction of the three additional laying hen houses that were originally included in their project proposal. Prior to approving any future project to increase the maximum number of laying hens or to construct additional poultry houses at the site, the facility will be required to demonstrate that PM_{10} emissions from the overall project (this ATC project and any future ATC project(s) for the additional laying hens and/or poultry houses) will not cause or make worse a violation of an Ambient Air Quality Standard (AAQS).

The following condition will be included on the proposed ATCs to ensure compliance:

- Issuance of any Authority to Construct (ATC) permit(s) or any construction that results in a further increase in the number of laying hens, pullets, or poultry houses at this facility such as described in the proposal for District ATC Project S-1180558, or the District CEQA document prepared for the project with the increase, shall be treated and analyzed as a part of Project S-1180558 for New and Modified Source Review (NSR) purposes to ensure that the cumulative emissions from the overall project will not cause or make worse a violation of an Ambient Air Quality Standard. [District Rule 2201 and California Environmental Quality Act]

II. Applicable Rules

Rule 1070	Inspections (12/17/92)
Rule 2201	New and Modified Stationary Source Review Rule (2/18/16)
Rule 2410	Prevention of Significant Deterioration (6/16/11)
Rule 2520	Federally Mandated Operating Permits (6/21/01)
Rule 4001	New Source Performance Standards (4/14/99)
Rule 4002	National Emissions Standards for Hazardous Air Pollutants (5/20/04)
Rule 4101	Visible Emissions (2/17/05)
Rule 4102	Nuisance (12/17/92)
Rule 4201	Particulate Matter Concentration (12/17/92)
Rule 4550	Conservation Management Practices (CMP) (8/19/04)
Rule 4570	Confined Animal Facilities (CAF) (10/21/10)
CH&SC 41700	Health Risk Assessment
CH&SC 42301.6	School Notice

Public Resources Code 21000-21177: California Environmental Quality Act (CEQA)
California Code of Regulations, Title 14, Division 6, Chapter 3, Sections 15000-15387: CEQA Guidelines

III. Project Location

The facility is located at 13606 Gun Club Rd in Wasco, CA. The equipment is not located within 1,000 feet of the outer boundary of a K-12 school. Therefore, the public notification requirement of California Health and Safety Code 42301.6 is not applicable to this project.

IV. Process Description

<u>Poultry Ranch</u>

The primary function of Central Valley Eggs is the production and packing of eggs for human consumption. These eggs may be sold as shell eggs (table eggs), or may be used in the production of liquid, frozen, or dehydrated eggs.

Laying hens reach sexual maturity and begin laying eggs between 16 and 20 weeks of age, depending on breed. Before the onset of egg production, birds are referred to as pullets. Central Valley Eggs will operate three pullet houses. Baby chicks will be purchased and brought to the facility between 24 to 48 hours of age. After 16 weeks of age, the pullets will be moved from the pullet houses to one of the proposed laying hen houses where they will begin producing eggs.

The laying hens at Central Valley Eggs typically have a production life of 102 weeks. The laying hens are usually replaced after 102 weeks because the natural decreasing rate of egg production becomes inadequate to cover feed costs. At this point, laying hens become spent hens and may be slaughtered or rendered to recover any remaining value.

Cage-Free Aviary Houses

The laying hens are confined in any of seven proposed cage-free housing systems which allows for automation of feed distribution and egg collection. In cage-free aviary houses laying hens are housed in climate-controlled buildings with multiple levels that allow the hens to roam freely in defined sectors of the building. Cage-free aviary houses have perches and nesting areas as well as open floor space that allows for natural bird behaviors, such as scratching and dust bathing. As in other houses for laying hens, there are wire mesh floors under the nesting areas that are slightly sloped so the eggs roll down to an egg collection belt; however, because the hens can move throughout the house, workers must also manually collect eggs from the feeding and watering and floor areas.

As in other houses, the laying hens have constant access to food and water. Manure is removed from cage-free aviary houses by mechanized belts below the nesting and feeding areas and scrapers below the bottom belt. The manure belt in each house advances by a minimum of half the length of the belt during a 24-hour period so it completes one full rotation within two days, and the moisture content of the manure is expected to be approximately 30%.and will allow the manure to be easily transferred within the manure management system. In cage-free aviary houses manure must also be periodically removed from the house aisle ways.

Each of the laying hen houses measures 651 feet x 90 feet x 43.5 feet and has a capacity of 327,000 birds. Additionally, each laying hen house is equipped with forty-eight 1.5 horsepower exhaust fans, each with a total airflow rate of 26,200 cfm. Each pullet house measures 684 feet x 111 feet x 25 feet and has a capacity of 350,000 birds. Each pullet house is equipped with thirty-eight 1.5 horsepower exhaust fans, each with a total airflow rate of 26,200 cfm. All houses are mechanically ventilated to remove moisture and carbon dioxide produced by respiration.

All of the exhaust fans are located on the end of each house. The exhaust fans draw air into the building through slots located under the eaves along the perimeter of the roof and exhaust air out the end of each building. When ambient temperatures call for it, the inlet air will be cooled using water and evaporative cooling cells. The cold air from each side will be directed toward the ceiling, and will get pushed toward the center of each house. The cold air will then mix with the hot air inside the house before it descends into the area occupied by the birds.

Wet manure from the poultry houses will be conveyed to a segregated enclosure at the end of each poultry house, on the opposite side of the wall where the fans exhaust air from the poultry living area. The end of each poultry house is partially open and a tarp covers approximately 40% of the upper part of the opening. ATC S-8841-1-1 will require the facility to have water sprays installed under the bottom edge of the tarp at the open end of each poultry house. The water sprays will be operated at all times, except during the periods of actual rainfall. ATC S-8841-1-2 will allow the facility to operate with optional water sprays that are installed at the open end of each poultry house.

Numerous belts under each tier of bird cages will collect and convey the manure from the front of the house to a floor conveyor at the back of the house. The floor conveyor transfers the manure to a covered incline conveyor located on the outside of the house. The incline conveyor carries the manure to an automated belt system that spreads the wet manure in three windrows to allow for efferent-controlled drying while maintaining a higher value of nitrogen and other elements, which lowers PM_{10} and ammonia (NH_3) emissions. The manure drying and storage operation will take place under a covered area at the end of each house. Storing the manure under a cover at the end of each poultry house eliminates exposure to wind and rain.

V. Equipment Listing

S-8841-1-1 & -1-2:	3,339,000 POULTRY RANCH CONSISTING OF SEVEN MECHANICALLY VENTILATED CAGE-FREE AVIARY LAYING HEN HOUSES AND THREE MECHANICALLY VENTILATED PULLET HOUSES

VI. Emission Control Technology Evaluation

PM_{10}, VOC, and ammonia (NH_3) are the major pollutants of concern from poultry farms. The ventilation rate of the poultry houses affects the amount of VOC, PM_{10}, and NH_3 that is emitted from the houses.

All pollutants emitted from the manure are expected to be included with the emissions from within the poultry houses. Mechanical ventilation will decrease the moisture content of the manure. As the moisture content of the manure decreases, volatilization of NH_3 from the manure will decrease. Once the manure is dry, emissions of VOC and NH_3 are expected to be negligible.

PM_{10} Emissions:

<u>S-8841-1-1 & -1-2:</u>

The in-house manure drying system will also act as a filter to reduce PM_{10} emissions from the houses. One study measured a greater than 80% reduction in PM_{10} concentrations from cage-free laying hen houses equipped with in-house manure drying systems.[1]

The end of each house is open where the exhaust fans blow air out. In order to help knock down any solid particles that may be exiting the open ends of the houses, a tarp has been installed that covers approximately 40% of the upper part of the opening. It is not known if the tarp covering the top 40% of the opening at the end of each house will provide additional PM_{10} emission control. Therefore, as a conservative estimate, additional PM_{10} control will not be included for the tarp for the purposes of this project.

[1] Winkel, A.; Mosquera Losada, J.; Ellen, H.H.; Aarnink, A.J.A.; Ogink, N.W.M. Dust filtering properties and ammonia emission of on-farm drying systems for poultry manure (2012) Proceedings of the International Symposium on Emissions of Gas and Dust from Livestock (EmiLi). p. 245 – 248. https://www.wageningenur.nl/en/Publication-details.htm?publicationId=publication-way-343235373735 Also see: https://colloque4.inra.fr/var/emili2012/storage/fckeditor/file/Documents/sp3/Presentation%20EmiLi%202012%20Albert%20Winkel%20v2.pdf.

S-8841-1-1:

The facility has proposed water sprays to help further reduce the PM_{10} emissions potentially being released to the atmosphere. The water sprays will be installed underneath a plastic tarp that is covering the top 40% of the opening at the end of each house. As a conservative estimate, it will be assumed that the water sprays will reduce PM_{10} emissions by an additional 50%[2].

The total PM_{10} control efficiency with in-house manure drying system and water sprays can be determined as follows:

$$\text{Total Control Efficiency} = [1 - ((1 - CE_{\text{Drying System}}) \times (1 - CE_{\text{Water Sprays}}))] \times 100\%$$
$$= [1 - ((1 - 0.8) \times (1 - 0.5))] \times 100\%$$

Total Control Efficiency = 90%

VOC Emissions:

S-8841-1-1 & -1-2:

The maximum number of proposed birds that can be kept at the facility as a result of this project will cause all of the poultry houses at the facility to be subject to the requirements of District Rule 4570, *Confined Animal Facilities*.

The mitigation measures that the applicant has selected to comply with District Rule 4570 and VOC control efficiency for the measures selected are shown in the following table.

District Rule 4570 Mitigation Measures Chosen	
Housing Mitigation Measures	Control Efficiency
Use drinkers that do not drip continuously AND inspect water pipes and drinkers and repair leaks daily.	10%
Feed Mitigation Measures	Control Efficiency
Feed according to National Research Council (NRC) guidelines.	10%
Feed animals probiotics designed to improve digestion according to manufacturer recommendations.	10%
Feed animals an amino acid supplemented diet to meet their nutrient requirements.	10%
Feed animals feed additives such as amylase, xylanase, and protease, designed to maximize digestive efficiency according to manufacturer recommendations.	10%
Total Control Efficiency	**41%**

[2] AP42, Section 11.19.1, *Sand And Gravel Processing*, Paragraph 11.19.1.2, *Emissions and Controls*, page 11.19.1-3 indicates that water spray systems at transfer points and on material handling operations have been estimated to reduce emissions 70 to 95%. As a conservative estimate for the purpose of this project, a conservative estimate of 50% control for PM_{10} emissions will be utilized.

Ammonia (NH_3) Emissions:

S-8841-1-1 & -1-2:

Central Valley Eggs is proposing to feed their laying hens a very low crude protein diet supplemented with amino acids. The Mitigating Air Emissions from Animal Feed Operations Conference Proceedings from Iowa State University (https://store.extension.iastate.edu/Product/Mitigating-Air-Emissions-Conference-Proceedings) includes several papers documenting significant NH_3 reduction with dietary manipulation. One such paper, *Dietary Manipulation to Reduce Ammonia Emissions from high-Rise Layer Houses* states that their study documents an 11% NH_3 reduction with a low crude protein (CP) diet (0.4% to 1.2% lower than standard poultry feed). This study is supported by a 2nd article, *Dietary Manipulations to Lower Ammonia Emission from Laying-Hen Manure*, which documented a 10% reduction in NH_3 based on a 1% CP decrease in the bird's diet. Therefore, a 10% reduction in NH_3 emissions will be applied for every 1% drop in CP in the diet of the laying hens at this facility. Reference article documents included in Appendix C.

In order to determine the NH_3 control efficiency for the proposed facility, a baseline CP content of poultry feed must be established. The uncontrolled NH_3 emission factor for the laying hen houses is based on an emission study performed by the Coalition for Sustainable Egg Supply. The study measured emissions from two bird flocks. In accordance with the final research results of that study, the final research results appendix, Tables 20 (Flock 1) and 22 (Flock 2), documented that the nitrogen content of the feed given to the birds in aviary style housing was 2.67% and 2.89% respectively. This results in an average nitrogen content of 2.78% between the two flocks studied.

Based on the article titled "How Important is Crude Protein in Layer Feed" (see: http://www.completefeeds.co.nz/general-articles/how-important-is-crude-protein-in-layer-feed/), the CP content of poultry feed can be estimated by multiplying the nitrogen content by 6.25. Therefore, the baseline CP content of the poultry feed associated with the study referenced above can be determined by taking the average nitrogen content of the two bird flocks and multiplying by 6.25:

Baseline Feed Crude Protein Content = Average Nitrogen Content x 6.25
= 2.78% x 6.25

Baseline Feed Crude Protein Content = 17.38%

Central Valley Eggs is proposing to limit the CP content of the feed given to the laying hens at this facility to 15%. Using a 10% control efficiency for every 1% drop in CP content, the total NH3 control efficiency for the proposed operation will be as follows:

Total NH_3 CE = 10% / % CP Drop x (Baseline CP – Proposed CP)
Total NH_3 CE = 10% / % CP Drop x (17.38% – 15%)

Total NH_3 CE = 23.8%

In addition, many District Rule 4570 mitigation measures will also reduce NH_3 emissions. However, because of limited data, at this time this District cannot accurately apply control efficiencies to calculate the NH_3 emissions reductions attributed to the Rule 4570 mitigation measures.

VII. General Calculations

A. Assumptions

Laying Hen Houses

- The emission factors for poultry are on a per bird basis, and account for multiple sources of emissions. That is, emissions from the hen housing and solid manure handling are included in the per bird emission factors. Therefore, except as noted below, emissions from the hen housing and solid manure handling permits are calculated together.
- Emissions from solid manure are considered negligible once the manure is dried. Therefore, all emissions from solid manure will be attributed to the poultry houses.
- A maximum of 327,000 hens can be kept in each of the seven proposed adult laying hen houses. As a worst case for calculation purposes, the laying hen houses will be at their maximum capacity for 24 hours per day and 365 days per year (per applicant).
- Each poultry house operates independently and has separate exhaust ventilation. Therefore, each poultry house is a separate emissions unit.
- The Final Project Report on Southeastern Broiler Gaseous and Particulate Matter Emissions Monitoring (December 2009) by Iowa State University and University of Kentucky gives a ratio of 0.40 for PM_{10}/Total Suspended Particulate (TSP). Based on this information, PM_{10} emissions from the poultry houses are assumed to be 40% of TSP emissions, and TSP emissions from the poultry houses will be calculated as 250% (1/0.40 = 2.5) of PM_{10} emissions unless otherwise noted.
- The maximum crude protein content of the laying hen feed shall be 15% (proposed by the applicant).

Pullet Houses

- The pullet houses will be populated in cycles. A typical pullet house cycle will last 18 weeks and consist of six weeks with chick starters (ages 0 – 6 weeks), 10 weeks with pullet growers (ages 6 – 16 weeks), and two empty weeks for cleaning and sanitation (proposed by the applicant).

- A maximum of 350,000 pullets (young hens) can be kept in each of the three pullet houses. As a worst case for calculation purposes, the pullet houses will be at their maximum capacity for three full cycles per year for chick starters (18 weeks per year) and pullet growers (30 weeks per year), and two cycles for cleaning and sanitation (4 weeks per year) (proposed by the applicant).

To streamline emission calculations, PM2.5 emissions are assumed to be equal to PM10 emissions. Only if needed to determine if a project is a Federal major modification for PM2.5 will specific PM2.5 emission calculations be performed.

B. Emission Factors

S-8841-1-1 & -1-2:

Laying Hen Houses:

Uncontrolled Emission Factors:

PM_{10} and NH_3 Emissions

Maximum and Average Uncontrolled Emission Factors for Cage-Free Aviary Hen Houses			
Pollutant	**Max Daily EF**	**Ave. EF**	**Source**
	g/bird-day	**g/bird-day**	
PM_{10}	0.31 (from Figure 4)	0.103	Environmental assessment of three laying-hen housing systems–Part II: Air emissions. Poultry Science 2015 94: 534-543[3] and "Ammonia, Greenhouse Gas, and Particulate Matter Emissions of Aviary Layer Houses in the Midwestern U.S." (2013). *Agricultural and Biosystems Engineering Publications.* Paper 452, Reference documents included in Appendix A. *(The PM_{10} EF from the respective studies was 0.1003 g/bird-day (Table 5) and 0.105 g/bird-day (page 1930), resulting in an average PM_{10} EF of 0.103 g/bird-day)*
NH_3	0.52 (0.34 from Figure 2 + 0.18 from manure storage from Figure 5)	0.30 (from Table 5)	Environmental assessment of three laying-hen housing systems–Part II: Air emissions. Poultry Science 2015 94: 534-543[3], Reference document included in Appendix A.

The PM_{10} and NH_3 uncontrolled emission factors referenced above were generated from a 27-month long study of laying hen housing system emissions that was conducted in 2011, 2012 and 2013.

[3] Shepherd, T., Y. Zhao, and H. Xin. 2014. Environmental assessment of three laying-hen housing systems–Part II: Part II: *Ammonia, greenhouse gas, and particulate matter emissions.* Poultry Science 2015 94: 534-543 http://ps.oxfordjournals.org/content/94/3/534.full.pdf+html This study measured emission rates from three different types of housing systems for laying hens – conventional cage, aviary, and enriched colony.

The study established average emissions factors based on all the data collected but also showed that on a few specific days during the study period, the PM_{10} and NH_3 emissions spiked to maximum values higher than the average emission factors listed above.

However, the aviary style house in the study referenced above differs significantly from the houses proposed by Central Valley Eggs in this project. The proposed houses utilize automated belts under the cages and automated scraper bars on the lowest floor to remove manure from the houses. Central Valley Eggs will also manually sweep the aisles of the lowest floor in each house on a daily basis. In contrast, the under-cage belts in the aviary style house from the study were operated only once every third or fourth day to remove manure. Further, manure was not removed from the lowest floor of the house until the end of the flock cycle. The study house also utilized floor bedding, which the applicant will prohibit as part of their disease and vector prevention program. The applicant will also replace conventional foraging areas within the houses with automated trough feeding to reduce emissions associated with foraging behaviors. Part I of the study cited above specifically attributes higher PM_{10} emissions in aviary style housing (as compared to conventional cage or enriched colony) to the floor bedding and litter. Part I of the study notes that "when floor bedding or litter is provided in housing systems to accommodate animal natural behaviors (e.g., dustbathing and foraging for laying hens), PM generation can be higher by a pronounced amount."

The manure drying systems also differs significantly between the study house and the ranch houses. As noted above, the study house employed the conventional practice to dry the manure by forcing heated air through a tiered series of perforated belts that free drop litter from one belt to the next over a several-day period. The applicant is proposing to convey the litter directly to windrows inside the back of the houses, requiring a single drop. Efferent drying will be used to develop a crust on the manure windrows to help further mitigate PM_{10} and NH_3 emissions.

Based on the proposed house designs, automated and manual manure removal practices, efferent drying system, elimination of bedding, and replacement of forage areas with automated troughs, uncontrolled daily emission rates of PM_{10} and NH_3 from these poultry houses are expected to be lower than those predicted by the study. Therefore, using the average PM_{10} and NH_3 emission values from the study will serve as a very conservative estimate of the uncontrolled emission rates expected from the proposed aviary houses and will be used as the maximum emission rates for the purposes of this project.

Uncontrolled Emission Factors for Central Valley Eggs' Cage-Free Aviary Hen Houses		
Pollutant	**g/bird-day**	**(lb/1,000 birds-day)***
PM_{10}	0.103	0.2271
NH_3	0.30	0.6614

*Conversion from g/bird-day to lb/1,000 birds-day performed using the following equation: EF (g/bird-day) x 1 lb /453.6 g x 1,000 birds/1 bird

VOC Emissions

Uncontrolled Emission Factors for Cage-Free Aviary Poultry Houses			
Pollutant	**(lb/bird-year)**	**(lb/1,000 birds-day)***	**Source**
VOC	0.025	0.0685	"Quantification of Gaseous Emissions from California Broiler Production Houses": Table 7, Reactive Organic Gas Source tests were conducted on mechanically ventilated broiler houses during the spring and fall of 2004. The participants in the project include the following: AIRx Testing; California Air Resources Board; California Department of Food and Agriculture; California Poultry Federation; Foster Farms; & University of California, Davis - Animal Science, Reference document included in Appendix B

*Conversion from lb/bird-year to lb/1,000 birds-day performed using the following equation: EF (lb/bird-year) x 1 year/365 days x 1,000 birds/1 bird

Controlled Emission Factors:

PM_{10} Emissions

S-8841-1-1:

As discussed above, the applicant is proposing to install an in-house manure drying system, a tarp covering the top 40% of the open end of each house and water sprays over the open house ends that will reduce the overall PM_{10} emissions from the houses by 90%. Therefore, the controlled PM_{10} emission factor is calculated as follows:

Controlled PM_{10} EF = EF x (1 – Total Control Efficiency)
Controlled PM_{10} EF = 0.2271 lb-PM_{10}/1,000 bird-day x (1 – 0.90)

Controlled PM_{10} EF = 0.02271 lb-PM_{10}/1,000 birds-day

S-8841-1-2:

The PM_{10} emission factor of 0.02271 lb/1,000 birds-day established for ATC S-8841-1-1 is a conservative emission factor. The facility has proposed to utilize the same PM_{10} emission factor without water sprays and will source test to demonstrate compliance with this limit.

Controlled PM_{10} EF = 0.02271 lb-PM_{10}/1,000 birds-day

VOC Emissions

As discussed above, the Rule 4570 mitigation measures that will be performed in these poultry houses will reduce VOC emissions from the houses by 41%. Therefore, the controlled VOC emission factor is calculated as follows:

Controlled VOC EF = Uncontrolled EF (lb/bird-yr) x (1 – Total Control Efficiency)
Controlled VOC EF = 0.0685 lb-VOC/1,000 birds-day x (1 - 0.41)

Controlled VOC EF = 0.0404 lb-VOC/1,000 birds-day

NH_3 Emissions

As discussed above, the facility is proposing to limit the crude protein levels in the feed for the adult laying hens that will reduce NH_3 emissions from each house by 23.8%. Therefore, the controlled NH_3 emission factor is calculated as follows:

Controlled NH_3 EF = Uncontrolled EF (lb/bird-yr) x (1 – Total Control Efficiency)
Controlled NH_3 EF = 0.6614 lb-NH_3/1,000 birds-day x (1 - 0.238)

Controlled NH_3 EF = 0.504 lb-NH_3/1,000 birds-day

Pullet Houses:

Pullets are smaller in size, eat less feed, and produce less manure than adult laying hens. Therefore, it is expected that the emissions generated by pullets are going to be less than the emissions generated by adult laying hens. The emissions factors for pullets will be estimated by comparing the amount of feed pullets consume versus the amount of feed adult laying hens consume.

In accordance with the article "Feeding Chickens for Egg Production" from eXtension.org (http://articles.extension.org/pages/69065/feeding-chickens-for-egg-production) the average amount of feed consumed by pullets and adult laying hens are shown in the following table:

Bird Type	Age	Average Feed Intake per Age Period	Average Weekly Feed Intake
Chick Starter	0-6 weeks	24.5 lb/6 weeks	4.08 lb/week
Pullet Grower	6-20 weeks	125 lb/14 weeks	8.93 lb/week
Laying Hen	20 weeks and up	21 lb/week	21 lb/week

Therefore, the amount of emissions expected from pullets as compared to adult laying hens can be determined using the following equation:

Pullet Emissions = Laying Hen Emissions x (Pullet Feed Rate / Laying Hen Feed Rate)

And the pullet emissions will be estimated as follows:

Bird Type	Average Feed Rate	Average Laying Hen Feed Rate	% of Laying Hen Feed Rate
Chick Starter	4.08 lb/week	21 lb/week	19.4%
Pullet Grower	8.93 lb/week	21 lb/week	42.5%

Uncontrolled Emission Factors:

The uncontrolled pullet emission factors will be determined using the uncontrolled laying hen emission factors referenced in this document above and multiplying them by the

Uncontrolled Pullet Emission Factors					
Pollutant	Laying Hen Emission Factor (lb/1,000 birds-day)	Chick Starter Percentage of Laying Hen Emissions	Chick Starter Emission Factor (lb/1,000 birds-day)	Pullet Grower Percentage of Laying Hen Emissions	Pullet Grower Emission Factor (lb/1,000 birds-day)
PM_{10}	0.2271	0.194	0.0441	0.425	0.09652
VOC	0.0685	0.194	0.01329	0.425	0.029
NH_3	0.6614	0.194	0.1283	0.425	0.2811

Controlled Emission Factors:

PM_{10} Emissions

The mitigation measures and controls that are applicable to the laying hen houses, as described above, will also apply to the pullet houses.

S-8841-1-1:

As discussed above, the applicant is proposing to install an in-house manure drying system, a tarp covering the top 40% of the open end of each house and water sprays over the open house ends that will reduce the overall PM_{10} emissions from the houses by 90%. Therefore, the controlled PM_{10} emission factor is calculated as follows:

Controlled PM_{10} EF = EF x (1 – Total Control Efficiency)
= 0.09652 lb-PM_{10}/1,000 bird-day x (1 – 0.90)

Controlled PM_{10} EF = 0.009652 lb-PM_{10}/1,000 birds-day

S-8841-1-2:

The PM_{10} emission factor of 0.009652 lb/1,000 birds-day established for ATC S-8841-1-1 is a conservative emission factor. The facility has proposed to utilize the same PM_{10} emission factor without water sprays and will source test to demonstrate compliance with this limit.

PM_{10} EF = 0.009652 lb-PM_{10}/1,000 birds-day

VOC Emissions

The mitigation measures and controls that are applicable to the laying hen houses, as described above, will also apply to the pullet houses. Therefore, the pullet houses are expected to have a total VOC control efficiency of 41%. Therefore, the controlled VOC emission factors can be determined using the following equation and the controlled pullet emission factors are shown in the table below:

Controlled EF = Uncontrolled EF (lb/bird-year) x (1 – CE)

NH_3 Emissions

Once the pullets arrive at the facility, they begin maturing and growing in size to become viable laying hens by 16 weeks of age. Thus, the crude protein level in the feed for pullets is typically higher than that of laying hens and Central Valley Eggs does not wish to take a limit on the protein level of the pullet feed. No other ammonia emission mitigation measures are being proposed for the pullet houses for the purposes of this project. Therefore, the uncontrolled emission factors for chick starters and pullet growers listed above will be used as the controlled emission factors for the pullet houses.

Controlled Pullet Emission Factors					
Pollutant	Total Control Efficiency (%)	Uncontrolled Chick Starter Emission Factor (lb/1,000 birds-day)	Controlled Chick Starter Emission Factor (lb/1,000 birds-day)	Uncontrolled Pullet Grower Emission Factor (lb/1,000 birds-day)	Controlled Pullet Grower Emission Factor (lb/1,000 birds-day)
PM_{10}	90	0.0441	0.00441	0.09652	0.009652
VOC	41	0.01329	0.00784	0.029	0.01711
NH_3	N/A	0.1283	0.1283	0.2811	0.2811

C. Calculations

1. Pre-Project Potential to Emit (PE1)

Since these units are treated as new emissions units, PE1 = 0 for all pollutants.

2. Post-Project Potential to Emit (PE2)

S-8841-1-1 & -1-2:

Laying Hen Houses:

The daily emissions can be determined using the controlled emission factors listed above and the maximum amount of birds in each laying hen house. The annual emissions will be determined by taking the daily emissions and multiplying by a worst case operating scenario of 365 days per year.

Daily PE2 (lb/day) = Number of Birds x Controlled EF (lb/1,000 birds-day)

Annual PE2 (lb/year) = Daily PE2 (lb/day) x 365 days/year

Daily PE2 for Each Laying Hen House					
Pollutant	# of Birds	x	EF (lb/1,000 birds-day)	=	PE2 (lb/day)
PM_{10}	327,000	x	0.02271	=	7.4
VOC	327,000	x	0.0404	=	13.2
NH_3	327,000	x	0.504	=	164.8

Annual PE2 for Each Laying Hen House					
Pollutant	Daily PE2	x	Operation (days/year)	=	PE2 (lb/year)
PM_{10}	7.4	x	365	=	2,701
VOC	13.2	x	365	=	4,818
NH_3	164.8	x	365	=	60,152

The facility consists of seven laying hen houses; therefore, the total emissions from all seven houses will be determined as follows:

Total $PE_{\text{Laying Hen Houses}}$ = $PE_{\text{Per House}}$ x 7 Houses

Total PE2 for all Seven Laying Hen Houses							
Pollutant	Daily PE2 per House (lb/day)	Annual PE2 per House (lb/yr)	x	Number of Laying Hen Houses	=	Total Daily PE2 for All Hen Houses (lb/day)	Total Annual PE2 for All Hen Houses (lb/yr)
PM_{10}	7.4	2,701	x	7	=	51.8	18,907
VOC	13.2	4,818	x	7	=	92.4	33,726
NH_3	164.8	60,152	x	7	=	1,153.6	421,064

Pullet Houses:

The pullet houses will have chick starters for 18 weeks per year (126 days), pullet growers for 30 weeks per year (210 days) and be empty for cleaning and sanitation for 4 weeks per year (28 days). Therefore, the emission rates from the pullet houses will be calculated as follows:

Daily PE2:

The daily PE2 from the pullet houses can be determined using the daily controlled EF and the maximum amount of birds in a house at any given time. Since the pullet houses will house birds in cycles, the worst case daily emissions from each pullet house will be the highest daily emission rates from either chick starters or pullet growers.

Daily PE2 (lb/day) = Number of Birds x Controlled EF (lb/1,000 birds-day)

Chick Starters:

Chick Starter Daily PE2 for Each Pullet House					
Pollutant	# of Birds	x	EF (lb/1,000 birds-day)	=	PE2 (lb/day)
PM_{10}	350,000	x	0.00441	=	1.5
VOC	350,000	x	0.00784	=	2.7
NH_3	350,000	x	0.1283	=	44.9

Pullet Growers:

Pullet Grower Daily PE2 for Each Pullet House					
Pollutant	# of Birds	x	EF (lb/1,000 birds-day)	=	PE2 (lb/day)
PM_{10}	350,000	x	0.009652	=	3.4
VOC	350,000	x	0.01711	=	6.0
NH_3	350,000	x	0.2811	=	98.4

As shown above, the worst case daily emissions from the pullet houses is during the pullet grower cycle. Therefore, the pullet grower PE2 values will be set as the maximum daily emission rates from each pullet houses.

<u>Annual PE2:</u>

The annual emissions for each house will be the sum of the chick starter emissions for 126 days per year and pullet grower emissions for 210 days per year.

Annual $PE_{Chick\ Starters}$ (lb/year) = # of Birds x EF (lb/1,000 birds-day) x 126 days/year

Annual $PE_{Pullet\ Growers}$ (lb/year) = # of Birds x EF (lb/1,000 birds-day) x 210 days/year

Annual $PE_{Pullet\ House}$ (lb/year) = Annual $PE_{Chick\ Starters}$ (lb/year) + Annual $PE_{Pullet\ Growers}$ (lb/year)

Chick Starters:

Chick Starter Annual PE2 for Each Pullet House							
Pollutant	# of Birds	x	EF (g/bird-yr)	x	Number of Days Chick Starters Housed (day/year)	=	Annual PE2 (lb/year)
PM_{10}	350,000	x	0.00441	x	126	=	194
VOC	350,000	x	0.00784	x	126	=	346
NH_3	350,000	x	0.1283	x	126	=	5,658

Pullet Growers:

Pullet Grower Annual PE2 for Each Pullet House							
Pollutant	# of Birds	x	EF (g/bird-yr)	x	Number of Days Pullet Grower Housed (day/year)	=	Annual PE2 (lb/year)
PM_{10}	350,000	x	0.009652	x	210	=	709
VOC	350,000	x	0.01711	x	210	=	1,258
NH_3	350,000	x	0.2811	x	210	=	20,661

Annual PE2 per Pullet House:

Annual PE2 for Each Pullet House					
Pollutant	Chick Starter Annual PE2 (lb/yr)	+	Pullet Grower Annual PE2 (lb/yr)	=	Annual PE2 (lb/yr)
PM_{10}	194	+	709	=	903
VOC	346	+	1,258	=	1,604
NH_3	5,658	+	20,661	=	26,319

Total PE2 for all Three Pullet Houses:

The facility consists of three pullet houses; therefore, the total annual emissions from all three houses will be determined as follows:

Total $PE_{Pullet\ Houses}$ = $PE_{Per\ House}$ x 3 Houses

Total PE2 for all Three Pullet Houses							
Pollutant	Daily PE2 per House (lb/day)	Annual PE2 per House (lb/yr)	x	Number of Laying Hen Houses	=	Total Daily PE2 for All Pullet Houses (lb/day)	Total Annual PE2 for All Pullet Houses (lb/yr)
PM_{10}	3.4	903	x	3	=	10.2	2,709
VOC	6.0	1,604	x	3	=	18.0	4,812
NH_3	98.4	26,319	x	3	=	295.2	78,957

Total Emissions from All Ten Poultry Houses:

The total emissions from all ten poultry houses can be determined by summing the emissions from the seven laying hen houses and the three pullet houses.

Total Emissions = $PE2_{\text{Laying Hen Houses}} + PE2_{\text{Pullet Houses}}$

Total Daily PE2 for Ten Poultry Houses					
Pollutant	Total Daily PE2 for Seven Laying Hen Houses (lb/day)	+	Total Daily PE2 for Three Pullet Houses (lb/day)	=	Total Daily PE2 for Ten Poultry Houses (lb/day)
PM_{10}	51.8	+	10.2	=	**62.0**
VOC	92.4	+	18.0	=	**110.4**
NH_3	1,153.6	+	295.2	=	**1,448.8**

Total Annual PE2 for Ten Poultry Houses					
Pollutant	Total Annual PE2 for Seven Laying Hen Houses (lb/yr)	+	Total Annual PE2 for Three Pullet Houses (lb/yr)	=	Total Annual PE2 for Ten Poultry Houses (lb/yr)
PM_{10}	18,907	+	2,709	=	**21,616**
VOC	33,726	+	4,812	=	**38,538**
NH_3	421,064	+	78,957	=	**500,021**

3. Pre-Project Stationary Source Potential to Emit (SSPE1)

Pursuant to District Rule 2201, the SSPE1 is the Potential to Emit (PE) from all units with valid Authorities to Construct (ATC) or Permits to Operate (PTO) at the Stationary Source and the quantity of Emission Reduction Credits (ERC) which have been banked since September 19, 1991 for Actual Emissions Reductions (AER) that have occurred at the source, and which have not been used on-site.

The annual PE values for permit units S-8841-2 to S-8841-15 used in the following SSPE1 table are taken from the PE values calculated in project S-1161654.

SSPE1 (lb/year)						
Permit Unit	**NO_X**	**SO_X**	**PM_{10}**	**CO**	**VOC**	**NH3**
S-8841-2-0*	0	0	0	0	0	0
S-8841-3-0	126	0	4	87	7	0
S-8841-4-0	126	0	4	87	7	0
S-8841-5-0	126	0	4	87	7	0
S-8841-6-0	126	0	4	87	7	0
S-8841-7-0	126	0	4	87	7	0
S-8841-8-0	126	0	4	87	7	0
S-8841-9-0	126	0	4	87	7	0
S-8841-10-0	126	0	4	87	7	0
S-8841-11-0	126	0	4	87	7	0
S-8841-12-0	126	0	4	87	7	0
S-8841-13-0	126	0	4	87	7	0
S-8841-14-0	126	0	4	87	7	0
S-8841-15-0	309	0	7	33	16	0
SSPE1	**1,821**	**0**	**55**	**1,077**	**100**	**0**

*The potential emissions for the solid manure handling system (permit unit -2) are included in the potential emissions from the poultry ranch (permit unit -1). Since ATC S-8841-1-0 cannot be implemented, permit unit -1 will be re-permitted under this project. Therefore, there are no emissions from permit unit -1, and consequently there are no emissions from permit unit -2.

4. Post-Project Stationary Source Potential to Emit (SSPE2)

Pursuant to District Rule 2201, the SSPE2 is the PE from all units with valid ATCs or PTOs at the Stationary Source and the quantity of ERCs which have been banked since September 19, 1991 for AER that have occurred at the source, and which have not been used on-site.

The annual PE values for permit units S-8841-2 to S-8841-15 used in the following SSPE2 table are taken from the PE values calculated in project S-1161654, and from the calculations performed for permit unit S-8841-1 in Sections VII.C.2 of this application review.

SSPE2 (lb/year)						
Permit Unit	**NO_X**	**SO_X**	**PM_{10}**	**CO**	**VOC**	**NH3**
S-8841-1-1 or -1-2*	0	0	21,616	0	38,538	500,021
S-8841-2-0**	0	0	0	0	0	0
S-8841-3-0	126	0	4	87	7	0
S-8841-4-0	126	0	4	87	7	0
S-8841-5-0	126	0	4	87	7	0
S-8841-6-0	126	0	4	87	7	0
S-8841-7-0	126	0	4	87	7	0
S-8841-8-0	126	0	4	87	7	0
S-8841-9-0	126	0	4	87	7	0
S-8841-10-0	126	0	4	87	7	0
S-8841-11-0	126	0	4	87	7	0
S-8841-12-0	126	0	4	87	7	0
S-8841-13-0	126	0	4	87	7	0
S-8841-14-0	126	0	4	87	7	0
S-8841-15-0	309	0	7	33	16	0
SSPE2	**1,821**	**0**	**21,671**	**1,077**	**38,638**	**500,021**

*Both ATCs S-8841-1-1 & -1-2 have the same potential to emit, and the facility can implement either of the ATCs issued under this project.

**The potential emissions for the solid manure handling system (permit unit -2) are included in the potential emissions from the poultry ranch (permit unit -1). Therefore, post-project emissions for permit unit -2 are included in post-project emissions for permit unit -1.

5. Major Source Determination

Rule 2201 Major Source Determination:

Pursuant to District Rule 2201, a Major Source is a stationary source with a SSPE2 equal to or exceeding one or more of the following threshold values. For the purposes of determining major source status the following shall not be included:

- any ERCs associated with the stationary source
- Emissions from non-road IC engines (i.e. IC engines at a particular site at the facility for less than 12 months)
- Fugitive emissions, except for the specific source categories specified in 40 CFR 51.165

Rule 2201 Major Source Determination (lb/year)						
	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO	VOC
SSPE1	1,821	0	55	55	1,077	100
SSPE2	1,821	0	21,671	21,671	1,077	38,638
Major Source Threshold	20,000	140,000	140,000	140,000	200,000	20,000
Major Source?	No	No	No	No	No	Yes

Note: PM2.5 assumed to be equal to PM10

As seen in the table above, the facility is not an existing Major Source for any pollutant; however, it is becoming a Major Source for VOC emissions as a result of this project.

Rule 2410 Major Source Determination:

The facility or the equipment evaluated under this project is not listed as one of the categories specified in 40 CFR 52.21 (b)(1)(iii). Therefore the PSD Major Source threshold is 250 tpy for any regulated NSR pollutant.

PSD Major Source Determination (tons/year)						
	NO_2	VOC	SO_2	CO	PM	PM_{10}
Estimated Facility PE before Project Increase	0.9	0.1	0.0	0.5	0.0	0.0
PSD Major Source Thresholds	250	250	250	250	250	250
PSD Major Source ? (Y/N)	N	N	N	N	N	N

As shown on the previous page, the facility is not an existing PSD major source for any regulated NSR pollutant expected to be emitted at this facility.

6. Baseline Emissions (BE)

The BE calculation (in lb/year) is performed pollutant-by-pollutant for each unit within the project to calculate the QNEC, and if applicable, to determine the amount of offsets required.

Pursuant to District Rule 2201, BE = PE1 for:

- Any unit located at a non-Major Source,
- Any Highly-Utilized Emissions Unit, located at a Major Source,
- Any Fully-Offset Emissions Unit, located at a Major Source, or
- Any Clean Emissions Unit, located at a Major Source.

otherwise,

BE = Historic Actual Emissions (HAE), calculated pursuant to District Rule 2201.

Since the units within this project are all new emissions units, the BE = PE1 = 0 for all pollutants.

7. SB 288 Major Modification

SB 288 Major Modification is defined in 40 CFR Part 51.165 as "any physical change in or change in the method of operation of a major stationary source that would result in a significant net emissions increase of any pollutant subject to regulation under the Act."

Since this facility is not a major source for any of the pollutants addressed in this project, this project does not constitute an SB 288 major modification.

8. Federal Major Modification

District Rule 2201 states that a Federal Major Modification is the same as a "Major Modification" as defined in 40 CFR 51.165 and part D of Title I of the CAA.

Since this facility is not an existing Major Source for any pollutants, this project does not constitute a Federal Major Modification.

9. Rule 2410 – Prevention of Significant Deterioration (PSD) Applicability Determination

Rule 2410 applies to any pollutant regulated under the Clean Air Act, except those for which the District has been classified nonattainment. The pollutants which must be addressed in the PSD applicability determination for sources located in the SJV and which are emitted in this project are: (See 52.21 (b) (23) definition of significant)

- PM
- PM10

I. Project Emissions Increase - New Major Source Determination

The post-project potentials to emit from all new and modified units are compared to the PSD major source thresholds to determine if the project constitutes a new major source subject to PSD requirements.

The facility or the equipment evaluated under this project is not listed as one of the categories specified in 40 CFR 52.21 (b)(1)(iii). The PSD Major Source threshold is 250 tpy for any regulated NSR pollutant.

PSD Major Source Determination: Potential to Emit (tons/year)						
	NO_2	VOC	SO_2	CO	PM*	PM_{10}
Total PE from New and Modified Units	0.0	19.3	0.0	0.0	27.0	10.8
PSD Major Source threshold	250	250	250	250	250	250
New PSD Major Source?	N	N	N	N	N	N

* PM from hen houses assumed to be equal to be 250% of PM_{10}

As shown in the table above, the potential to emit for the project, by itself, does not exceed any PSD major source threshold. Therefore Rule 2410 is not applicable and no further analysis is required.

10. Quarterly Net Emissions Change (QNEC)

The QNEC is calculated solely to establish emissions that are used to complete the District's PAS emissions profile screen. Detailed QNEC calculations are included in Appendix I.

VIII. Compliance Determination

Rule 1070 Inspections

This rule applies to any source operation which emits or may emit air contaminants.

This rule allows the District to perform inspections for the purpose of obtaining information necessary to determine whether air pollution sources are in compliance with applicable rules and regulations. The rule also allows the District to require record keeping, to make inspections and to conduct tests of air pollution sources. Therefore, the following conditions will be listed on each ATC to ensure compliance:

- Upon presentation of appropriate credentials, a permittee shall allow an authorized representative of the District to enter the permittee's premises where a permitted source is located or emissions related activity is conducted, or where records must be kept under condition of the permit. [District Rule 1070]

- Upon presentation of appropriate credentials, a permittee shall allow an authorized representative of the District to have access to and copy, at reasonable times, any records that must be kept under the conditions of the permit. [District Rule 1070]

Rule 2201 New and Modified Stationary Source Review Rule

A. Best Available Control Technology (BACT)

1. BACT Applicability

BACT requirements are triggered on a pollutant-by-pollutant basis and on an emissions unit-by-emissions unit basis. Unless specifically exempted by Rule 2201, BACT shall be required for the following actions*:

a. Any new emissions unit with a potential to emit exceeding two pounds per day,
b. The relocation from one Stationary Source to another of an existing emissions unit with a potential to emit exceeding two pounds per day,
c. Modifications to an existing emissions unit with a valid Permit to Operate resulting in an Adjusted Increase in Permitted Emissions (AIPE) exceeding two pounds per day, and/or
d. Any new or modified emissions unit, in a stationary source project, which results in an SB 288 Major Modification or a Federal Major Modification, as defined by the rule.

*Except for CO emissions from a new or modified emissions unit at a Stationary Source with an SSPE2 of less than 200,000 pounds per year of CO.

a. New emissions units – PE > 2 lb/day

S-8841-1-1 & -1-2:

As seen in Section VII.C.2 above, the applicant is proposing to permit 10 new poultry layer houses each with a PE greater than 2 lb/day for VOC, PM_{10}, and NH_3 emissions. Therefore, BACT is triggered for VOC, PM_{10}, and NH_3 emissions.

b. Relocation of emissions units – PE > 2 lb/day

As discussed in Section I above, there are no emissions units being relocated from one stationary source to another; therefore BACT is not triggered.

c. Modification of emissions units – AIPE > 2 lb/day

As discussed in Section I above, there are no modified emissions units associated with this project. Therefore BACT is not triggered.

d. SB 288/Federal Major Modification

As discussed in Sections VII.C.7 and VII.C.8 above, this project does not constitute an SB 288 and/or Federal Major Modification for any pollutant. Therefore BACT is not triggered for any pollutant.

2. BACT Guideline

S-8841-1-1 and -1-2:

BACT Guideline 5.7.2 applies to poultry layer houses. Central Valley Eggs is proposing to permit 10 new poultry layer houses. Therefore, BACT Guideline 5.7.2 is applicable to these poultry layer houses and is included in Appendix E.

3. Top-Down BACT Analysis

Per Permit Services Policies and Procedures for BACT, a Top-Down BACT analysis shall be performed as a part of the application review for each application subject to the BACT requirements pursuant to the District's NSR Rule.

Pursuant to the attached Top-Down BACT Analysis (see Appendix F), BACT has been satisfied with the following:

PM_{10}: Completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; and belt manure aeration/drying and removal system with manure removal at least twice per week.

VOC: Completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; belt manure aeration/drying and removal system with manure removal at least twice per week; all birds fed in accordance with NRC or other District-approved guidelines; and all mortality removed from houses at least once per day.

NH_3: Completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; belt manure aeration/drying and removal system with manure removal at least twice per week; all birds fed in accordance with NRC or other District-approved guidelines; and all mortality removed from houses at least once per day.

The following conditions will be included on the ATCs S-8841-1-1 & -1-2 to ensure compliance with BACT requirements.

- Each poultry house shall be completely enclosed and mechanically ventilated with evaporative cooling pads, fans, and a computer control system. [District Rule 2201]

- Each poultry house shall be equipped with a belt manure aeration and removal system that advances by a minimum of half the length of the belt every 24 hours. [District Rule 2201]

- All mortality in each poultry house shall be removed at least once per day. [District Rule 2201]
- Permittee shall feed all animals according to National Research Council (NRC) guidelines. [District Rules 2201 and 4570]

B. Offsets

1. Offset Applicability

Offset requirements shall be triggered on a pollutant by pollutant basis and shall be required if the SSPE2 equals or exceeds the offset threshold levels in Table 4-1 of Rule 2201.

The SSPE2 is compared to the offset thresholds in the following table.

Offset Determination (lb/year)					
	NO_X	**SO_X**	**PM_{10}**	**CO**	**VOC**
SSPE2	1,821	0	21,671	1,077	38,638
Offset Thresholds	20,000	54,750	29,200	200,000	20,000
Offsets triggered?	No	No	No	No	Yes

2. Quantity of Offsets Required

As seen above, the SSPE2 is greater than the offset thresholds for VOC only. Therefore offset calculations will be required for this project.

The quantity of offsets in pounds per year for VOC is calculated as follows for sources with an SSPE1 less than the offset threshold levels before implementing the project being evaluated.

Offsets Required (lb/year) = [(SSPE2 – ROT + ICCE) x DOR]

Where,
SSPE2 = Post Project Stationary Source Potential to Emit
ROT = Respective Offset Threshold, for the respective pollutant
ICCE = Increase in Cargo Carrier Emissions
DOR = Distance Offset Ratio, determined pursuant to Section 4.8

Emergency equipment that is used exclusively as emergency standby equipment for electrical power generation or any other emergency equipment as approved by the APCO that does not operate more than 200 hours per year of non-emergency purposes and is not used pursuant to voluntary arrangements with a power supplier to curtail power, is exempt from providing emission offsets. Permit units S-8841-3 through -15 are for emergency standby IC engines and the emissions associated with these permit units will be excluded from the SSPE2 prior to calculating actual offset amounts.

Offsets Required (lb/year) = [(SSPE2 – Emergency Equipment – ROT + ICCE) x DOR]

SSPE2 (VOC)	= 38,638 lb/year
S-8841-3-0 to -15-0 (VOC)	= 100 lb/year
Offset threshold (VOC)	= 20,000 lb/year
ICCE	= 0 lb/year

In accordance with Rule 2201, Section 4.8.1, the DOR for VOC offsets for projects that are new Major Sources shall be 1.5:1. As shown in Section VII.C.8, this project constitutes a new Major Source for VOC emissions. Therefore, the DOR will be 1.5:1 and the total amount of VOC ERCs that need to be withdrawn for this project is:

Offsets Required (lb/year) = [(38,638 – 100 – 20,000 + 0) x 1.5]
= 18,538 x 1.5
= 27,807 lb-VOC/year

Calculating the appropriate quarterly emissions to be offset is as follows:

Quarterly offsets required (lb/qtr) = (27,807 lb-VOC/year) ÷ (4 quarters/year)
= 6,951.75 lb/qtr

As shown in the calculation above, the quarterly amount of offsets required for this project, when evenly distributed to each quarter, results in fractional pounds of offsets being required each quarter. Since offsets are required to be withdrawn as whole pounds, the quarterly amounts of offsets need to be adjusted to ensure the quarterly values sum to the total annual amount of offsets required.

To adjust the quarterly amount of offsets required, the fractional amount of offsets required in each quarter will be summed and redistributed to each quarter based on the number of days in each quarter. The redistribution is based on Quarter 1 having 90 days, Quarter 2 having 91 days, and Quarters 3 and 4 having 92 days.

Therefore the appropriate quarterly emissions to be offset for the poultry ranch are as follows:

1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Annual
6,951	6,952	6,952	6,952	27,807

The applicant has stated that the facility plans to use ERC certificate S-4718-1 to offset the increases in VOC emissions associated with this project. The above certificate has available quarterly VOC credits as follows:

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
ERC #S-4718-1	14,082	14,082	14,082	14,082

As seen above, the facility has sufficient credits to fully offset the quarterly VOC emissions increases associated with this project.

Proposed Rule 2201 (offset) Conditions:

- Prior to operating equipment under this Authority to Construct, permittee shall surrender VOC emission reduction credits for the following quantity of emissions: 1st quarter – 6,951 lb, 2nd quarter – 6,952 lb, 3rd quarter – 6,952 lb, and 4th quarter – 6,952 lb. These amounts include the applicable offset ratio specified in Rule 2201 Section 4.8 (as amended 2/18/16). [District Rule 2201 and Public Resources Code 21000-21177: California Environmental Quality Act]

- ERC Certificate Number S-4718-1 (or a certificate split from this certificate) shall be used to supply the required offsets, unless a revised offsetting proposal is received and approved by the District, upon which this Authority to Construct shall be reissued, administratively specifying the new offsetting proposal. Original public noticing requirements, if any, shall be duplicated prior to reissuance of this Authority to Construct. [District Rule 2201 and Public Resources Code 21000-21177: California Environmental Quality Act]

C. Public Notification

1. Applicability

Public noticing is required for:

a. New Major Sources, Federal Major Modifications, and SB 288 Major Modifications,
b. Any new emissions unit with a Potential to Emit greater than 100 pounds during any one day for any one pollutant,
c. Any project which results in the offset thresholds being surpassed,
d. Any project with an SSIPE of greater than 20,000 lb/year for any pollutant, and/or
e. Any project which results in a Title V significant permit modification

a. New Major Sources, Federal Major Modifications, and SB 288 Major Modifications

New Major Sources are new facilities, which are also Major Sources. Since this is not a new facility, public noticing is not required for this project for New Major Source purposes.

As demonstrated in Sections VII.C.7 and VII.C.8, this project does not constitute an SB 288 or Federal Major Modification; therefore, public noticing for SB 288 or Federal Major Modification purposes is not required.

b. PE > 100 lb/day

Applications which include a new emissions unit with a PE greater than 100 pounds during any one day for any pollutant will trigger public noticing requirements.

S-8841-1-1 & -1-2:

As seen in Section VII.C.2 above, this project includes new laying hen house emission units which have daily emissions greater than 100 lb/day for NH_3 emissions, therefore public noticing for PE > 100 lb/day purposes is required.

c. Offset Threshold

The SSPE1 and SSPE2 are compared to the offset thresholds in the following table.

Offset Thresholds				
Pollutant	**SSPE1 (lb/year)**	**SSPE2 (lb/year)**	**Offset Threshold**	**Public Notice Required?**
NO_X	1,821	1,821	20,000 lb/year	No
SO_X	0	0	54,750 lb/year	No
PM_{10}	55	21,671	29,200 lb/year	No
CO	1,077	1,077	200,000 lb/year	No
VOC	100	38,638	20,000 lb/year	Yes
NH_3	0	500,021	N/A	No

As detailed above, the offset threshold was surpassed for VOC with this project; therefore public noticing is required for offset purposes.

d. SSIPE > 20,000 lb/year

Public notification is required for any permitting action that results in a SSIPE of more than 20,000 lb/year of any affected pollutant. According to District policy, the SSIPE = SSPE2 – SSPE1. The SSIPE is compared to the SSIPE Public Notice thresholds in the following table.

SSIPE Public Notice Thresholds					
Pollutant	**SSPE2 (lb/year)**	**SSPE1 (lb/year)**	**SSIPE (lb/year)**	**SSIPE Public Notice Threshold**	**Public Notice Required?**
NO_x	1,821	1,821	0	20,000 lb/year	No
SO_x	0	0	0	20,000 lb/year	No
PM_{10}	21,671	55	21,616	20,000 lb/year	Yes
CO	1,077	1,077	0	20,000 lb/year	No
VOC	38,638	100	38,538	20,000 lb/year	Yes
NH_3	500,021	0	500,021	20,000 lb/year	Yes

As demonstrated above, the SSIPEs for PM_{10}, VOC and NH_3 are greater than 20,000 lb/year; therefore public noticing for SSIPE purposes is required.

e. Title V Significant Permit Modification

Since this facility does not have a Title V operating permit, this change is not a Title V significant Modification, and therefore public noticing is not required.

2. Public Notice Action

As discussed above, public noticing is required for this project for NH_3 emissions in excess of 100 lb/day, the VOC emission offset threshold being surpassed, and the SSIPE exceeding 20,000 lb/year for VOC, PM_{10}, and NH_3 emissions. Therefore, public notice documents will be submitted to the California Air Resources Board (CARB) and a public notice will be published in a local newspaper of general circulation prior to the issuance of the ATCs for this equipment.

D. Daily Emission Limits (DELs)

DELs and other enforceable conditions are required by Rule 2201 to restrict a unit's maximum daily emissions, to a level at or below the emissions associated with the maximum design capacity. The DEL must be contained in the latest ATC and contained in or enforced by the latest PTO and enforceable, in a practicable manner, on a daily basis. DELs are also required to enforce the applicability of BACT.

<u>S-8841-1-1 & -1-2:</u>

- No more than 327,000 birds shall be kept in each of the seven laying hen houses at any time. [District Rule 2201]

- No more than 350,000 birds (chick starters or pullet growers) shall be kept in each of the three pullet houses at any time. For the purposes of this permit, chick starters are defined as birds from zero to six weeks of age and pullet growers are defined as birds from six weeks to 16 weeks of age. [District Rule 2201]

- Each pullet house shall not contain chick starters for more than 126 days per rolling 12-month period and pullet growers for more than 210 days per rolling 12-month period. [District Rule 2201]

- Emissions from each laying hen house shall not exceed any of the following limits: 0.02271 lb-PM_{10}/1,000 birds-day, 0.0404 lb-VOC/1,000 birds-day, or 0.504 lb-NH_3/1,000 birds-day. [District Rule 2201]

- Emissions from each pullet house shall not exceed any of the following limits: 1) Chick Starters: 0.00441 lb-PM_{10}/1,000 birds-day, 0.00784 lb-VOC/1,000 birds-day, or 0.1283 lb-NH_3/1,000 birds-day; and 2) Pullet Growers: 0.009652 lb-PM_{10}/1,000 birds-day, 0.01711 lb-VOC/1,000 birds-day, or 0.2811 lb-NH_3/1,000 birds-day. [District Rule 2201]

- Each poultry house shall be completely enclosed and mechanically ventilated with evaporative cooling pads, fans, and a computer control system. [District Rule 2201]

- Each poultry house shall be equipped with a belt manure aeration and removal system that advances by a minimum of half the length of the belt every 24 hours. [District Rule 2201]

- The tarp used to reduce PM emissions from the exhaust fans shall be inspected on a quarterly basis. The tarp shall be inspected thoroughly for rips, tears, leaks, or any evidence of structural failures that result in excessive PM emissions and shall be repaired or replaced as needed. [District Rule 2201]

- No bedding or litter materials shall be used on the bottom floor of the poultry houses at this facility. [District Rule 2201]

- All mortality in each poultry house shall be removed at least once per day. [District Rule 2201]

- The maximum crude protein content of the feed given to all laying hens at this facility shall not exceed 15%. [District Rule 2201]

- Permittee shall feed all animals according to National Research Council (NRC) guidelines. [District Rules 2201 and 4570]

- Permittee shall use drinkers that do not drip continuously. [District Rules 2201 and 4570]

- Permittee shall inspect water pipes and drinkers and repair leaks daily. [District Rules 2201 and 4570]

- Permittee shall feed animals probiotics designed to improve digestion according to manufacturer recommendations. [District Rules 2201 and 4570]

- Permittee shall feed animals an amino acid supplemented diet. [District Rules 2201 and 4570]

- Permittee shall feed animals additives such as amylase, xylanase, and protease, designed to maximize digestive efficiency. [District Rules 2201 and 4570]

<u>S-8841-1-1:</u>

- The open end of each poultry house shall be equipped with a tarp covering approximately 40% of the upper part of the opening. The open end shall also be equipped with water sprays installed under the bottom edge of the tarp to reduce particulate matter (PM) emissions from the exhaust fans. The water sprays shall operate at all times, except during periods of actual rainfall. [District Rule 2201]

- The water sprays used to reduce PM emissions from the exhaust fans shall be inspected on a quarterly basis. The water spray nozzles shall be inspected thoroughly for leaks, clogs, or any evidence of structural failures that result in excessive PM emissions and shall be repaired or replaced as needed.

- Permittee shall maintain records of inspections, maintenance, repair, and replacement of the tarps and water spray nozzles used to reduce PM emissions from the exhaust fans. The records shall include the dates of inspections and a description of any corrective actions taken. [District Rule 2201]

<u>S-8841-1-2:</u>

- The open end of each poultry house shall be equipped with a tarp covering approximately 40% of the upper part of the opening to reduce particulate matter (PM) emissions from the exhaust fans. Each poultry house may have optional water sprays equipped under the bottom edge of the tarp. [District Rule 2201]

- The tarp used to reduce PM emissions from the exhaust fans shall be inspected on a quarterly basis. The tarp shall be inspected thoroughly for rips, tears, holes, or any evidence of structural failures that result in excessive PM emissions and shall be repaired or replaced as needed. [District Rule 2201]

- Permittee shall maintain records of inspections, maintenance, repair, and replacement of the tarps used to reduce PM emissions from the exhaust fans. The records shall include the dates of inspections and a description of any corrective actions taken. [District Rule 2201]

E. Compliance Assurance

1. Source Testing

S-8841-1-1 & -1-2:

Per District Policy APR 1705, Source Testing, there are no specific source testing requirements for laying hen ranches or poultry houses. However, District Policy APR 1705, Section I.D states that when permit applicants propose emission factors that are new or are different from those typically used for similar sources, initial source testing shall be required. Central Valley Eggs has state of the art, cage-free aviary style laying hen houses at this facility that are expected to have low PM_{10} and NH_3 emission rates as compared to other similar poultry houses. This type of operation is new to the District and established reference materials for the expected emissions from this style of house are not well documented or readily available. Therefore, initial source testing for PM_{10} and NH_3 emissions will be required for at least one of the proposed laying hen houses.

District Policy APR 1705, Section I.E. states that when establishing source testing requirements, it must be noted that certain types of equipment do not lend themselves to source testing. Large sources (i.e. too big for total enclosure) of fugitive emissions without a stack are an example of such sources. As discussed above, Central Valley Eggs is proposing to operate each poultry house with up to 48 exhaust fans blowing the air exiting the open end of the houses. The houses are not equipped with exhaust stacks. In addition, the potentially large volume of airflow exiting the open end of each house makes it hard to capture and monitor the emission rates being generated. Therefore, this type of operation does not lend itself readily to source testing and periodic annual source testing to verify the PM_{10} and NH_3 emission factors will not be required for this operation.

Central Valley Eggs may request to further increase the maximum number of laying hens that may be housed at this facility or to construct additional poultry houses. The results of the initial source test may be used to establish PM_{10} and NH_3 emissions for the poultry houses at the facility.

All of the poultry and manure handling operations take place within each poultry house. The airflow rate generated by the fans all exhausts out the open end of each house. Therefore, each house is the only point of potential emissions for the poultry operations. In accordance with these requirements, the following conditions will be included on the ATCs for the poultry houses, S-8841-1-1 & -1-2:

- Initial source testing to demonstrate compliance with the PM_{10} and NH_3 emissions from at least one of the laying hen houses shall be initiated within 30 days of issuance of this ATC. [District Rule 2201]

- Source testing shall be conducted using the methods and procedures approved by the District. The District must be notified and a source test plan shall be submitted to the District for approval by the Permit Services and Compliance Divisions at least 15 days prior to any compliance source test. The source test plan shall include a detailed description of how testing will be conducted, the proposed duration of the test, and the methodology to be used. [District Rule 2201]

- All emission measurements shall be made with the laying hen house operating either at conditions representative of normal operations or conditions specified in the Authority to Construct. To the maximum extent possible that still allows for normal operation, emission measurements shall be taken in conditions that represent the maximum emission rates from the laying hen house. Those conditions shall include, but are not limited to, the laying hen house being filled at, or near, maximum capacity, a majority of the exhaust fans turned on, and the manure windrow stockpiles near capacity. [District Rule 2201]

- The following test methods shall be used: PM_{10} emission rates (filterable and condensable) shall be conducted using EPA Method 201 and 202, EPA Method 201a and 202, ARB Method 5 in combination with Method 501, or South Coast Air Quality Management District (SCAQMD) Method 5.1; and ammonia (NH_3) - BAAQMD ST-1B. If it is determined that these test methods are not appropriate to measure the PM_{10} and NH_3 emissions from this type of operation, emissions shall be measured using any other District approved alternative test methods. [District Rule 2201]

- The results of the source test shall be submitted to the District within 60 days thereafter. [District Rule 1081]

2. Monitoring

The capacity of the new poultry ranch under this project will result in the facility becoming subject to District Rule 4570 - Confined Animal Facilities.

<u>S-8841-1-1:</u>

The poultry houses will be required to utilize water sprays over the open ends of each house where the exhaust air escapes to the atmosphere to further reduce PM_{10} emissions. As discussed above, all of the emissions generating activities occur within each poultry house. Therefore, the following monitoring conditions will be included on the ATC:

- Permittee shall inspect water pipes and drinkers and repair leaks daily. [District Rules 2201 and 4570]

- The tarp used to reduce PM emissions from the exhaust fans shall be inspected on a quarterly basis. The tarp shall be inspected thoroughly for rips, tears, leaks, or any evidence of structural failures that result in excessive PM emissions and shall be repaired or replaced as needed. [District Rule 2201]

- The water sprays used to reduce PM emissions from the exhaust fans shall be inspected on a quarterly basis. The water spray nozzles shall be inspected thoroughly for leaks, clogs, or any evidence of structural failures that result in excessive PM emissions and shall be repaired or replaced as needed. [District Rule 2201]

S-8841-1-2:

As discussed above, all of the emissions generating activities occur within each poultry house. Therefore, the following monitoring conditions will be included on the ATC:

- Permittee shall inspect water pipes and drinkers and repair leaks daily. [District Rules 2201 and 4570]

- The tarp used to reduce PM emissions from the exhaust fans shall be inspected on a quarterly basis. The tarp shall be inspected thoroughly for rips, tears, holes, or any evidence of structural failures that result in excessive PM emissions and shall be repaired or replaced as needed. [District Rule 2201]

3. Recordkeeping

Recordkeeping is required to demonstrate compliance with the offset, public notification and daily emission limit requirements of Rule 2201. The following conditions will be listed on the ATCs:

S-8841-1-1:

- Permittee shall maintain records of inspections, maintenance, repair, and replacement of the tarps and water spray nozzles used to reduce PM emissions from the exhaust fans. The records shall include the dates of inspections and a description of any corrective actions taken. [District Rule 2201]

S-8841-1-2:

- Permittee shall maintain records of inspections, maintenance, repair, and replacement of the tarps used to reduce PM emissions from the exhaust fans. The records shall include the dates of inspections and a description of any corrective actions taken. [District Rule 2201]

S-8841-1-1 & -1-2:

- Permittee shall maintain records to demonstrate that the belt advances by a minimum of half of its length every 24 hours. [District Rule 2201]

- Permittee shall maintain quarterly records of maintenance and repair activities associated with the belt manure aeration and removal system that includes the dates of maintenance and repair, and a description of any corrective actions taken. [District Rule 2201]

- Permittee shall maintain records of feed content, formulation, and quantity of feed additive utilized, to demonstrate compliance with National Research Council (NRC) guidelines. Permittee shall also maintain records of the crude protein content of the feed given to all laying hens at this facility. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this requirement. [District Rules 2201 and 4570]

- Permittee shall maintain daily records of mortality removal in each poultry house. [District Rule 2201]

- Permittee shall maintain records of dates manure is removed from each poultry house. [District Rule 2201]

- Permittee shall maintain records indicating that water pipes and drinkers are inspected daily, and that any leaks are repaired. [District Rules 2201 and 4570]

- Permittee shall maintain records to demonstrate animals are fed probiotics designed to improve digestion. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this requirement. [District Rules 2201 and 4570]

- Permittee shall maintain records to demonstrate animals are fed an amino acid supplemented diet. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this. [District Rules 2201 and 4570]

- Permittee shall maintain records that demonstrate animals are fed feed additives such as amylase, xylanase, and protease. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this. [District Rules 2201 and 4570]

- Permittee shall maintain monthly records of the number of animals of each species and production group at the facility and records of any changes to this information. For the pullet houses, the permittee shall also maintain records of the age of birds, the growing stage the birds are in, and the total number of days each growing stage has been housed for the current rolling 12-month period. [District Rules 2201 and 4570]

- Permittee shall keep and maintain all records for a minimum of five (5) years and shall make records available to the APCO and EPA upon request. [District Rules 2201 and 4570]

4. Reporting

No reporting is required to demonstrate compliance with Rule 2201.

F. Ambient Air Quality Analysis (AAQA)

An AAQA shall be conducted for the purpose of determining whether a new or modified Stationary Source will cause or make worse a violation of an air quality standard. The District's Technical Services Division conducted the required analysis under project S-1161654. Since there is no increase in emissions from the poultry ranch, and there is no change in the maximum bird capacity and total number of poultry houses at the site, the original AAQA conducted in project S-1161654 is still valid and applicable to this project.

The proposed location is in an attainment area for NO_X, CO, and SO_X. As shown by the AAQA summary sheet (see Appendix H), the proposed equipment will not cause a violation of an air quality standard for NO_X, CO, or SO_X.

The proposed location is in a non-attainment area for the state's PM_{10} as well as federal and state $PM_{2.5}$ thresholds. As shown by the AAQA summary sheet the proposed equipment will not cause a violation of an air quality standard for PM_{10} and $PM_{2.5}$.

<u>S-8841-1-1 & -1-2</u>:

The following condition will be included on the proposed ATCs:

- Issuance of any Authority to Construct (ATC) permit(s) or any construction that results in a further increase in the number of laying hens, pullets, or poultry houses at this facility such as described in the proposal for District ATC Project S-1180558, or the District CEQA document prepared for the project, shall be treated and analyzed as a part of ATC Project S-1180558 for New and Modified Source Review (NSR) purposes to ensure that the cumulative emissions from the overall project will not cause or make worse a violation of an Ambient Air Quality Standard. [District Rule 2201 and California Environmental Quality Act]

Rule 2410 Prevention of Significant Deterioration

As shown in Section VII.C.9 above, this project does not result in a new PSD major source or PSD major modification. No further discussion is required.

Rule 2520 Federally Mandated Operating Permits

As discussed above, this facility is a major source. Pursuant to Rule 2520 and as required by permit condition, the facility will have up to 12 months from the date of ATC issuance to either submit a Title V Application or comply with District Rule 2530 Federally Enforceable Potential to Emit. The facility has already submitted Title V application under project S-1174067; therefore, compliance with this rule is expected.

Rule 4001 New Source Performance Standards (NSPS)

This rule incorporates NSPS from Part 60, Chapter 1, Title 40, Code of Federal Regulations (CFR); and applies to all new sources of air pollution and modifications of existing sources of air pollution listed in 40 CFR Part 60.

No subparts of 40 CFR Part 60 apply to poultry houses. Therefore, the requirements of Rule 4001 are not applicable to the operation.

Rule 4002 National Emission Standards for Hazardous Air Pollutants (NESHAPs)

This rule incorporates NESHAPs from Part 61, Chapter I, Subchapter C, Title 40, CFR and the NESHAPs from Part 63, Chapter I, Subchapter C, Title 40, CFR; and applies to all sources of hazardous air pollution listed in 40 CFR Part 61 or 40 CFR Part 63.

No subparts of 40 CFR Part 61 or 40 CFR Part 63 apply to poultry houses. Therefore, the requirements of Rule 4002 are not applicable to the operation.

Rule 4101 Visible Emissions

Rule 4101 states that no person shall discharge into the atmosphere emissions of any air contaminant aggregating more than 3 minutes in any hour which is as dark as or darker than Ringelmann 1 or 20% opacity.

Pursuant to Section 4.12, emissions subject to or specifically exempt from Regulation VIII (Fugitive PM_{10} Prohibitions) are exempt from this regulation. According to District Rule 8011, Section 4.0 - Exemptions, On-field agricultural sources are exempt from the provisions of Regulation VIII.

District Rule 8011, Section 3.34 defines an Off-field Agricultural Source as any agricultural source that meets the definition of: outdoor handling, storage and transport of bulk material; paved road; unpaved road; or unpaved vehicle/equipment traffic area. District Rule 8011, Section 3.35 defines an On-field Agricultural Source as any agricultural source that is not an off-field agricultural source. Therefore, this rule does not apply to the activities conducted solely for the raising of poultry.

Rule 4102 Nuisance

Rule 4102 prohibits discharge of air contaminants which could cause injury, detriment, nuisance or annoyance to the public. Public nuisance conditions are not expected as a result of these operations, provided the equipment is well maintained. Therefore, compliance with this rule is expected.

California Health & Safety Code 41700 (Health Risk Assessment)

District Policy APR 1905 – *Risk Management Policy for Permitting New and Modified Sources* specifies that for an increase in emissions associated with a proposed new source or modification, the District perform an analysis to determine the possible impact to the nearest resident or worksite.

An HRA for permit unit S-8841-1 was performed under project S-1161654 (see Appendix H). Since the facility cannot implement the original ATC issued, the equipment is being treated as new emission units for the purposes of this project. Since there is no change in any HRA parameter and there are no increases in emissions associated with this project, the original HRA completed in project S-1161654 is still valid and applicable to this project, and the permit unit will comply with the HRA requirements from the previous project.

Rule 4201 Particulate Matter Concentration

Section 3.1 prohibits discharge of dust, fumes, or total particulate matter into the atmosphere from any single source operation in excess of 0.1 grain per dry standard cubic foot.

Maximum PM emission rate for each poultry house (As discussed in Section VII.A, the PM is 250% of PM_{10}).

= 7.4 lb-PM_{10}/day x 2.5 lb-PM/lb-PM_{10} = 18.5 lb-PM/day

Each of the laying hen houses are equipped with 48 exhaust fans, each capable of an air flow rate of 26,200 cfm. Each of the pullet houses will be equipped with 38 exhaust fans. Although multiple fans will always be operating for the health of the birds, for the purpose of Rule 4201 compliance calculations, it will conservatively be assumed that only one fan is operating in each house, resulting in a minimum air flow rate of 26,200 cfm for each house.

Minimum house ventilation rate: = 26,200 scfm

PM Conc. (gr/scf) = [(18.5 lb/day) x (7,000 gr/lb)] ÷ [(26,200 ft^3/min) x (60 min/hr) x (24 hr/day)]
= 0.0034 gr/scf

PM Conc. (gr/scf) = 0.0034 gr/scf < 0. 1 gr/scf

As shown above, PM emissions concentrations from each of the poultry houses are below the applicable limit. Therefore, compliance with the requirements of this rule is expected.

Rule 4550 Conservation Management Practices (CMP)

This rule applies to agricultural operation sites located within the San Joaquin Valley Air Basin. The purpose of this rule is to limit fugitive dust emissions from agricultural operation sites.

Pursuant to Section 4.0, the provisions of this rule apply to agricultural sources where the total acreage of all agricultural parcels is 100 or more acres (excluding the animal feeding operation and exempted lands) and to animal feeding operations with at least 82,000 laying hens. This facility is proposing to house 2,289,000 laying hens and 1,050,000 brooders/pullets at this facility. Therefore, this rule applies to the laying hen ranch.

Pursuant to Section 5.1, effective on and after July 1, 2004, an owner/operator shall implement the applicable CMPs selected pursuant to Section 6.2.

Pursuant to Section 5.2, an owner/operator shall prepare and submit a CMP application for each agricultural operation site to the APCO for approval.

Pursuant to Section 6.3.3, an owner/operator shall submit a CMP application to the APCO within 90 days for an agricultural operation site or an agricultural parcel that is acquired or becomes subject to the provisions of Section 5.0 after October 31, 2004.

The facility has received approval of their current CMP plan on September 11, 2017. Continued compliance with the requirements of District Rule 4550 is expected.

Rule 4570 Confined Animal Facilities (CAF)

This rule applies to Confined Animal Facilities (CAFs) located within the San Joaquin Valley Air Basin. The purpose of this rule is to limit emissions of Volatile Organic Compounds (VOC) from CAFs.

Pursuant to Section 5.1, owners/operators of any CAF shall submit, for approval by the APCO, a permit application for each CAF. This facility has submitted an ATC application to authorize the installation of this CAF. Therefore, this requirement is satisfied.

Pursuant to Section 5.1.2, a thirty-day public noticing and commenting period shall be required for all large CAFs receiving their initial Permit-to-Operate or Authority-to-Construct. For poultry facilities, a large CAF is defined as a facility with at least 650,000 birds. The poultry ranch permitted under this project is a large CAF. However, the facility has already gone through public notice for compliance with the District Rule 4570 in project S-1161654; therefore, 30-day public notice will not be required for this project.

Pursuant to Section 5.1.3, owners/operators shall submit a facility emissions mitigation plan of the Permit-to-Operate application or Authority-to-Construct application. The mitigation plan shall contain the following information:

- The name, business address, and phone number of the owners/operators responsible for the preparation and the implementation of the mitigation measures listed in the permit.
- The signature of the owners/operators attesting to the accuracy of the information provided and adherence to implementing the activities specified in the mitigation plan at all times and the date that the application was signed.
- A list of all mitigation measures shall be chosen from the application portions of Sections 5.5 or 5.6.

The facility has submitted a District-approved Rule 4570 Phase II compliance application form under project S-1161654, which includes the required information listed above. Therefore, this section is satisfied.

Pursuant to Sections 5.1.4 through 5.1.6, the Permit-to-Operate or Authority-to-Construct application shall include the following information, which is in addition to the facility emission mitigation plan:

- The maximum number of animals at the facility in each production stage (facility capacity).
- Any other information necessary for the District to prepare an emission inventory of all regulated air pollutants emitted from the facility as determined by the APCO.
- The approved mitigation measures from the facility's mitigation plan will be listed on the Permit to Operate or Authority-to-Construct as permit conditions.
- The District shall act upon the Authority to Construct application or Permit to Operate application within six (6) months or receiving a complete application.

The facility's ATC application form submitted under project S-1161654 includes the required information listed above. Therefore, this section is satisfied.

Pursuant to Section 5.3, owners/operators of any CAF shall implement all VOC emission mitigation measures, as contained in the permit application, on and after 365 days from the date of issuance of either the Authority-to-Construct or the Permit-to Operate whichever is sooner.

The feed and housing mitigation measures selected by the facility will directly affect the VOC emission factor, which is used to calculate the potential to emit and determine the health risk for this project. Therefore, all of the Rule 4570 mitigation measures will be required to be implemented immediately instead of within the first 365 days of ATC or PTO issuance.

Pursuant to Section 5.4, an owner/operator may temporarily suspend use of mitigation measure(s) provided all of the following requirements are met:

- It is determined by a licensed veterinarian, certified nutritionist, CDFA, or USDA that any mitigation measure being suspended is detrimental to animal health or necessary for the animal to molt, and a signed written copy of this determination shall be retained on-site and made available for inspection upon request.
- The owner/operator notifies the District, within forty-eight (48) hours of the determination that the mitigation measure is being temporarily suspended; the specific health condition requiring the mitigation measure to be suspended; and the duration that the measure must be suspended for animal health reasons,
- The emission mitigation measure is not suspended for longer than recommended by the licensed veterinarian or certified nutritionist for animal health reasons,
- If such a situation exists, or is expected to exist for longer than thirty (30) days, the owners/operators shall, within that thirty (30) day period, submit a new emission mitigation plan designating a mitigation measure to be implemented in lieu of the mitigation measure that was suspended, and

- The APCO, ARB, and EPA approve the temporary suspension of the mitigation measure for the time period requested by the owner/operator and a signed written copy of this determination shall be retained on site.

The following condition will be placed on the ATCs:

- If a licensed veterinarian or a certified nutritionist determines that any VOC mitigation measure will be required to be suspended as a detriment to animal health or necessary for the animal to molt, the owners/operators must notify the District in writing within forty-eight (48) hours of the determination including the duration and the specific health condition requiring the mitigation measure to be suspended. If the situation is expected to exist longer than a thirty-day (30) period, the permittee shall submit a new emission mitigation plan designating a mitigation measure to be implemented in lieu of the suspended mitigation measure. [District Rules 2201 and 4570]

Section 5.5 lists Phase I mitigation measures. Per the compliance schedule listed in Section 8 of this rule, the facility is subject to the Phase II mitigation measures listed in Section 5.6. Therefore, Section 5.5 no longer applies.

Central Valley Eggs has chosen the following mitigation measures to comply with Section 5.6. All conditions required for compliance with Rule 4570 for the mitigation measures selected by the applicant are shown immediately below the selected mitigation measure. These conditions will be placed on the ATCs.

Layer Feed

Feed according to National Research Council (NRC) guidelines.

- Permittee shall feed all animals according to National Research Council (NRC) guidelines. [District Rules 2201 and 4570]

- Permittee shall maintain records of feed content, formulation, and quantity of feed additive utilized, to demonstrate compliance with National Research Council (NRC) guidelines. Records such as feed company guaranteed analyses (feed tags), ration sheets). [District Rules 2201 and 4570]

Feed animals probiotics designed to improve digestion according to manufacturer recommendations.

- Permittee shall feed animals probiotics designed to improve digestion according to manufacturer's recommendations. [District Rules 2201 and 4570]

- Permittee shall maintain records to demonstrate animals are fed probiotics designed to improve digestion. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this requirement. [District Rules 2201 and 4570]

Feed animals an amino acid supplemented diet to meet their nutrient requirements.

- Permittee shall feed animals an amino acid supplemented diet. [District Rules 2201 and 4570]

- Permittee shall maintain records to demonstrate animals are fed an amino acid supplemented diet. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this. [District Rules 2201 and 4570]

Feed animals feed additives such as amylase, xylanase, and protease, designed to maximize digestive efficiency according to manufacturer recommendations.

- Permittee shall feed animals additives such as amylase, xylanase, and protease, designed to maximize digestive efficiency. [District Rules 2201 and 4570]

- Permittee shall maintain records that demonstrate animals are fed feed additives such as amylase, xylanase, and protease. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this. [District Rules 2201 and 4570]

Layer Housing

Use drinkers that do not drip continuously.

- Permittee shall use drinkers that do not drip continuously. [District Rules 2201 and 4570]

Inspect water pipes and drinkers and repair leaks daily.

- Permittee shall inspect water pipes and drinkers and repair leaks daily. [District Rules 2201 and 4570]

- Permittee shall maintain records indicating that water pipes and drinkers are inspected daily, and that any leaks are repaired. [District Rules 2201 and 4570]

Section 7.1 lists recordkeeping requirements for CAFs claiming exemption pursuant to Section 4.0 of this rule. This facility is not claiming an exemption from this rule. Therefore, this section does not apply.

Section 7.2 lists the following general records for CAFs subject to Section 5.0 requirements:

- Copies of all of the facility's permits
- Copies of all laboratory tests, calculations, logs, records, and other information required to demonstrate compliance with all applicable requirements of this rule, as determined by the APCO, ARB, and EPA.
- Records of the number of animals of each species and production group at the facility on the permit issuance date. Quarterly records of any changes to this information shall also be maintained.

The following condition will be placed on the ATCs:

- Permittee shall maintain monthly records of the number of animals of each species and production group at the facility and records of any changes to this information. For the pullet houses, the permittee shall also maintain records of the age of birds, the growing stage the birds are in, and the total number of days each growing stage has been housed for the current rolling 12-month period. [District Rules 2201 and 4570]

Additional recordkeeping and monitoring conditions required to demonstrate compliance with this rule are shown above under the Section 5.6 discussion under the appropriate mitigation measures.

Pursuant to Section 7.9, owners/operators of a CAF subject to the requirements of Section 5.0 shall keep and maintain the required records in Sections 7.1 through 7.8.4, as applicable, for a minimum of five (5) years and the records shall be made available to the APCO and EPA upon request. Therefore, the following condition will be placed on the ATCs:

- Permittee shall keep and maintain all records for a minimum of five (5) years and shall make records available to the APCO and EPA upon request. [District Rules 2201 and 4570]

Section 7.10 requires specific monitoring or source testing conditions for each mitigation measure. These conditions are shown above under the Section 5.6 discussion under the appropriate mitigation measures.

California Health & Safety Code 42301.6 (School Notice)

The District has verified that this site is not located within 1,000 feet of a school. Therefore, pursuant to California Health and Safety Code 42301.6, a school notice is not required.

California Environmental Quality Act (CEQA)

CEQA requires each public agency to adopt objectives, criteria, and specific procedures consistent with CEQA Statutes and the CEQA Guidelines for administering its responsibilities under CEQA, including the orderly evaluation of projects and preparation of environmental documents. The District adopted its *Environmental Review Guidelines* (ERG) in 2001. The basic purposes of CEQA are to:

- Inform governmental decision-makers and the public about the potential, significant environmental effects of proposed activities;
- Identify the ways that environmental damage can be avoided or significantly reduced;
- Prevent significant, avoidable damage to the environment by requiring changes in projects through the use of alternatives or mitigation measures when the governmental agency finds the changes to be feasible; and
- Disclose to the public the reasons why a governmental agency approved the project in the manner the agency chose if significant environmental effects are involved.

Greenhouse Gas (GHG) Significance Determination

It is determined that no other agency has or will prepare an environmental review document for the project. Thus the District is the Lead Agency for this project.

Project specific impacts on global climate change were evaluated consistent with the adopted District policy – *Addressing GHG Emission Impacts for Stationary Source Projects Under CEQA When Serving as the Lead Agency*. The District's engineering evaluation (this document – Appendix G) demonstrates that project specific greenhouse gas emissions will be reduced by 29%, compared to business-as-usual. The District therefore concludes that the project would have a less than cumulatively significant impact on global climate change.

District CEQA Findings

The District determined that no other agency has broader discretionary approval power over the project and that the District is the first agency to act on the project, therefore establishing the District as the Lead Agency for the project (CEQA Guidelines §15051(b). An Initial Study was prepared, which demonstrated that through a combination of project design elements, compliance with District rules, permit conditions, and mitigation measures, the project would have a less than significant effect on the environment. Consistent with CEQA Guidelines §15070(b)(1), a Proposed Mitigated Negative Declaration was prepared and released for public review from September 14, 2016 to October 17, 2016. No comments were received during the public review period, and the Final Mitigated Negative Declaration was published in November 2016. The ATCs in project S-1180558 are covered under this Final Mitigated Negative Declaration.

Indemnification Agreement/Letter of Credit Determination

According to District Policy APR 2010 (CEQA Implementation Policy), when the District is the Lead or Responsible Agency for CEQA purposes, an indemnification agreement and/or a letter of credit may be required. The decision to require an indemnity agreement and/or a letter of credit is based on a case-by-case analysis of a particular project's potential for litigation risk, which in turn may be based on a project's potential to generate public concern, its potential for significant impacts, and the project proponent's ability to pay for the costs of litigation without a letter of credit, among other factors.

The criteria pollutant emissions and toxic air contaminant emissions associated with the proposed project are not significant, and there is minimal potential for public concern for this particular type of facility/operation. Therefore, an indemnification agreement and/or letter of credit will not be required for this project in the absence of expressed public concern.

The following conditions will be included on each ATC to assure compliance with the CEQA mitigation measure requirements:

- Prior to operating equipment under this Authority to Construct, permittee shall surrender VOC emission reduction credits for the following quantity of emissions: 1st quarter – 6,951 lbs, 2nd quarter – 6,951 lbs, 3rd quarter – 6,951 lbs, and 4th quarter – 6,952 lbs. These amounts include the applicable offset ratio specified in Rule 2201 Section 4.8 (as amended 2/18/16). [District Rule 2201 and Public Resources Code 21000-21177: California Environmental Quality Act]

- ERC Certificate Number S-4718-1 (or a certificate split from this certificate) shall be used to supply the required offsets, unless a revised offsetting proposal is received and approved by the District, upon which this Authority to Construct shall be reissued, administratively specifying the new offsetting proposal. Original public noticing requirements, if any, shall be duplicated prior to reissuance of this Authority to Construct. [District Rule 2201 and Public Resources Code 21000-21177: California Environmental Quality Act]

- A Qualified Biologist will conduct a focused pre-construction survey to determine the presence/absence of potential impacts on sensitive species prior to the onset of ground disturbance. The survey shall be conducted in accordance with the standard protocol of the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW). If more than 30 days pass before the onset of ground disturbance, an additional survey shall be conducted by a Qualified Biologist within 30 days prior to the onset of ground disturbance. Permittee shall make all biological surveys available to District staff upon request. [*Public Resources Code 21000-21177: California Environmental Quality Act*]

- A biological monitor will be present while ground-disturbing activities are occurring based on the sensitivity of the habitat in which a project occurs. [*Public Resources Code 21000-21177: California Environmental Quality Act*]

- In the event that archaeological resources are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the Permittee shall notify and retain a qualified archaeologist to assess and provide an evaluation of the significance of the find. A qualified archaeologist shall determine whether avoidance is necessary and feasible in light of the factors such as the nature of the find, project design, costs, and other considerations, and, if necessary, develop appropriate mitigation measures in consultation with Kern County and the Native American Heritage Commission (NAHC). In addition, should archaeological resources be discovered, the Permittee shall provide the District a written report in relation to the nature of the find. [*Public Resources Code 21000-21177: California Environmental Quality Act*]

- In the event that paleontological resources are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the Permittee shall notify and retain a qualified paleontologist to assess and provide an evaluation of the significance of the find. A qualified paleontologist shall determine whether avoidance is necessary and feasible in light of the factors such as the nature of the find, project design, costs, and other considerations, and, if necessary, develop appropriate mitigation measures in consultation with Kern County and the Native American Heritage Commission (NAHC). In addition, should paleontological resources be discovered, Permittee shall provide the District a written report in relation to the nature of the find. [*Public Resources Code 21000-21177: California Environmental Quality Act*]

- In the event that human remains are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the discovery shall immediately be reported to the County Coroner (CC) and Native American Heritage Commission (NAHC) for further assessment. Permittee shall identify appropriate measures for treatment or disposition of the remains in consultation with the CC and NAHC. In addition, should human remains be discovered during ground-disturbing activities, Permittee shall provide the District a written report in relation to the nature of the find. [*Public Resources Code 21000-21177: California Environmental Quality Act*]

- In the event that tribal cultural resources are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the Permittee shall notify and retain a qualified archaeologist to assess and provide an evaluation of the significance of the find. A qualified Native American Organization shall determine whether avoidance is necessary and feasible in light of the factors such as the nature of the find, project design, costs, and other considerations, and, if necessary, develop appropriate mitigation measures in consultation with Kern County and the NAHC. In addition, should tribal cultural resources be discovered, the Permittee shall provide the District a written report in relation to the nature of the find. [*Public Resources Code 21000-21177: California Environmental Quality Act*]

IX. Recommendation

Compliance with all applicable rules and regulations is expected. Pending a successful NSR Public Noticing period, issue ATCs S-8841-1-1 & -1-2 subject to the permit conditions on the attached draft ATCs in Appendix A.

X. Billing Information

Annual Permit Fees			
Permit Number	**Fee Schedule**	**Fee Description**	**Annual Fee**
S-8841-1-1 or -1-2	3020-01-F	561 electrical hp	$666

Appendixes

A: Draft ATCs
B: Uncontrolled PM_{10} and NH_3 Emission Factor References
C: Uncontrolled VOC Emission Factor Reference
D: Ammonia Emission Control from Dietary Restriction Reference Articles
E: BACT Guideline
F: BACT Analysis
G: Greenhouse Gas (GHG) Impacts Analysis
H: Health Risk Assessment (HRA) and Ambient Air Quality Analysis (AAQA) Summaries
I: Quarterly Net Emissions Change (QNEC)

APPENDIX A

Draft ATCs

San Joaquin Valley
Air Pollution Control District

AUTHORITY TO CONSTRUCT

DRAFT

PERMIT NO: S-8841-1-1 **ISSUANCE DATE:** DRAFT

LEGAL OWNER OR OPERATOR: CENTRAL VALLEY EGGS LLC
MAILING ADDRESS: 13606 GUN CLUB RD
WASCO, CA 93280

LOCATION: 13606 GUN CLUB RD
WASCO, CA 93280

EQUIPMENT DESCRIPTION:
3,339,000 POULTRY RANCH CONSISTING OF SEVEN MECHANICALLY VENTILATED CAGE-FREE AVIARY LAYING HEN HOUSES AND THREE MECHANICALLY VENTILATED PULLET HOUSES

CONDITIONS

1. This Authority to Construct (ATC) cancels and supersedes ATC S-8841-1-0. [District Rule 2201]
2. Prior to operating equipment under this Authority to Construct, permittee shall surrender VOC emission reduction credits for the following quantity of emissions: 1st quarter - 6,951 lb, 2nd quarter - 6,952 lb, 3rd quarter - 6,952 lb, and 4th quarter - 6,952 lb. These amounts include the applicable offset ratio specified in Rule 2201 Section 4.8 (as amended 2/18/16). [District Rule 2201 and Public Resources Code 21000-21177: California Environmental Quality Act]
3. ERC Certificate Number S-4718-1 (or a certificate split from this certificate) shall be used to supply the required offsets, unless a revised offsetting proposal is received and approved by the District, upon which this Authority to Construct shall be reissued, administratively specifying the new offsetting proposal. Original public noticing requirements, if any, shall be duplicated prior to reissuance of this Authority to Construct. [District Rule 2201 and Public Resources Code 21000-21177: California Environmental Quality Act]
4. {3215} Upon presentation of appropriate credentials, a permittee shall allow an authorized representative of the District to enter the permittee's premises where a permitted source is located or emissions related activity is conducted, or where records must be kept under condition of the permit. [District Rule 1070]
5. {3216} Upon presentation of appropriate credentials, a permittee shall allow an authorized representative of the District to have access to and copy, at reasonable times, any records that must be kept under the conditions of the permit. [District Rule 1070]

CONDITIONS CONTINUE ON NEXT PAGE

YOU MUST NOTIFY THE DISTRICT COMPLIANCE DIVISION AT (661) 392-5500 WHEN CONSTRUCTION IS COMPLETED AND PRIOR TO OPERATING THE EQUIPMENT OR MODIFICATIONS AUTHORIZED BY THIS AUTHORITY TO CONSTRUCT. This is NOT a PERMIT TO OPERATE. Approval or denial of a PERMIT TO OPERATE will be made after an inspection to verify that the equipment has been constructed in accordance with the approved plans, specifications and conditions of this Authority to Construct, and to determine if the equipment can be operated in compliance with all Rules and Regulations of the San Joaquin Valley Unified Air Pollution Control District. Unless construction has commenced pursuant to Rule 2050, this Authority to Construct shall expire and application shall be cancelled two years from the date of issuance. The applicant is responsible for complying with all laws, ordinances and regulations of all other governmental agencies which may pertain to the above equipment.

Seyed Sadredin, Executive Director / APCO

DRAFT

Arnaud Marjollet, Director of Permit Services

S-8841-1-1 : Apr 5 2018 2:56PM -- BRARG : Joint Inspection NOT Required

6. If a licensed veterinarian or a certified nutritionist determines that any VOC mitigation measure will be required to be suspended as a detriment to animal health or necessary for the animal to molt, the owners/operators must notify the District in writing within forty-eight (48) hours of the determination including the duration and the specific health condition requiring the mitigation measure to be suspended. If the situation is expected to exist longer than a thirty-day (30) period, the owner/operator shall submit a new emission mitigation plan designating a mitigation measure to be implemented in lieu of the suspended mitigation measure. [District Rules 2201 and 4570]
7. Particulate matter emissions from each poultry house shall not exceed 0.1 grains/dscf in concentration. [District Rule 4201]
8. No more than 327,000 birds shall be kept in each of the seven laying hen houses at any time. [District Rule 2201]
9. No more than 350,000 birds (chick starters or pullet growers) shall be kept in each of the three pullet houses at any time. For the purposes of this permit, chick starters are defined as birds from zero to six weeks of age and pullet growers are defined as birds from six weeks to 16 weeks of age. [District Rule 2201]
10. Each pullet house shall not contain chick starters for more than 126 days per rolling 12-month period and pullet growers for more than 210 days per rolling 12-month period. [District Rule 2201]
11. Emissions from each laying hen house shall not exceed any of the following limits: 0.02271 lb-PM10/1,000 birds-day, 0.0404 lb-VOC/1,000 birds-day, or 0.504 lb-NH3/1,000 birds-day. [District Rule 2201]
12. Emissions from each pullet house shall not exceed any of the following limits: 1) Chick Starters: 0.00441 lb-PM10/1,000 birds-day, 0.00784 lb-VOC/1,000 birds-day, or 0.1283 lb-NH3/1,000 birds-day; and 2) Pullet Growers: 0.009652 lb-PM10/1,000 birds-day, 0.01711 lb-VOC/1,000 birds-day, or 0.2811 lb-NH3/1,000 birds-day. [District Rule 2201]
13. Each poultry house shall be completely enclosed and mechanically ventilated with evaporative cooling pads, fans, and a computer control system. [District Rule 2201]
14. Each poultry house shall be equipped with a belt manure aeration and removal system that advances by a minimum of half the length of the belt every 24 hours. [District Rule 2201]
15. Permittee shall maintain records to demonstrate that the belt advances by a minimum of half of its length every 24 hours. [District Rule 2201]
16. Permittee shall maintain quarterly records of maintenance and repair activities associated with the belt manure aeration and removal system that includes the dates of maintenance and repair, and a description of any corrective actions taken. [District Rule 2201]
17. The open end of each poultry house shall be equipped with a tarp covering approximately 40% of the upper part of the opening. The open end shall also be equipped with water sprays installed under the bottom edge of the tarp to reduce particulate matter (PM) emissions from the exhaust fans. The water sprays shall operate at all times, except during periods of actual rainfall. [District Rule 2201]
18. The tarp used to reduce PM emissions from the exhaust fans shall be inspected on a quarterly basis. The tarp shall be inspected thoroughly for rips, tears, leaks, or any evidence of structural failures that result in excessive PM emissions and shall be repaired or replaced as needed. [District Rule 2201]
19. The water sprays used to reduce PM emissions from the exhaust fans shall be inspected on a quarterly basis. The water spray nozzles shall be inspected thoroughly for leaks, clogs, or any evidence of structural failures that result in excessive PM emissions and shall be repaired or replaced as needed. [District Rule 2201]
20. Permittee shall maintain records of inspections, maintenance, repair, and replacement of the tarps and water spray nozzles used to reduce PM emissions from the exhaust fans. The records shall include the dates of inspections and a description of any corrective actions taken. [District Rule 2201]
21. No bedding or litter materials shall be used on the bottom floor of the poultry houses at this facility. [District Rule 2201]
22. All mortality in each poultry house shall be removed at least once per day. [District Rule 2201]
23. Permittee shall maintain daily records of mortality removal in each poultry house. [District Rule 2201]

CONDITIONS CONTINUE ON NEXT PAGE

24. The maximum crude protein content of the feed given to all laying hens at this facility shall not exceed 15%. [District Rule 2201]
25. Permittee shall feed all animals according to National Research Council (NRC) guidelines. [District Rules 2201 and 4570]
26. Permittee shall maintain records of feed content, formulation, and quantity of feed additive utilized, to demonstrate compliance with National Research Council (NRC) guidelines. Permittee shall also maintain records of the laying hen feed crude protein content. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this requirement. [District Rules 2201 and 4570]
27. Permittee shall use drinkers that do not drip continuously. [District Rules 2201 and 4570]
28. Permittee shall inspect water pipes and drinkers and repair leaks daily. [District Rules 2201 and 4570]
29. Permittee shall maintain records indicating that water pipes and drinkers are inspected daily, and that any leaks are repaired. [District Rules 2201 and 4570]
30. Permittee shall feed animals probiotics designed to improve digestion according to manufacturer recommendations. [District Rules 2201 and 4570]
31. Permittee shall maintain records to demonstrate animals are fed probiotics designed to improve digestion. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this requirement. [District Rules 2201 and 4570]
32. Permittee shall feed animals an amino acid supplemented diet. [District Rules 2201 and 4570]
33. Permittee shall maintain records to demonstrate animals are fed an amino acid supplemented diet. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this. [District Rules 2201 and 4570]
34. Permittee shall feed animals additives such as amylase, xylanase, and protease, designed to maximize digestive efficiency. [District Rules 2201 and 4570]
35. Permittee shall maintain records that demonstrate animals are fed feed additives such as amylase, xylanase, and protease. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this. [District Rules 2201 and 4570]
36. Initial source testing to demonstrate compliance with the PM10 and NH3 emissions from at least one of the laying hen houses shall be initiated within 30 days of issuance of this ATC. [District Rule 2201]
37. Source testing shall be conducted using the methods and procedures approved by the District. The District must be notified and a source test plan shall be submitted to the District for approval by the Permit Services and Compliance Divisions at least 15 days prior to any compliance source test. The source test plan shall include a detailed description of how testing will be conducted, the proposed duration of the test, and the methodology to be used. [District Rule 2201]
38. All emission measurements shall be made with the laying hen house operating either at conditions representative of normal operations or conditions specified in the Authority to Construct. To the maximum extent possible that still allows for normal operation, emission measurements shall be taken in conditions that represent the maximum emission rates from the laying hen house. Those conditions shall include, but are not limited to, the laying hen house being filled at, or near, maximum capacity, a majority of the exhaust fans turned on, and the manure windrow stockpiles near capacity. [District Rule 2201]
39. The following test methods shall be used: PM10 emission rates (filterable and condensable) shall be conducted using EPA Method 201 and 202, EPA Method 201a and 202, ARB Method 5 in combination with Method 501, or South Coast Air Quality Management District (SCAQMD) Method 5.1; and ammonia (NH3) - BAAQMD ST-1B. If it is determined that these test methods are not appropriate to measure the PM10 and/or NH3 emissions from this type of operation, emissions shall be measured using any other District approved alternative test methods. [District Rule 2201]
40. The results of the source test shall be submitted to the District within 60 days thereafter. [District Rule 1081]

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CONDITIONS CONTINUE ON NEXT PAGE

41. Permittee shall maintain monthly records of the number of animals of each species and production group at the facility and records of any changes to this information. For the pullet houses, the permittee shall also maintain records of the age of birds, the growing stage the birds are in, and the total number of days each growing stage has been housed for the current rolling 12-month period. [District Rules 2201 and 4570]

42. Permittee shall keep and maintain all records for a minimum of five (5) years and shall make records available to the APCO and EPA upon request. [District Rules 2201 and 4570]

43. Issuance of any Authority to Construct (ATC) permit(s) or any construction that results in a further increase in the number of laying hens, pullets, or poultry houses at this facility such as described in the proposal for District ATC Project S-1180558, or the District CEQA document prepared for the project, shall be treated and analyzed as a part of ATC Project S-1180558 for New and Modified Source Review (NSR) purposes to ensure that the cumulative emissions from the overall project will not cause or make worse a violation of an Ambient Air Quality Standard. [District Rule 2201 and California Environmental Quality Act]

44. A Qualified Biologist will conduct a focused pre-construction survey to determine the presence/absence of potential impacts on sensitive species prior to the onset of ground disturbance. The survey shall be conducted in accordance with the standard protocol of the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW). If more than 30 days pass before the onset of ground disturbance, an additional survey shall be conducted by a Qualified Biologist within 30 days prior to the onset of ground disturbance. Permittee shall make all biological surveys available to District staff upon request. [Public Resources Code 21000-21177: California Environmental Quality Act]

45. A biological monitor will be present while ground-disturbing activities are occurring based on the sensitivity of the habitat in which a project occurs. [Public Resources Code 21000-21177: California Environmental Quality Act]

46. In the event that archaeological resources are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the Permittee shall notify and retain a qualified archaeologist to assess and provide an evaluation of the significance of the find. A qualified archaeologist shall determine whether avoidance is necessary and feasible in light of the factors such as the nature of the find, project design, costs, and other considerations, and, if necessary, develop appropriate mitigation measures in consultation with Kern County and the Native American Heritage Commission (NAHC). In addition, should archaeological resources be discovered, the Permittee shall provide the District a written report in relation to the nature of the find. [Public Resources Code 21000-21177: California Environmental Quality Act]

47. In the event that paleontological resources are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the Permittee shall notify and retain a qualified paleontologist to assess and provide an evaluation of the significance of the find. A qualified paleontologist shall determine whether avoidance is necessary and feasible in light of the factors such as the nature of the find, project design, costs, and other considerations, and, if necessary, develop appropriate mitigation measures in consultation with Kern County and the Native American Heritage Commission (NAHC). In addition, should paleontological resources be discovered, Permittee shall provide the District a written report in relation to the nature of the find. [Public Resources Code 21000-21177: California Environmental Quality Act]

48. In the event that human remains are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the discovery shall immediately be reported to the County Coroner (CC) and Native American Heritage Commission (NAHC) for further assessment. Permittee shall identify appropriate measures for treatment or disposition of the remains in consultation with the CC and NAHC. In addition, should human remains be discovered during ground-disturbing activities, Permittee shall provide the District a written report in relation to the nature of the find. [Public Resources Code 21000-21177: California Environmental Quality Act]

49. In the event that tribal cultural resources are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the Permittee shall notify and retain a qualified archaeologist to assess and provide an evaluation of the significance of the find. A qualified Native American Organization shall determine whether avoidance is necessary and feasible in light of the factors such as the nature of the find, project design, costs, and other considerations, and, if necessary, develop appropriate mitigation measures in consultation with Kern County and the NAHC. In addition, should tribal cultural resources be discovered, the Permittee shall provide the District a written report in relation to the nature of the find. [Public Resources Code 21000-21177: California Environmental Quality Act]

San Joaquin Valley
Air Pollution Control District

AUTHORITY TO CONSTRUCT

PERMIT NO: S-8841-1-2 **ISSUANCE DATE:** DRAFT

LEGAL OWNER OR OPERATOR: CENTRAL VALLEY EGGS LLC
MAILING ADDRESS: 13606 GUN CLUB RD
WASCO, CA 93280

LOCATION: 13606 GUN CLUB RD
WASCO, CA 93280

EQUIPMENT DESCRIPTION:
3,339,000 POULTRY RANCH CONSISTING OF SEVEN MECHANICALLY VENTILATED CAGE-FREE AVIARY LAYING HEN HOUSES AND THREE MECHANICALLY VENTILATED PULLET HOUSES

CONDITIONS

1. This Authority to Construct (ATC) cancels and supersedes ATC S-8841-1-0. [District Rule 2201]
2. Prior to operating equipment under this Authority to Construct, permittee shall surrender VOC emission reduction credits for the following quantity of emissions: 1st quarter - 6,951 lb, 2nd quarter - 6,952 lb, 3rd quarter - 6,952 lb, and 4th quarter - 6,952 lb. These amounts include the applicable offset ratio specified in Rule 2201 Section 4.8 (as amended 2/18/16). [District Rule 2201 and Public Resources Code 21000-21177: California Environmental Quality Act]
3. ERC Certificate Number S-4718-1 (or a certificate split from this certificate) shall be used to supply the required offsets, unless a revised offsetting proposal is received and approved by the District, upon which this Authority to Construct shall be reissued, administratively specifying the new offsetting proposal. Original public noticing requirements, if any, shall be duplicated prior to reissuance of this Authority to Construct. [District Rule 2201 and Public Resources Code 21000-21177: California Environmental Quality Act]
4. {3215} Upon presentation of appropriate credentials, a permittee shall allow an authorized representative of the District to enter the permittee's premises where a permitted source is located or emissions related activity is conducted, or where records must be kept under condition of the permit. [District Rule 1070]
5. {3216} Upon presentation of appropriate credentials, a permittee shall allow an authorized representative of the District to have access to and copy, at reasonable times, any records that must be kept under the conditions of the permit. [District Rule 1070]

CONDITIONS CONTINUE ON NEXT PAGE

YOU MUST NOTIFY THE DISTRICT COMPLIANCE DIVISION AT (661) 392-5500 WHEN CONSTRUCTION IS COMPLETED AND PRIOR TO OPERATING THE EQUIPMENT OR MODIFICATIONS AUTHORIZED BY THIS AUTHORITY TO CONSTRUCT. This is NOT a PERMIT TO OPERATE. Approval or denial of a PERMIT TO OPERATE will be made after an inspection to verify that the equipment has been constructed in accordance with the approved plans, specifications and conditions of this Authority to Construct, and to determine if the equipment can be operated in compliance with all Rules and Regulations of the San Joaquin Valley Unified Air Pollution Control District. Unless construction has commenced pursuant to Rule 2050, this Authority to Construct shall expire and application shall be cancelled two years from the date of issuance. The applicant is responsible for complying with all laws, ordinances and regulations of all other governmental agencies which may pertain to the above equipment.

Seyed Sadredin, Executive Director / APCO

DRAFT

Arnaud Marjollet, Director of Permit Services

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6. If a licensed veterinarian or a certified nutritionist determines that any VOC mitigation measure will be required to be suspended as a detriment to animal health or necessary for the animal to molt, the owners/operators must notify the District in writing within forty-eight (48) hours of the determination including the duration and the specific health condition requiring the mitigation measure to be suspended. If the situation is expected to exist longer than a thirty-day (30) period, the owner/operator shall submit a new emission mitigation plan designating a mitigation measure to be implemented in lieu of the suspended mitigation measure. [District Rules 2201 and 4570]

7. Particulate matter emissions from each poultry house shall not exceed 0.1 grains/dscf in concentration. [District Rule 4201]

8. No more than 327,000 birds shall be kept in each of the seven laying hen houses at any time. [District Rule 2201]

9. No more than 350,000 birds (chick starters or pullet growers) shall be kept in each of the three pullet houses at any time. For the purposes of this permit, chick starters are defined as birds from zero to six weeks of age and pullet growers are defined as birds from six weeks to 16 weeks of age. [District Rule 2201]

10. Each pullet house shall not contain chick starters for more than 126 days per rolling 12-month period and pullet growers for more than 210 days per rolling 12-month period. [District Rule 2201]

11. Emissions from each laying hen house shall not exceed any of the following limits: 0.02271 lb-PM10/1,000 birds-day, 0.0404 lb-VOC/1,000 birds-day, or 0.504 lb-NH3/1,000 birds-day. [District Rule 2201]

12. Emissions from each pullet house shall not exceed any of the following limits: 1) Chick Starters: 0.00441 lb-PM10/1,000 birds-day, 0.00784 lb-VOC/1,000 birds-day, or 0.1283 lb-NH3/1,000 birds-day; and 2) Pullet Growers: 0.009652 lb-PM10/1,000 birds-day, 0.01711 lb-VOC/1,000 birds-day, or 0.2811 lb-NH3/1,000 birds-day. [District Rule 2201]

13. Each poultry house shall be completely enclosed and mechanically ventilated with evaporative cooling pads, fans, and a computer control system. [District Rule 2201]

14. Each poultry house shall be equipped with a belt manure aeration and removal system that advances by a minimum of half the length of the belt every 24 hours. [District Rule 2201]

15. Permittee shall maintain records to demonstrate that the belt advances by a minimum of half of its length every 24 hours. [District Rule 2201]

16. Permittee shall maintain quarterly records of maintenance and repair activities associated with the belt manure aeration and removal system that includes the dates of maintenance and repair, and a description of any corrective actions taken. [District Rule 2201]

17. The open end of each poultry house shall be equipped with a tarp covering approximately 40% of the upper part of the opening to reduce particulate matter (PM) emissions from the exhaust fans. Each poultry house may have optional water sprays equipped under the bottom edge of the tarp. [District Rule 2201]

18. The tarp used to reduce PM emissions from the exhaust fans shall be inspected on a quarterly basis. The tarp shall be inspected thoroughly for rips, tears, holes, or any evidence of structural failures that result in excessive PM emissions and shall be repaired or replaced as needed. [District Rule 2201]

19. Permittee shall maintain records of inspections, maintenance, repair, and replacement of the tarps used to reduce PM emissions from the exhaust fans. The records shall include the dates of inspections and a description of any corrective actions taken. [District Rule 2201]

20. No bedding or litter materials shall be used on the bottom floor of the poultry houses at this facility. [District Rule 2201]

21. All mortality in each poultry house shall be removed at least once per day. [District Rule 2201]

22. Permittee shall maintain daily records of mortality removal in each poultry house. [District Rule 2201]

23. The maximum crude protein content of the feed given to all laying hens at this facility shall not exceed 15%. [District Rule 2201]

24. Permittee shall feed all animals according to National Research Council (NRC) guidelines. [District Rules 2201 and 4570]

CONDITIONS CONTINUE ON NEXT PAGE

25. Permittee shall maintain records of feed content, formulation, and quantity of feed additive utilized, to demonstrate compliance with National Research Council (NRC) guidelines. Permittee shall also maintain records of the laying hen feed crude protein content. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this requirement. [District Rules 2201 and 4570]

26. Permittee shall use drinkers that do not drip continuously. [District Rules 2201 and 4570]

27. Permittee shall inspect water pipes and drinkers and repair leaks daily. [District Rules 2201 and 4570]

28. Permittee shall maintain records indicating that water pipes and drinkers are inspected daily, and that any leaks are repaired. [District Rules 2201 and 4570]

29. Permittee shall feed animals probiotics designed to improve digestion according to manufacturer recommendations. [District Rules 2201 and 4570]

30. Permittee shall maintain records to demonstrate animals are fed probiotics designed to improve digestion. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this requirement. [District Rules 2201 and 4570]

31. Permittee shall feed animals an amino acid supplemented diet. [District Rules 2201 and 4570]

32. Permittee shall maintain records to demonstrate animals are fed an amino acid supplemented diet. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this. [District Rules 2201 and 4570]

33. Permittee shall feed animals additives such as amylase, xylanase, and protease, designed to maximize digestive efficiency. [District Rules 2201 and 4570]

34. Permittee shall maintain records that demonstrate animals are fed feed additives such as amylase, xylanase, and protease. Records such as feed company guaranteed analyses (feed tags), ration sheets, or feed purchase records may be used to meet this. [District Rules 2201 and 4570]

35. Initial source testing to demonstrate compliance with the PM10 and NH3 emissions from at least one of the laying hen houses shall be initiated within 30 days of issuance of this ATC. [District Rule 2201]

36. Source testing shall be conducted using the methods and procedures approved by the District. The District must be notified and a source test plan shall be submitted to the District for approval by the Permit Services and Compliance Divisions at least 15 days prior to any compliance source test. The source test plan shall include a detailed description of how testing will be conducted, the proposed duration of the test, and the methodology to be used. [District Rule 2201]

37. All emission measurements shall be made with the laying hen house operating either at conditions representative of normal operations or conditions specified in the Authority to Construct. To the maximum extent possible that still allows for normal operation, emission measurements shall be taken in conditions that represent the maximum emission rates from the laying hen house. Those conditions shall include, but are not limited to, the laying hen house being filled at, or near, maximum capacity, a majority of the exhaust fans turned on, and the manure windrow stockpiles near capacity. [District Rule 2201]

38. The following test methods shall be used: PM10 emission rates (filterable and condensable) shall be conducted using EPA Method 201 and 202, EPA Method 201a and 202, ARB Method 5 in combination with Method 501, or South Coast Air Quality Management District (SCAQMD) Method 5.1; and ammonia (NH3) - BAAQMD ST-1B. If it is determined that these test methods are not appropriate to measure the PM10 and/or NH3 emissions from this type of operation, emissions shall be measured using any other District approved alternative test methods. [District Rule 2201]

39. The results of the source test shall be submitted to the District within 60 days thereafter. [District Rule 1081]

40. Permittee shall maintain monthly records of the number of animals of each species and production group at the facility and records of any changes to this information. For the pullet houses, the permittee shall also maintain records of the age of birds, the growing stage the birds are in, and the total number of days each growing stage has been housed for the current rolling 12-month period. [District Rules 2201 and 4570]

41. Permittee shall keep and maintain all records for a minimum of five (5) years and shall make records available to the APCO and EPA upon request. [District Rules 2201 and 4570]

CONDITIONS CONTINUE ON NEXT PAGE

42. Issuance of any Authority to Construct (ATC) permit(s) or any construction that results in a further increase in the number of laying hens, pullets, or poultry houses at this facility such as described in the proposal for District ATC Project S-1180558, or the District CEQA document prepared for the project, shall be treated and analyzed as a part of ATC Project S-1180558 for New and Modified Source Review (NSR) purposes to ensure that the cumulative emissions from the overall project will not cause or make worse a violation of an Ambient Air Quality Standard. [District Rule 2201 and California Environmental Quality Act]

43. A Qualified Biologist will conduct a focused pre-construction survey to determine the presence/absence of potential impacts on sensitive species prior to the onset of ground disturbance. The survey shall be conducted in accordance with the standard protocol of the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW). If more than 30 days pass before the onset of ground disturbance, an additional survey shall be conducted by a Qualified Biologist within 30 days prior to the onset of ground disturbance. Permittee shall make all biological surveys available to District staff upon request. [Public Resources Code 21000-21177: California Environmental Quality Act]

44. A biological monitor will be present while ground-disturbing activities are occurring based on the sensitivity of the habitat in which a project occurs. [Public Resources Code 21000-21177: California Environmental Quality Act]

45. In the event that archaeological resources are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the Permittee shall notify and retain a qualified archaeologist to assess and provide an evaluation of the significance of the find. A qualified archaeologist shall determine whether avoidance is necessary and feasible in light of the factors such as the nature of the find, project design, costs, and other considerations, and, if necessary, develop appropriate mitigation measures in consultation with Kern County and the Native American Heritage Commission (NAHC). In addition, should archaeological resources be discovered, the Permittee shall provide the District a written report in relation to the nature of the find. [Public Resources Code 21000-21177: California Environmental Quality Act]

46. In the event that paleontological resources are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the Permittee shall notify and retain a qualified paleontologist to assess and provide an evaluation of the significance of the find. A qualified paleontologist shall determine whether avoidance is necessary and feasible in light of the factors such as the nature of the find, project design, costs, and other considerations, and, if necessary, develop appropriate mitigation measures in consultation with Kern County and the Native American Heritage Commission (NAHC). In addition, should paleontological resources be discovered, Permittee shall provide the District a written report in relation to the nature of the find. [Public Resources Code 21000-21177: California Environmental Quality Act]

47. In the event that human remains are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the discovery shall immediately be reported to the County Coroner (CC) and Native American Heritage Commission (NAHC) for further assessment. Permittee shall identify appropriate measures for treatment or disposition of the remains in consultation with the CC and NAHC. In addition, should human remains be discovered during ground-disturbing activities, Permittee shall provide the District a written report in relation to the nature of the find. [Public Resources Code 21000-21177: California Environmental Quality Act]

48. In the event that tribal cultural resources are discovered during ground-disturbing activities, all work within 100 feet of the find shall cease and the Permittee shall notify and retain a qualified archaeologist to assess and provide an evaluation of the significance of the find. A qualified Native American Organization shall determine whether avoidance is necessary and feasible in light of the factors such as the nature of the find, project design, costs, and other considerations, and, if necessary, develop appropriate mitigation measures in consultation with Kern County and the NAHC. In addition, should tribal cultural resources be discovered, the Permittee shall provide the District a written report in relation to the nature of the find. [Public Resources Code 21000-21177: California Environmental Quality Act]

APPENDIX B

Uncontrolled PM_{10} and NH_3 Emission Factor References

Environmental Assessment of Three Laying-Hen Housing Systems - Part II: Ammonia, Greenhouse Gas, and Particulate Matter Emissions.

Environmental assessment of three egg production systems — *Part II. Ammonia, greenhouse gas, and particulate matter emissions*

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ABSTRACT As an integral part of the Coalition for Sustainable Egg Supply (CSES) Project, this study simultaneously monitored air emissions of 3 commercially operated egg production systems at the house level and associated manure storage over 2 single-cycle flocks (18 to 78 wk of age). The 3 housing systems were 1) a conventional cage house (CC) with a 200,000-hen capacity (6 hens in a cage at a stocking density of 516 cm^2/hen), 2) an enriched colony house (EC) with a 50,000-hen capacity (60 hens per colony at a stocking density of 752 cm^2/hen), and 3) an aviary house (AV) with a 50,000-hen capacity (at a stocking density of 1253 to 1257 cm^2/hen). The 3 hen houses were located on the same farm and were populated with Lohmann white hens of the same age. Indoor environment and house-level gaseous (ammonia [NH_3] and greenhouse gasses [GHG], including carbon dioxide [CO_2], methane [CH_4], and nitrous oxide [N_2O]) and particulate matter (PM_{10}, $PM_{2.5}$) emissions were monitored continually. Gaseous emissions from the respective manure storage of each housing system were also monitored. Emission rates (ERs) are expressed as emission quantities per hen, per animal unit (AU, 500 kg live BW), and per kilogram of egg output. House-level NH_3 ER (g/hen/d) of EC (0.054) was significantly lower than that of CC (0.082) or AV (0.112) ($P < 0.05$). The house-level CO_2 ER (g/hen/d) was lower for CC (68.3) than for EC and AV (74.4 and 74.0, respectively), and the CH_4 ER (g/hen/d) was similar for all 3 houses (0.07 to 0.08). The house-level PM ER (mg/hen/d), essentially representing the farm-level PM ER, was significantly higher for AV (PM_{10} 100.3 and $PM_{2.5}$ 8.8) than for CC (PM_{10} 15.7 and $PM_{2.5}$ 0.9) or EC (PM_{10} 15.6 and $PM_{2.5}$ 1.7) ($P < 0.05$). The farm-level (house plus manure storage) NH_3 ER (g/hen/d) was significantly lower for EC (0.16) than for CC (0.29) or AV (0.30) ($P < 0.05$). As expected, the magnitudes of GHG emissions were rather small for all 3 production systems. Data from this study enable comparative assessment of conventional vs. alternative hen housing systems regarding air emissions and enhance the U.S. national air emissions inventory for farm animal operations.

Key words: air emissions, egg production, alternative hen housing

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INTRODUCTION

The U.S. egg industry may gradually transition toward alternative hen housing systems, such as enriched colony and aviary houses, to meet specific animal welfare regulations. Housing system design and management has a significant role in the environmental footprint of egg production; however, limited information is available on the environmental impact of alternative hen housing systems in the United States. Thus, quantification of aerial emissions from alternative housing systems in comparison to the conventional housing system is needed to develop baseline emission values and comparisons for inclusion in the U.S. national air emissions inventory for farm animal operations. This article results from the multidisciplinary and multiinstitutional endeavor known as the Coalition for Sustainable Egg Supply (**CSES**) project, which evaluated a conventional cage house (**CC**), an aviary house (**AV**), and an enriched colony house (**EC**) with regards to animal health and well-being, environmental impact, food safety, food affordability, and worker health (Swanson et al., 2014).

As part of the Socially Sustainable Egg Production Project (**SSEP**), Xin et al. (2011) reviewed the current state of science and subsequently identified specific knowledge gaps and future research needs to improve understanding of the environmental impacts of conventional and alternative laying hen production systems. Key research areas identified were: 1) quantification

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of indoor air quality, barn emissions, thermal conditions, and energy use in alternative hen housing systems along with conventional housing systems and 2) assessment of interactions between air quality, housing systems, worker health, and animal health and well-being. While studies on emissions of ammonia (**NH_3**), greenhouse gases (**GHGs**), and particulate matter (**PM**) from commercial laying hen houses have been carried out on both conventional and alternative hen housing systems in Europe and the United States, studies to simultaneously compare different housing systems are difficult to accurately perform; hence, information is very limited. Indoor air quality and emissions depend on environmental conditions (weather) encountered during each study and management decisions at the farm level (e.g., stocking density and production goals and schedule, which lead to differences in flock age, feed formulation, in-house temperature, and manure management practices). Comparisons among studies with similar housing systems often yield differences that cannot be fully discerned due to the confounding effects of the environmental conditions and farm management. Laboratory and pilot-scale studies can provide insight into specific factors (e.g., stocking density, feed formulation, manure handling) affecting gaseous emissions; however, field-scale trials are often necessary to verify the impact of these factors under commercial conditions. Thus, a study that normalizes the effects of environmental factors by co-locating multiple housing systems at a common site and using similar management practices to the extent possible (system specific) provides an ideal opportunity to characterize and compare the housing systems of interest at the commercial scale.

The goal of this component of the CSES project was to assess the environmental impact of the 3 housing systems. Specific objectives were to quantify and compare 1) house-level emission rates (**ERs**) of NH_3, GHGs (including carbon dioxide [**CO_2**], nitrous oxide [**N_2O**] and methane [**CH_4**]), and particulate matter (**PM_{10} and $PM_{2.5}$**); 2) gaseous ER associated with the long-term manure storage of each housing system; and 3) farm-level (i.e., house plus corresponding manure storage) gaseous emissions of each housing system. It should be noted that PM emissions from the static manure storage piles are trivial, as such PM emissions form each house were considered to represent the farm-level PM ERs. The companion paper by Zhao et al. (2014a) delineates indoor air quality, thermal environment, and building ventilation rate (**VR**) for each of the housing types.

MATERIALS AND METHODS

The 27 mo environmental monitoring was carried out in 3 laying hen housing systems located at the same farm in the U.S. Midwest over 2 single-cycle flocks. The housing systems included 1) a CC with a 200,000-hen capacity; 2) an EC with a 50,000-hen capacity; and 3) an AV with a 50,000-hen capacity. Lohmann LSL White laying hens of the same age were placed and managed under standard commercial practices until approx. 77 to 78 wk of age per flock with no molt. The monitoring periods were April 2011 to June 2012 for flock 1 and July 2012 to August 2013 for flock 2, with a 3 wk downtime between flocks when no monitoring was performed.

A detailed description of each housing system design and management practices is given in the companion paper by Zhao et al. (2014b). Similarly, a detailed description of installation and operation of the monitoring system for the house-level gaseous and PM concentrations and building VR is given in another companion paper by Zhao et al. (2014a). Thus, only information related to the additional monitoring system for manure storage emissions and determination of ERs is presented in this paper.

Manure Storage Monitoring System

Three individual manure storage bays were constructed within the footprint of the communal manure storage to quantify the emissions of NH_3, CO_2, CH_4, and N_2O gases associated with the storage of manure generated from the 3 monitored houses. Each storage bay (13.7 by 7.6 m) was separated by 2.4 m tall concrete T-walls and enclosed with a 6 mil reinforced polyethylene canopy (DuraSkrim, Raven Industries, Sioux Falls, SD) suspended from the ceiling at a height of 5.4 m and fixed to the perimeter walls (Figure 1). The east end (entrance) of each storage bay was fitted with a sliding tarp to allow access for manure loading and unloading and provide an air inlet at the bottom when closed. Continuous mechanical ventilation of each storage bay was provided with a single-speed, 0.91 m exhaust fan installed in the west wall. The remainder of the otherwise open wall was sealed with clear plastic. The experimental manure storage bays were designed for a 12,000 bird, 6 mo storage capacity.

Prior to placement in long-term storage, manure removed from each house was weighed with a commercially operated certified grain scale located at the farm. Three continuous emission monitoring periods, each 6 mo long, were conducted during the study: November 2011 to May 2012 (flock 1), August 2012 to March 2013 (flock 2), and April 2013 to August 2013 (flock 2). During the first and second monitoring periods, the bays were loaded on a 2 wk schedule. During the first week, relatively equal amounts of manure (approx. 11 tonnes) were placed into each respective storage bay, with the remainder placed in the general storage area; during the second week, manure was weighed and placed directly into the general storage area. During the third monitoring period, the stored manure was loaded into the monitoring bays every week. At the end of each storage period, manure was removed from the monitoring bays and weighed again.

Monitoring of the manure storage system was accomplished with a self-contained air emission monitoring system housed in the manure storage shed.

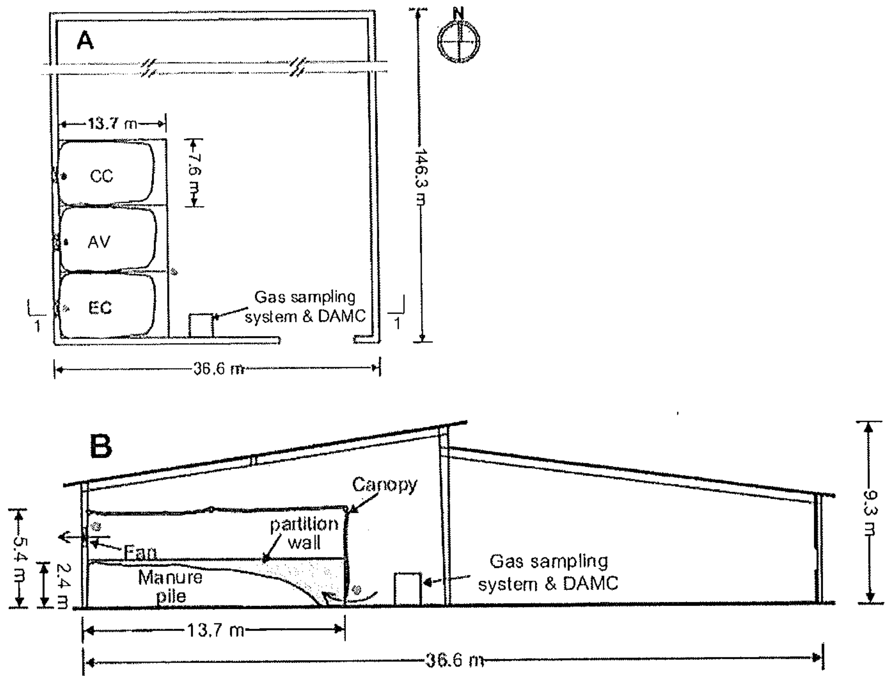

Figure 1. Schematic layout (A) and 1–1 cross-section (B) view of the manure storage bay enclosures for the conventional cage house (CC), aviary house (AV), and enriched colony house (EC). Red dots represent gas sampling locations.

Similar in principle to the mobile air emissions monitoring unit (**MAEMU**), the self-contained system integrated a data acquisition (**DAQ**) system (Compact Fieldpoint, National Instruments, Austin, TX) and 4 pumps to automatically collect and analyze exhaust air samples from each bay and one sample of the intake air to the storage bays. The positive-pressure air sampling system sequentially sampled each location for 15 min (the first 7 min were for stabilization, and the last 8 min were averaged for measurement), yielding 60 min data of gaseous concentrations. Concentrations of NH_3, CO_2, CH_4, NO_2, and dew-point temperature (**DP**) were measured with a photoacoustic multigas analyzer (INNOVA 1412, LumaSense Technologies A/S, Ballerup, Denmark). Air temperature was measured at the air intake of the storage bays and at the exhaust fan of each bay. Manure pile temperatures were measured periodically through the storage cycles with a temperature probe attached to a portable data logger (HOBO Pro Series, Onset, Bourne, MA) at depths of 0.3 and 0.6 m below the surface. The surface temperature was measured with a thermal imaging camera (T440, FLIR Systems, Inc., Boston, MA). Each exhaust fan was calibrated in situ at the end of each storage cycle with a 1.37 m fan assessment numeration system (**FANS**) unit (Gates et al., 2004).

Calculation of Gaseous and Particulate Matter Emission Rates

The house-level and manure storage gaseous ERs were calculated according to Equation (1). For the house-level ERs, the gaseous concentrations from each sampling cycle were linearly interpolated to the corresponding 30 s VR data, providing a dynamic emission value that was then summed over each day to yield the daily ER. Manure storage ERs were calculated with a 1 hr integration time based on the average hourly gaseous concentration and VR. Equation (2) provides the calculation of PM ERs, which utilized the 30 s average PM_{10} (particulate matter with an aerodynamic diameter of 10 μm or less) and $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5 μm or less) concentrations, measured with tapered element oscillating microbalances (**TEOMs**), and the corresponding house VR. Daily ERs for each system were then normalized to the units of per hen, per animal unit (**AU**, 500 kg live BW), and per kilogram of egg output based on the corresponding hen production and performance data.

$$[ER_G]_t = \sum_{e=1}^{2} [Q_e]_t \left([G]_e - \frac{\rho_e}{\rho_i}[G]_i \right) \times 10^{-6} \times \frac{w_m}{V_m} \times \frac{T_{std}}{T_a} \times \frac{P_a}{P_{std}} \quad (1)$$

$$[ER_{PM}]_t = \sum_{e=1}^{2} [Q_e]_t \left([PM]_e - \frac{\rho_e}{\rho_i}[PM]_i \right) \times 10^{-6} \times \frac{T_{std}}{T_a} \times \frac{P_a}{P_{std}} \quad (2)$$

Where:

$[ER_G]_t$ = Gaseous emission rate of the house at sample time t (g/house/t)
$[ER_{PM}]_t$ = PM emission rate of the house at sample time t (g/house/t)
$[Q_e]_t$ = VR through location e under the field temperature and barometric pressure at sample time t (m^3/house/t)
$[G]_i$ = Volumetric gaseous concentration of incoming air (ppm_v)
$[G]_e$ = Volumetric gaseous concentration of the exhaust air at location e (ppm_v)
$[PM]_i$ = PM concentration of incoming ventilation air ($\mu g/m^3$)
$[PM]_e$ = PM concentration of exhaust ventilation air at location e ($\mu g/m^3$)
w_m = Molar weight of the gas under consideration (g/mole)
V_m = Molar volume of gas at standard temperature (0°C) and pressure (1 atmosphere) (STP), 0.022414 m^3/mole
T_{std} = Standard temperature, 273.15 K
T_a = Absolute house temperature (°C + 273.15) (K)
P_{std} = Standard barometric pressure, 101.325 kPa
P_a = Atmospheric barometric pressure for the site elevation (kPa)
ρ_i, ρ_e = Air density of incoming and exhaust air (kg dry air per m^3 moist air).

Statistical analysis was performed to compare the daily mean gaseous and PM ERs among the 3 housing systems using the GLIMMIX model in Statistical Analysis System version 9.3 (SAS 9.3, SAS Institute Inc., Cary, NC). Equation 3 provides the statistical model used for the analysis. Ambient temperature was divided into 5 ranges based on daily means to delineate the housing impact at different climatic conditions: <0°C, 0 to 10°C, 10 to 20°C, 20 to 25°C, and >25°C. Weekly averages of daily means were used as repeated measures in this model. The time step chosen corresponded to the weekly manure removal to reduce potential time dependence of the data. Log transformation of weekly based ERs was performed to provide even residual distribution. The effects were considered significant at a threshold probability level of 0.05. To be included in the analysis, dynamic daily data were first required to pass the quality assurance and quality control (QA/QC) checks as described by Zhao et al. (2014a). In addition, only days when all 3 houses had complete ER data sets were considered, and a minimum of 3 complete daily data sets per week were required for inclusion.

$$\log(ER) = house + flock + ambient\ temperature + house \times flock + house \times ambient\ temperature \quad (3)$$

RESULTS AND DISCUSSION

Over the 27 mo monitoring period, data completeness of daily house-level gaseous ERs was 64% for NH_3 and CO_2, and 40% for CH_4. Measured concentrations of ambient and in-barn N_2O concentrations were near or below the detection limit (0.2 ppm) of the INNOVA 1412 and thus were excluded from the analysis. Issues with instrument malfunction, pump failures, and on-farm instrument calibration events account for the missing days of gaseous ERs. The TEOMs operated 2 to 5 d per week with valid readings before high dust concentrations led to saturation of the filter element, providing 31% data completeness for PM_{10}. Availability of fewer TEOM units during flock 1 and assessment of spatial variation of PM_{10} during flock 2 reduced the total number of days for $PM_{2.5}$ measurement, leading to a lower data completeness of 17% for $PM_{2.5}$. Daily manure storage ERs were determined on 329 out of 512 d during the manure loading period, giving 64% data completeness. Table 1 summarizes hen performance and production of both flocks. Table 2 summarizes the manure loading cycle for each monitoring period. It includes the total mass loaded throughout the monitoring period, total mass removed at the end of each monitoring period, the percentage of total manure production from each house placed in the monitoring bays, and the equivalent number of hens represented.

House-Level Ammonia Emission Rates

The daily mean NH_3 ERs on a per hen basis and its relationship with ambient temperature observed in the study are illustrated in Figure 2 for each housing system across both flocks. The overall means and SE based on different units of per hen, per AU, and per kilogram of egg output are summarized in Table 3. The AV had the highest house-level mean ER (g/hen/d), 0.112, followed by the CC at 0.082 and the EC at 0.054 ($P < 0.05$). The observed NH_3 ERs from this study were within literature values of 0.05 to 0.10 g/hen/d reported for conventional manure belt houses (Liang et al., 2005) and similar aviary houses operated under conditions in the U.S. Midwest: 0.13 to 0.16 g/hen/d (Hayes et al., 2013a) and 0.05 to 0.30 g/hen/d, respectively (Zhao et al., 2013).

Ammonia ERs of the houses at different ambient temperatures are further delineated by the summary data in Table 4. For the CC and EC, NH_3 ERs correlate with ambient temperature (i.e., higher ERs at higher temperatures), with temperatures above 20°C providing statistically higher ERs than lower temperatures. The AV had a different ER profile in that the lowest ERs occurred between 0 and 20°C, with higher ERs occurring at temperatures above and below this range. When comparing NH_3 ERs among the 3 houses at common ambient temperatures, the CC and AV were not significantly different, but both had significantly higher ERs than the EC for ambient

Table 1. Two-flock summary of 20 to 78 wk production performance of Lohmann LSL white hens in the conventional cage house (CC), aviary house (AV), and enriched colony house (EC).

Production parameter	Housing type			Reference[2]
	Conventional cage (CC)[1]	Aviary (AV)[1]	Enriched colony (EC)[1]	
No. of hens/house (wk 20)	**196,120** (193,424/198,816)	**49,754** (49,830/49,677)	**46,762** (46,795/46,729)	—
Cumulative mortality (%)	**4.4** (4.7/4.2)	**11.5** (11.5/11.5)	**4.8** (5.1/4.4)	4 to 6
Hen-day egg production (%)	**89.4** (87.3/91.4)	**87.3** (86.6/87.9)	**92.3** (90.5/94.1)	87.0
Eggs per hen housed	**362** (352/369)	**342** (340/344)	**373** (363/381)	360
Egg weight (g)	**58.8** (58.5/59.1)	**58.5** (58.4/58.6)	**59.1** (59.1/59.0)	66.9
Feed use (g/hen/d)	**106** (105/107)	**108** (108/108)	**107** (107/106)	105 to 115
Water use (g/hen/d)	**220** (221/219)	**184** (183/185)	**192** (193/191)	—
Feed conversion ratio (feed:egg)	**1.99** (2.02/1.96)	**2.08** (2.12/2.04)	**1.97** (1.99/1.94)	2.0 to 2.1
Average BW (kg)	**1.60** (1.55/1.64)	**1.56** (1.56/1.56)	**1.55** (1.52/1.57)	1.72 to 1.86

[1]Values are the mean of 2 flocks, with values in paranthese representing flock1 and flock 2 (fock1/flock2), respectively.
[2]Breeder company reference for Lohmann LSL white hen (20 to 78 wk) (Layer Management Guide, http://www.lskpoultry.fi/materialit/lsl managementguide.pdf, accessed on December 5, 2013)

Table 2. Summary of manure loading into and removal from the storage bays of the conventional cage (CC), aviary (AV), and enriched colony (EC) houses during the 2 flock cycles.

Period	Manure loaded or removed*	Housing system		
		Conventional cage (CC)	Aviary (AV)	Enriched colony (EC)
November 2011 to May 2012	Manure loaded (tonne)	723	703	676
	Manure removed (tonne)	531	509	498
	% of total output	6%	32%	26%
	Equivalent no. of hens	11,600	14,700	11,700
August 2012 to March 2013	Manure loaded (tonne)	798	681	698
	Manure removed (tonne)	548	502	504
	% of total output	7%	28%	26%
	Equivalent no. of hens	13,600	13,300	12,200
April 2013 to August 2013	Manure loaded (tonne)	943	688	728
	Manure removed (tonne)	730	504	583
	% of total output	15%	54%	54%
	Equivalent no. of hens	29,700	24,500	24,500

*Manure loaded is the total mass of manure placed into each storage bay over the monitoring period. Manure removed is the total mass of manure removed from each storage bay at the end of the monitoring period.

temperatures above 10°C. At ambient temperatures below 0°C, NH_3 ERs of the CC and EC were not significantly different, but both were significantly lower than that of the AV. The higher NH_3 ERs found under ambient temperatures above 20°C were partially attributed to increased water consumption by the birds (hence deposit of wetter feces on the manure belt and litter floor) and greater air velocities in the barn, both of which promote NH_3 volatilization. The higher NH_3 emissions of the AV at lower temperatures were attributed to extended periods of low VRs, which caused moisture to accumulate in the littered floor, thus increasing NH_3 volatilization due to conditions more favorable for microbial decomposition of uric acid to NH_3. The elevated NH_3 ERs during the winter were the primary reason for the difference between the AV and CC. The differences in NH_3 ERs between the CC and EC were likely driven by the difference in stocking density of the hens and thus manure load on the belt and effectiveness of each manure drying system. The EC had the lowest manure belt stocking density at 745 cm^2/hen in comparison to the CC at 568 cm^2/hen. Moisture content (MC) of the manure removed from the houses revealed that the EC had the driest manure at 45.6%, followed by the AV at 51.7% and the CC at 53.6% (unpublished data by Zhang et al., 2014, University of California–Davis). As with the littered floor, higher MC of manure on the belts makes conditions more favorable for the microbial decomposition of uric acid to NH_3.

House-Level Greenhouse Gas Emission Rates

The daily mean CO_2 ERs across both flocks and vs. ambient temperature are presented in Figure 3 on a per

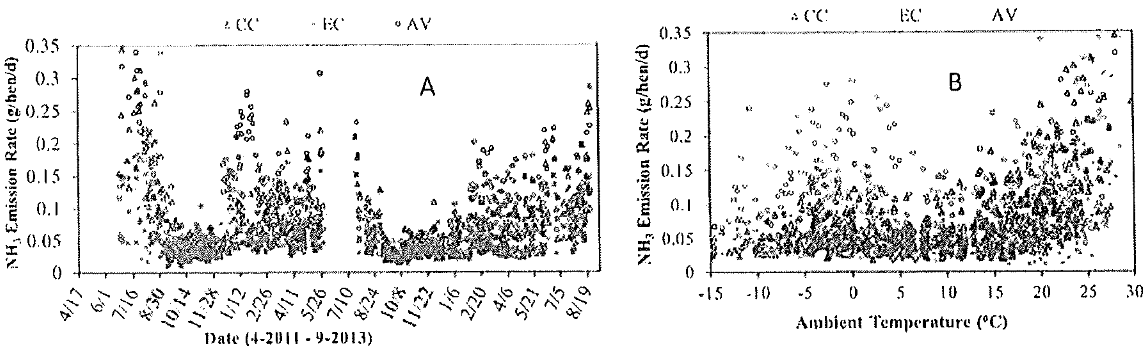

Figure 2. (A) Daily NH_3 emission rates (ERs) (g/hen/d) and (B) their relationship to ambient temperature for the conventional cage house (CC), aviary house (AV), and enriched colony house (EC).

Table 3. House-level daily emission rates (ERs; mean and SE) of ammonia (NH_3), carbon dioxide (CO_2), methane (CH_4), and particulate matter (PM_{10} and $PM_{2.5}$) for the conventional cage (CC), aviary (AV), and enriched colony (EC) houses expressed in different units for each of the 2 flocks.

Gas or PM	Unit	Conventional cage (CC)		Aviary (AV)		Enriched colony (EC)	
		Flock 1	Flock 2	Flock 1	Flock 2	Flock 1	Flock 2
NH_3	g/hen/d	0.097	0.068	0.136	0.088	0.059	0.049
	SE	(0.010)	(0.004)	(0.011)	(0.006)	(0.006)	(0.004)
	g/AU/d	31.2	20.7	43.4	28.1	19.3	15.6
	SE	(3.22)	(1.22)	(3.51)	(3.22)	(1.97)	(1.27)
	g/(kg egg)	1.90	1.26	2.69	1.71	1.10	0.88
	SE	(0.20)	(0.07)	(0.22)	(0.12)	(0.11)	(0.07)
CO_2[a]	g/hen/d	68.5	68.1	72.5	75.6	74.9	73.9
	SE	(0.85)	(0.57)	(0.93)	(1.68)	(1.19)	(1.02)
	g/AU/d	22,054	20,750	23,133	24,169	24,557	23,550
	SE	(274)	(174)	(297)	(537)	(390)	(325)
	g/(kg egg)	1,341	1,261	1,434	1,468	1,400	1,331
	SE	(17)	(11)	(18)	(33)	(22)	(18)
CH_4	g/hen/d	0.09	0.07	0.10	0.05	0.11	0.05
	SE	(0.007)	(0.004)	(0.007)	(0.003)	(0.008)	(0.005)
	g/AU/d	29.0	21.3	31.9	16.0	36.1	15.9
	SE	(2.25)	(1.22)	(2.23)	(0.96)	(2.62)	(1.59)
	g/(kg egg)	1.8	1.3	2.0	1.0	2.1	0.9
	SE	(0.14)	(0.07)	(0.14)	(0.06)	(0.15)	(0.09)
PM_{10}	mg/hen/d	16.9	14.5	87.6	113.0	13.9	17.3
	SE	(1.02)	(0.90)	(3.92)	(5.07)	(0.66)	(0.90)
	g/AU/d	5.4	4.4	28.0	36.1	4.6	5.5
	SE	(0.33)	(0.27)	(1.25)	(1.62)	(0.22)	(0.29)
	g/(kg egg)	331	268	1,732	2194	260	312
	SE	(20)	(17)	(78)	(98)	(12)	(16)
$PM_{2.5}$	mg/hen/d	1.0	0.9	8.6	9.1	1.5	1.9
	SE	(0.24)	(0.14)	(0.32)	(0.27)	(0.10)	(0.15)
	g/AU/d	0.32	0.27	2.74	2.91	0.49	0.61
	SE	(0.08)	(0.04)	(0.10)	(0.09)	(0.03)	(0.05)
	g/(kg egg)	19.6	16.7	170	177	28.0	34.2
	SE	(4.70)	(2.59)	(6.3)	(5.2)	(1.87)	(2.70)

AU = animal unit = 500 kg live body mass.

[a]Includes CO_2 contributions from animal respiration (majority) and CO_2 production from manure (minor).

hen basis for each housing system. The overall means and SE of GHG ERs on the basis of per hen, per AU, and per kilogram of egg output are summarized in Table 3. The EC and AV had statistically higher daily CO_2 ERs than the CC (74.4, 74.0, and 68.3 g/hen/d, respectively). Literature reports comparable CO_2 ERs for a manure belt system of 70 to 85 g/hen/d (Liang et al., 2005; Neser et al., 1997) and 67 to 83 g/hen/d in a similar AV system housing brown birds operated in the U.S. Midwest (Hayes et al., 2013a). The relatively higher levels of CO_2 emissions in the AV and EC in comparison to the CC were presumably due to

Table 4. Summary of house-level average daily emission rates (ERs) of ammonia (NH_3) and particulate matter (PM_{10}) for the conventional cage (CC), aviary (AV), and enriched colony (EC) housing systems under different ranges of ambient temperature conditions.

Gas or PM	Daily avg. ambient temperature range (°C)	Average daily ERs (Mean and SE)		
		Conventional cage (CC)	Aviary (AV)	Enriched colony (EC)
NH_3 (g/hen/d)	<0	0.055 (0.003)^{c,B}	0.119 (0.010)^{c,A}	0.045 (0.003)^{c,B}
	0 to 10	0.053 (0.003)^{c,A,B}	0.077 (0.009)^{d,A}	0.036 (0.002)^{c,B}
	10 to 20	0.075 (0.005)^{c,A}	0.088 (0.008)^{d,A}	0.048 (0.004)^{c,B}
	20 to 25	0.133 (0.017)^{b,A}	0.151 (0.019)^{b,A}	0.080 (0.010)^{b,B}
	>25	0.189 (0.053)^{a,A}	0.197 (0.066)^{a,A}	0.121 (0.036)^{a,B}
PM_{10} (mg/hen/d)	<0	5.9 (0.3)^{b,B}	80.8 (5.5)^{c,A}	7.2 (0.6)^{c,B}
	0 to 10	9.4 (0.9)^{b,B}	100.6 (8.0)^{b,A}	10.3 (0.6)^{b,c,B}
	10 to 20	24.5 (2.9)^{a,B}	138.0 (10.8)^{a,A}	16.5 (1.2)^{a,b,B}
	20 to 25	28.3 (2.0)^{a,B}	91.6 (17.1)^{b,c,A}	25.5 (1.9)^{a,C}
	>25	37.5 (5.3)^{a,A,B}	65.9 (30.4)^{c,A}	25.9 (5.4)^{a,B}

Within a housing system (column), NH_3 or PM_{10} ER means with different lowercase superscripts are significantly different ($P < 0.05$). Among the housing systems (i.e., within each row), NH_3 or PM_{10} ER means with different uppercase superscripts are significantly different ($P < 0.05$).

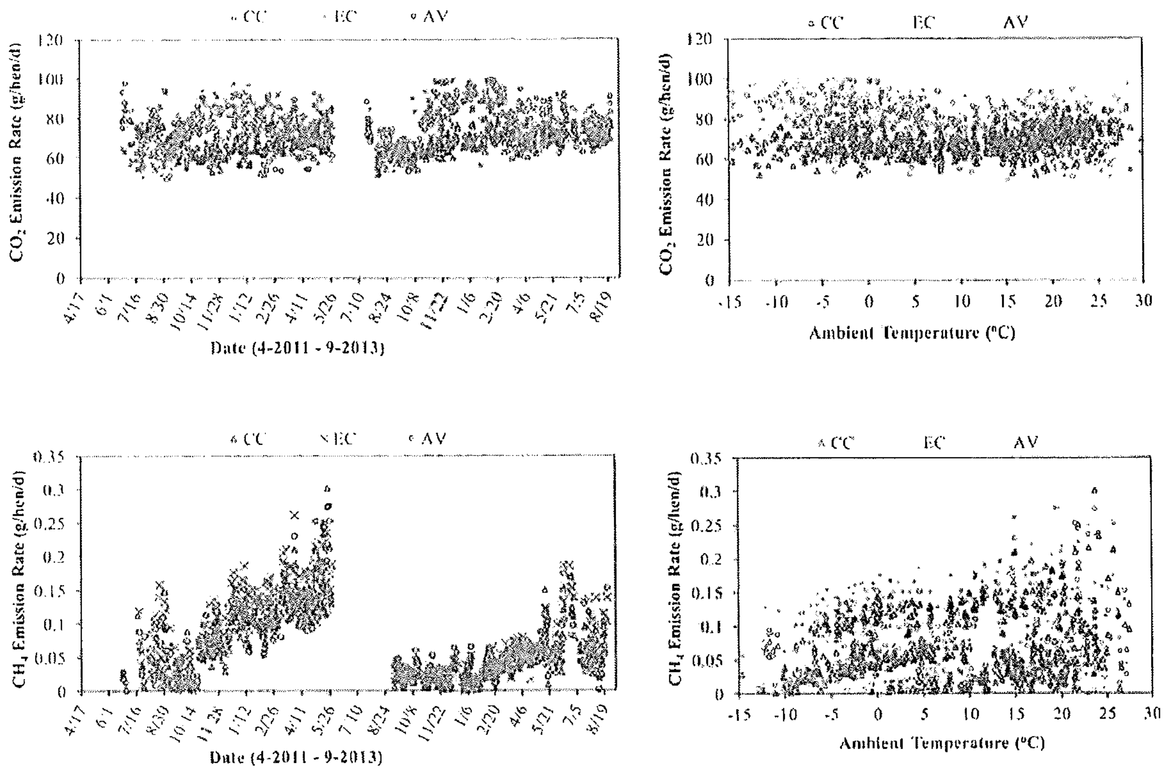

Figure 3. Daily mean CO_2 and CH_4 emission rates (ERs) (g/hen/d) and their relationship to ambient temperature for the conventional cage house (CC), aviary house (AV), and enriched colony house (EC).

increased hen activity associated with lower stocking densities. Animal activity level affects metabolic rate, and increased metabolic rate leads to a higher rate of CO_2 respiration. CIGR (1999) provides guidelines for ventilation design based on the total and latent heat production rates of laying hens, which accounts for the increased activity and metabolic rates of laying hens housed in floor systems vs. cage systems. In addition to hen respiration, CO_2 is generated from the decomposition of manure deposited on the manure belts in all houses and from the littered floor of the AV. Ning (2008) reported that CO_2 generated from manure decomposition contributed to between 1 and 5% of the total daily CO_2 emission as manure accumulation time increased from 1 to 5 d. Hayes et al. (2013b) measured and partitioned the CO_2 emissions of a similar AV system and reported that the littered floor represented 3% of the house-level emissions.

The daily mean CH_4 ERs across both flocks and vs. ambient temperature observed in the study are shown

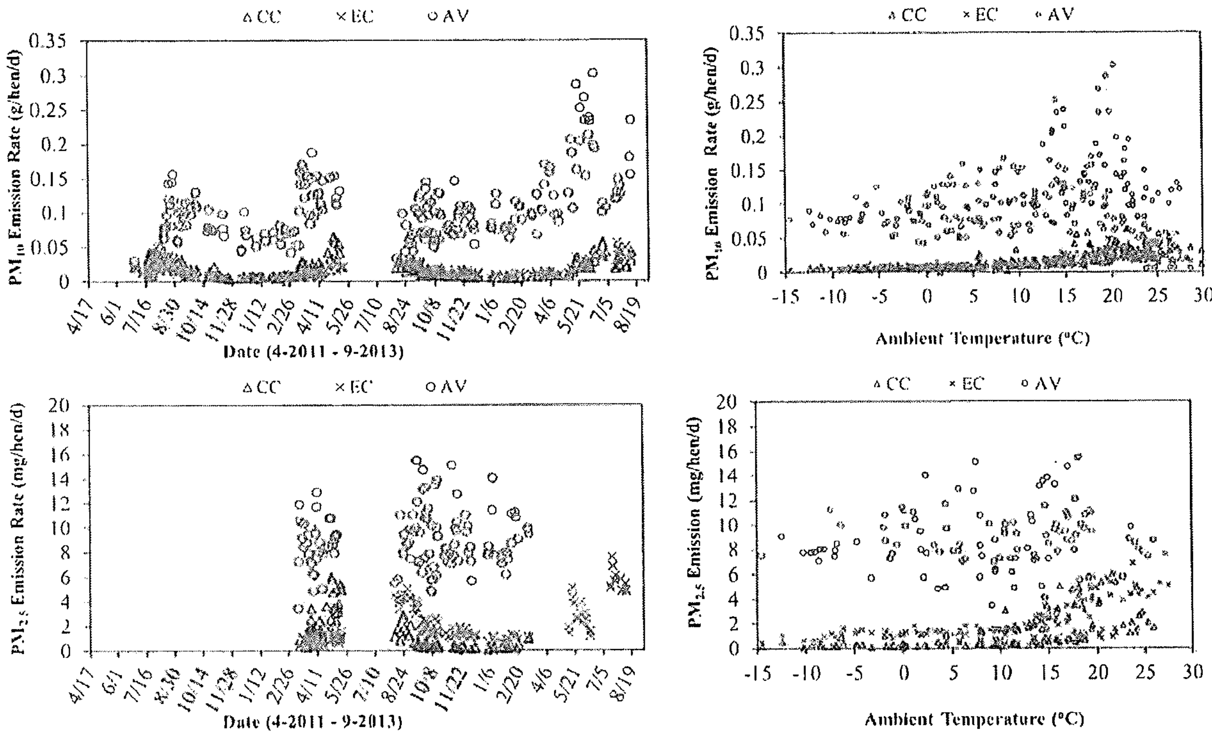

Figure 4. Daily mean particulate matter (PM_{10} and $PM_{2.5}$) emission rates (ERs) (g/hen/d) and (mg/hen/d), respectively and their relationship to ambient temperature for the conventional cage house (CC), aviary house (AV), and enriched colony house (EC).

in Figure 3 on a per hen basis for each housing system. All 3 housing systems had similar average daily CH_4 ERs of 0.07 to 0.08 g/hen/d. The observed CH_4 ERs from this study fall within the ranges reported in literature of 0.08 to 0.13 g/hen/d in conventional manure belt systems (Fabbri et al., 2007; Groot Koerkamp et al., 1998; Monteny et al., 2001; Wathes et al., 1997) and 0.08 to 0.10 g/hen/d in U.S. AV houses with brown birds (Hayes et al., 2013a).

House-Level Particulate Matter Emission Rates

The daily mean PM_{10} and $PM_{2.5}$ ERs across both flocks and vs. ambient temperature are shown in Figure 4 on a per hen basis for each housing system. The overall daily ER means and SE on the basis of per hen, per AU, and per kilogram of egg output are summarized in Table 3. The AV had a significantly higher average daily PM_{10} ER (mg/hen/d) of 100.3 than the CC at 15.7 and the EC at 15.6 ($P < 0.05$). The observed values of PM_{10} ERs of the EC and CC were in the lower end of the range reported from U.S.-based studies, i.e., 9 to 48 mg/hen/d in the CC high-rise houses (Li et al., 2011). The AV PM_{10} ERs were within reported values of 80 to 110 mg/hen/d for similar U.S. AV houses (Hayes et al., 2013a).

The relationship between PM_{10} ERs and ambient temperature is further delineated by the data in Table 4. For all temperature groupings below 25°C, the AV had significantly higher PM_{10} ERs than the CC and EC houses ($P < 0.05$). For temperature ranges below 20°C, no difference in ERs was found between the CC and EC. The PM_{10} ERs of the CC and EC were directly related to ambient temperatures. This outcome was believed to arise from increased air velocity across the barn driven by higher VRs, allowing less PM to settle within the house. The AV showed a similar pattern to the EC and CC, but ERs at temperatures above 20°C were confounded by bird age and the absence of litter accumulation on the floor prior to 35 wk of age in both flocks. Further analysis of the PM_{10} data, omitting data when litter were not available or established in the AV (18 to 35 wk of age), showed no significant difference in PM_{10} ERs in the temperature ranges of 10 to 20°C, 20 to 25°C, and >25°C (mean ± SE of 132.5 ± 7.0, 134.5 ± 16.0, and 105.3 ± 12.5 mg/hen/d, respectively).

The AV had the highest mean daily $PM_{2.5}$ ER (mg/hen/d) of 8.8, followed by the EC at 1.7 and CC at 0.9. The $PM_{2.5}$ ER values observed in the CC and EC were lower than those reported for CC high-rise houses (3.6 to 14 mg/hen/d) (Li et al., 2011), whereas the AV $PM_{2.5}$ ERs were comparable to ranges reported for similar U.S. AV housing (5 to 10 mg/hen/d) (Hayes et al., 2013a). The ratio of $PM_{2.5}$ to PM_{10} found in this study, 7% (CC), 10% (AV), and 11% (EC), paralleled the PM partitioning observed in the literature (Li et al., 2011, Hayes et al., 2013a). The lower levels of both PM_{10} and $PM_{2.5}$ found in this study for the CC

Table 5. Summary of house-level, manure storage, and farm-level daily emission rates of ammonia (NH_3), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and particulate matter (PM_{10} and $PM_{2.5}$) for the conventional cage (CC), aviary (AV), and enriched colony (EC) housing systems over the 27 mo monitoring period.

Gas or PM	Source	Housing system								
		Conventional cage (CC)			Aviary (AV)			Enriched colony (EC)		
		g/hen/d	g/(kg egg)	% of total	g/hen/d	g/(kg egg)	% of total	g/hen/d	g/(kg egg)	% of total
NH_3	House	0.082^b	1.62	28	0.112^a	2.19	40	0.054^c	0.99	31
	Manure storage	0.21^a	4.00	72	0.18^a	3.52	60	0.11^b	2.02	69
	Farm	0.29	5.52	100	0.30	5.88	100	0.16	2.94	100
CO_2	House	68.3^b	1,300	89	74.0^a	1,450	90	74.4^a	1,365	91
	Manure storage	8.1	154	11	8.0	157	10	7.1	130	9
	Farm	76.4	1,454	100	82.0	1,607	100	81.5	1,495	100
CH_4	House	0.07	1.33	70	0.07	1.37	70	0.08	1.47	80
	Manure storage	0.03	0.57	30	0.03	0.59	30	0.02	0.37	20
	Farm	0.10	1.90	100	0.10	1.96	100	0.10	1.84	100
N_2O	House	—	—	—	—	—	—	—	—	—
	Manure storage	0.03	0.57	—	0.03	0.59	—	0.01	0.18	—
	Farm	0.03	0.57	—	0.03	0.59	—	0.01	0.18	—
PM_{10}	House	0.0157^b	0.299	100	0.1003^a	1. 909	100	0.0156^b	0.297	100
	Manure storage	—	—	—	—	—	—	—	—	—
	Farm	0.0157	0.299	100	0.1003	1. 909	100	0.0156	0.297	100
$PM_{2.5}$	House	0.0009^b	0.018	100	0.0088^a	0.168	100	0.0017^b	0.032	100
	Manure storage	—	—	—	—	—	—	—	—	—
	Farm	0.0009	0.018	100	0.0088	0.168	100	0.0017	0.032	100

Means of gaseous or particulate matter emission rates of the housing systems with different superscript letters significantly differ ($P < 0.05$).

and EC compared to the literature values are likely due to differences in housing/manure management and ventilation design. Specifically, the PM ER values reported by Li et al. (2011) were for high-rise houses that stored the manure in the lower level for nearly a year.

Manure Storage and Farm-Level Emission Rates

The daily mean gaseous emissions observed from the 3 manure storage monitoring periods, in g/hen/d, were NH_3: 0.21 (CC), 0.18 (AV), and 0.11 (EC); CO_2: 8.1 (CC), 8.0 (AV), and 7.1 (EC); CH_4: 0.03 (CC), 0.03 (AV), and 0.02 (EC); and N_2O: 0.03 (CC), 0.03 (AV), and 0.01 (EC). The differences in manure emissions were related to the MC of each manure source, with the EC having the driest manure at 45.6%, followed by the AV at 51.7%, and the CC at 53.6%. A lab-scale assessment of gaseous emissions from laying hen manure by Li and Xin (2010) showed a direct correlation between MC and NH_3 ERs and a range of gaseous ERs (g/hen/d) of NH_3: 0.06 to 0.22; CO_2: 1.6 to 4.8; and CH_4: 0.007 to 0.032.

Table 5 provides a summary of farm-level gaseous ERs based on per hen and per kilogram of egg output, combining the house-level and associated manure storage contributions. Farm-level ERs of NH_3 (g/hen/d) were highest for the AV and CC at 0.30 and 0.29, respectively, and lowest for the EC at 0.16 ($P < 0.05$). The primary difference in the farm-level NH_3 ERs is believed to be driven by the manure drying effectiveness in each house and the littered floor of the AV. The EC system had the lowest manure belt stocking density, followed by the AV and CC, resulting in more effective in-barn manure drying and lower house-level and farm-level NH_3 emissions. The CC had the highest manure belt stocking density, manure MC, and manure storage ER, with over 70% of emissions originating from the long-term manure storage. A similar proportion (69%) of overall farm-level emissions was from the manure storage for the EC. In comparison, 60% of the farm-level emissions originated from the long-term manure storage for the AV, although the littered floor can significantly change this partitioning if moisture accumulates in the litter for an extended period. These results illustrate the impact of manure belt drying design and operation and manure/litter management on both house-level and long-term manure storage emissions.

Conclusions

Gaseous and particulate matter emissions from 3 commercial laying hen houses (CC, EC, and AV) and their respective manure storage were monitored over 2 single-cycle production flocks in the U.S. Midwest. The following observations and conclusions were made.

- House-level NH_3 emissions were highest in the AV at 0.112, followed by the CC at 0.082 and the EC at 0.054 g/hen/d ($P < 0.05$).
- House-level CH_4 emissions were similar for all houses and small (0.07 to 0.08 g/hen/d).
- PM_{10} and $PM_{2.5}$ emissions were highest for the AV at 100.3 and 8.8 mg/hen/d, respectively, resulting

from hen activities on the litter floor. PM emissions of the CC and EC were similar, amounting to 16% of the AV PM_{10} ER and 10–20% of the AV $PM_{2.5}$ ER—PM_{10}: 15.7 (CC), 15.6 (EC); $PM_{2.5}$: 0.9 (CC), 1.7 (EC) mg/hen/d ($P < 0.05$).

- Farm-level NH_3 emissions were lower for the EC (0.16 g/hen/d) than for the AV or CC (0.30 and 0.29 g/hen/d, respectively).
- Ammonia emissions from the manure storage accounted for 60 to 70% of the farm-level emissions. Hence, future NH_3 mitigation efforts should focus on manure storage.

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Ammonia, Greenhouse Gas, and Particulate Matter Emissions of Aviary Layer Houses in the Midwestern US

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AMMONIA, GREENHOUSE GAS, AND PARTICULATE MATTER EMISSIONS OF AVIARY LAYER HOUSES IN THE MIDWESTERN U.S.

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ABSTRACT. *There has been an increased interest in alternative housing for laying hens in certain parts of the world, including the U.S. Associated with the movement are many questions concerning sustainability of such systems. This study continually quantified concentrations and emissions of ammonia* (NH_3), *carbon dioxide* (CO_2), *methane* (CH_4), *nitrous oxide* (N_2O), *and particulate matter* (PM_{10} *and* $PM_{2.5}$) *for two side-by-side aviary barns each housing 50,000 Hy-Line brown laying hens, located in the Midwestern U.S. The gaseous concentrations were continually monitored using an infrared photoacoustic multi-gas analyzer, while the PM concentrations were measured with tapered element oscillating microbalances (TEOMs). Barn ventilation rate was determined by monitoring the operation time of ventilation fans that had been calibrated in situ. Nineteen consecutive months of monitored data (June 2010 to December 2011) are analyzed and presented. Daily indoor aerial concentrations (mean ±SD) were 8.7 (±8.4) ppm* NH_3, *1,636 (±1,022) ppm* CO_2, *10.0 (±6.8) ppm* CH_4, *2.3 (±1.6) mg* m^{-3} PM_{10}, *and 0.25 (±0.26) mg* m^{-3} $PM_{2.5}$. *The aerial emissions are expressed as quantities per hen, per animal unit (AU, 500 kg body weight), and per kg egg output. Daily emission rates (g* $bird^{-1}$*) were 0.15 (±0.08)* NH_3, *75 (±15)* CO_2, *0.09 (±0.08)* CH_4, *0.11 (±0.04)* PM_{10}, *and 0.008 (±0.006)* $PM_{2.5}$. *The results were compared to reported emission values for conventional (high-rise and manure-belt cage) U.S. laying-hen housing systems. Data from this study provide baseline concentration and emission values for the aviary housing system in the Midwestern U.S., which will also contribute to improvement of the U.S. national air emissions inventory for farm animal operations.*

Keywords. *Aerial emissions, Air quality, Aviary, Concentrations, Laying hen.*

In the past decade, concerns over animal welfare issues have led to a shift among certain egg producers from conventional laying-hen cage houses to cage-free and/or enriched cage housing. There are many questions about the performance and sustainability of these alternative housing systems, including indoor air quality and air emissions. An Air Compliance Agreement (ACA) was reached in 2005 between the U.S. EPA and certain sectors of the U.S. livestock and poultry industries, namely, broiler, egg, swine, and dairy. The ACA studies have yielded or will yield more baseline data on air emissions from U.S. animal feeding operations (AFOs). However, no alternative laying-hen housing sites were monitored in the ACA studies, and there is very little information on the emissions from these alternative systems, particularly under U.S. operational conditions.

The barns used in this study are colony-style aviary houses with the Natura 60 design (Big Dutchman, Holland, Mich.; www.bigdutchmanusa.com/eggproduction/cagefree/aviary/natura60.html). The birds in this system have floor access for part of the day (light hours) and spend the rest of their time in tiered colonies (including feeding, drinking, perching, and laying eggs). The system is defined as cage-free alternative housing. Studies have been conducted to quantify aerial emissions for conventional (cage) laying-hen housing in the U.S. and conventional and alternative housing in Europe. The European cage-free systems are generally designed with no restrictions within the barns and with no ability to contain birds in colonies for certain hours of the day or night. Moreover, outdoor access is often available in these European systems. Nevertheless, results of these studies provided some insight into the elevated concentrations and emissions compared to conventional (cage) houses in the U.S.

The two constituents of most concern for elevated levels in alternative housing are ammonia (NH_3) and particulate matter (PM). The European studies showed NH_3 emission rates for cage-free barns of 0.27 and 0.85 g $bird^{-1}$ d^{-1} (Groot Koerkamp et al., 1998, Müller et al., 2003). The higher NH_3

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emission values in the reported European studies are comparable to those of high-rise housing in the U.S. Liang et al. (2003) showed NH_3 emission rates of 0.05 to 0.1 g $bird^{-1}$ d^{-1} for manure-belt cage hen houses and 0.95 g $bird^{-1}$ d^{-1} for high-rise cage hen houses in the U.S. Li et al. (2012) reported an almost identical NH_3 emission rate of 0.96 g $bird^{-1}$ d^{-1} for high-rise cage houses in the Midwestern U.S. Based on the literature, the expectation is that the NH_3 emission rate for aviary houses will be between the values for manure-belt and high-rise cage houses. Cage-free systems in Europe were reported to have PM_{10} emissions 2 to 3 times greater than conventional houses (Takai et al., 1998). Literature on conventional (cage) laying-hen housing reported $PM_{2.5}$ emissions of 0.0036 to 0.014 g $bird^{-1}$ d^{-1} and PM_{10} emissions ranging from 0.019 to 0.048 g $bird^{-1}$ d^{-1} (Li et al., 2011). The expectation is that PM values for the aviary houses will be higher than those of cage houses in the U.S. due to activities (e.g., dustbathing) of the hens on the litter floor. Carbon dioxide (CO_2) emissions from manure-belt cage houses have been reported to be 70 to 85 g $bird^{-1}$ d^{-1} (Liang et al., 2003; Neser et al., 1997), and similar values are expected for the aviary houses. For methane (CH_4), the literature suggests that all housing systems emit between 0.08 and 0.13 g $bird^{-1}$ d^{-1} (Groot Koerkamp et al., 1997; Monteny et al., 2001; Fabbri et al., 2007; Wathes et al., 1997).

Therefore, the objectives of this study were to characterize concentrations and emission rates of ammonia (NH_3); the greenhouse gases (GHG) carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O); and particulate matter (PM) with aerodynamic diameter of 10 and 2.5 µm (PM_{10} and $PM_{2.5}$) from colony-style aviary houses in the Midwestern U.S., one of the alternative hen housing systems being used by U.S. egg producers. The gaseous and PM emission rates were then compared to literature values. Collection of baseline emissions data for the aviary houses and comparisons of the data with those for conventional systems are important in terms of enhancing the U.S. national emissions inventory and developing realistic regulatory guidelines specific to the animal production systems.

Materials and Methods

Site Description

This field study was conducted with aviary houses that featured a commercial housing design (Natura 60, Big Dutchman, Holland, Mich.). Two aviary houses in a double-wide building located in Iowa were used. Each house measured 167.6 m × 19.8 m with a capacity of 50,000 hens (Hy-Line Brown) and had a production cycle from approximately 17 to 80 weeks of age with no molt. The new flock started the fourth week of April 2010 in one house (house 3 or H3) and the second week of September 2010 in the other (house 2 or H2). A cross-sectional schematic of the houses is shown in figure 1. Each house was divided into ten 14.5 m sections along the length. The houses had open litter floors (2.6 m wide per section for the center aisles and 1.2 m per section for the outer aisles), nest boxes, and perches. To minimize floor eggs and improve manure management, the hens were trained to be off the floor and return to the aviary colonies at night and remained in the colonies until the next morning. Each row had three tiers, and manure belts with a manure-drying air duct were placed underneath the lower two tiers. The three tiers were divided into nest, feeding, and drinking areas from top to bottom. Each house had 20 exhaust fans, all on one sidewall (fig. 2), including twelve 1.2 m fans, four 0.9 m fans, and four 0.5 m fans. Ceiling box air inlets (75 bi-directional, 0.6 × 0.6 m each) were used. Four 73.25 kW heaters were placed equidistant along the sidewall. Compact fluorescent lighting was used with a 16 h light period. Table 1 summarizes the housing and management characteristics of the aviary houses.

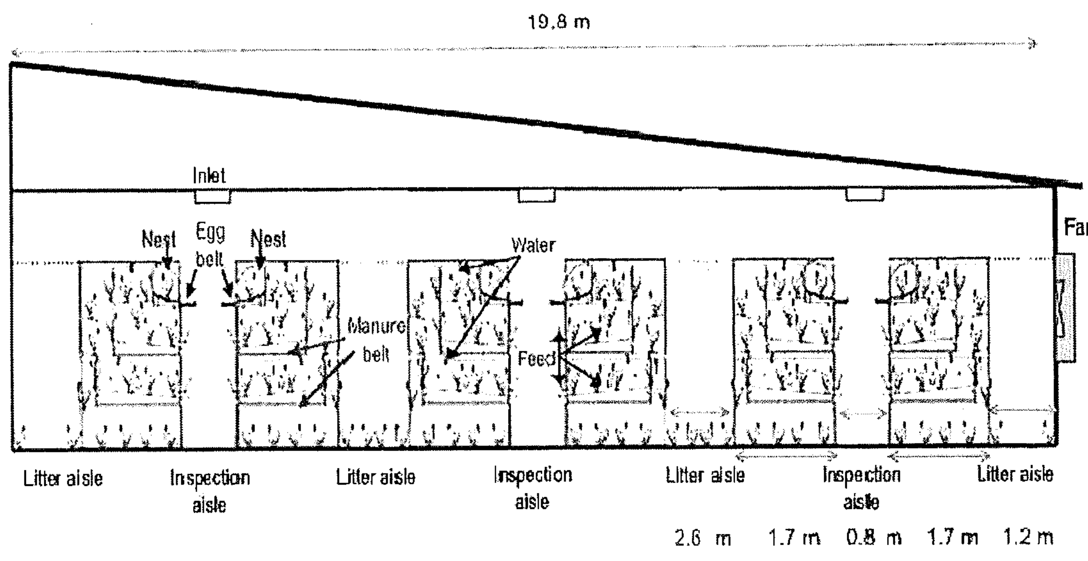

Figure 1. Cross-sectional view of the monitored aviary hen house (one side of the double houses) (not to scale).

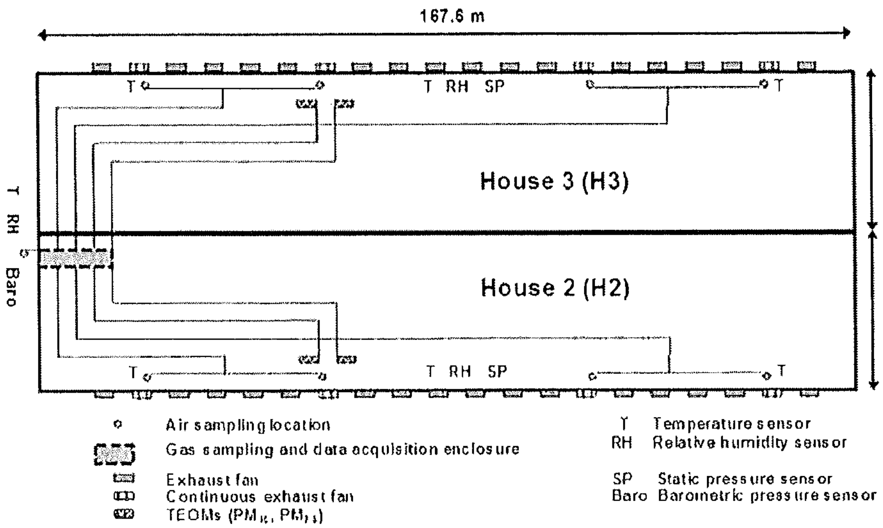

Figure 2. Schematic representation of air sampling locations in the aviary laying hen houses (not to scale).

Table 1. Housing characteristics of the aviary hen houses monitored in this study.

Ventilation	Stage	No. of Fans	Fan Size (m)	Motor Size (W)	On if > Setpoint by (°C)
	1	4	0.5	250	Continuous
	2	4	0.9	375	1.1
	3	2	1.2	750	1.1
	4	2	1.2	750	1.1
	5	2	1.2	750	1.1
	6	2	1.2	750	1.1
	7	2	1.2	750	1.1
	8	2	1.2	750	1.1
Heaters		No. of Heaters	Capacity (kW)		On if < Setpoint by (°C)
		4	73.25		2.2
Manure-drying blower		No. of Blowers		Motor Size (kW)	
		3		5.6	
Lighting	No. of Lights	Bulb Type	Nominal Size (W)	Light Mode	
Inspection aisle	315	CFL	9	Dimmable	
Litter aisle	180	CFL	15	Dimmable	
Worker area	16	Incandescent	75		
Event Timing					
Feeding	5:45 a.m., 11:15 a.m., 3:30 p.m., and 7:15 p.m.				
Lights on/off	Lights on at 5:45 a.m.; lights off at 9:45 p.m.				
Floor access	On floor at 11:30 a.m.; off floor at 9:30 p.m.				
Daily manure belt movement	1/3 belt (winter) for 15 min; 1/7 belt (summer) for 7 min				
Space Allowance (50,000 hens)					
Wire floor	676 cm² bird⁻¹				
Litter floor	613 cm² bird⁻¹				
Nest space	60 cm² bird⁻¹				
Perch length	15.9 cm bird⁻¹				
Feed trough length	10.6 cm bird⁻¹				
Nipple drinker	8.55 birds nipple⁻¹				

MEASUREMENT SYSTEM

Concentrations of NH_3 and GHG (CO_2, N_2O, and CH_4) at four locations in each house were measured continually with a fast-response, high-precision infrared (IR) photoacoustic multi-gas analyzer (model 1412, Innova AirTech Instruments, Ballerup, Denmark). Two locations (near two continuous ventilation fans) were combined into one composite sample; hence, two composite sampling lines were used from the four continuously running ventilation fans per house (fig. 2). FEP Teflon tubing (0.95 cm o.d., 0.635 cm i.d.) was used for air sampling to avoid NH_3 absorption to the sampling lines. Each sampling port was equipped with a coarse filter (3011 NAPA, Atlanta, Ga.) and a fine dust filter (47 mm filter membrane, 5 to 6 μm, Savillex, Eden Prairie, Minn.) to keep particulates from plugging the sample tubing or damaging the gas analyzer. Since one gas analyzer was used to measure multiple locations in two barns, the air samples from all locations were taken sequentially using an automatically controlled (positive-pressure) gas sampling system (fig. 3). To ensure measurement of the real concentration values, considering the response time of the analyzers, each location was sampled for 6 min, with the first 5.5 min for stabilization and the last 0.5 min readings for measurement. This sequential measurement yielded 30 min data of gaseous concentrations. Each sampling location had its own designated air sampling pump; hence, a total of five pumps were utilized. Sampling pumps were run for 1 min prior to the location sampling and turned off as soon as the sampling was finished. Use of the intermittent pumping was to increase the longevity of pump's operation. In addition, every 2 h the outside air was drawn and analyzed. Less frequent sampling and analysis of the outside air was used because its composition remained much more stable than that of the indoor air.

Concentrations of PM_{10} and $PM_{2.5}$ inside the houses were measured continuously with real-time tapered element oscillating microbalances (TEOM) equipped with the respective PM head (model 1400a, Thermo Fisher Scientific, Waltham, Mass.) (fig. 3). A 300 s integration time was used. Two collocated TEOM units ran continuously for two days each week in each house, with mass concentrations of both particle sizes reported every 30 s. The TEOM units were placed next to a minimum continuous ventilation fan (fan 7) in both barns. Selection of the TEOM's location was based on prior examination of PM distributions near the four minimum ventilation fans and the best representation of the exhaust air PM concentrations. Temperature (type-T thermocouple, Cole-Parmer, Vernon Hills, Ill.), RH (HMW60, Vaisala, Woburn, Mass.), and building static pressure (model 264, Setra Systems, Boxborough, Mass.) were measured at the middle of the house at 1 s intervals and reported as 30 s averages.

Instead of using a mobile air emission monitoring lab (trailer), all sampling lines, data acquisition, and instrumentation for this study were kept in an enclosure in the south end of H2. The enclosure was supplied with fresh air from the attic in a positive-pressure manner to minimize entrance of dust from the indoor air.

The building ventilation rate (VR) was determined based on *in situ* calibrated fan curves with fan assessment numeration systems (FANS) sized 0.9 m, 1.2 m, and 1.4 m (Gates et al., 2004). Individual fan curves were established for each stage (1 to 8) including operational ranges of the variable speed control of the lower stages twice each year. Fans at this site (new at commencement of the monitoring study) operated between 88% and 97% of their reported VR based on FANS calibration. Over the 19 months of monitoring, the VR decreased between 3% and 6%. The fan curves were adjusted after each semiannual calibration; however, no interpolation was made to the curves between calibrations because of these minimal drops in VR. The runtime of all stages of ventilation fans was recorded continuously with inductive current switches (Muhlbauer et al., 2011). Magnetic proximity sensors (MP1007, ZF Electronics, Pleasant, Prairie, Wisc.) were used to measure the fan speed (in rpm) of the variable-speed fans. Fan runtime and speed along with the corresponding building static pressure were recorded every second. These samples taken at 1 s intervals were averaged to 30 s values and reported to the on-site PC. Using the calibrated curves for each stage with the above data, an overall building VR was calculated. All data were collected with a data acquisition system (DAQ, Compact Fieldpoint, National Instruments, Austin, Tex.).

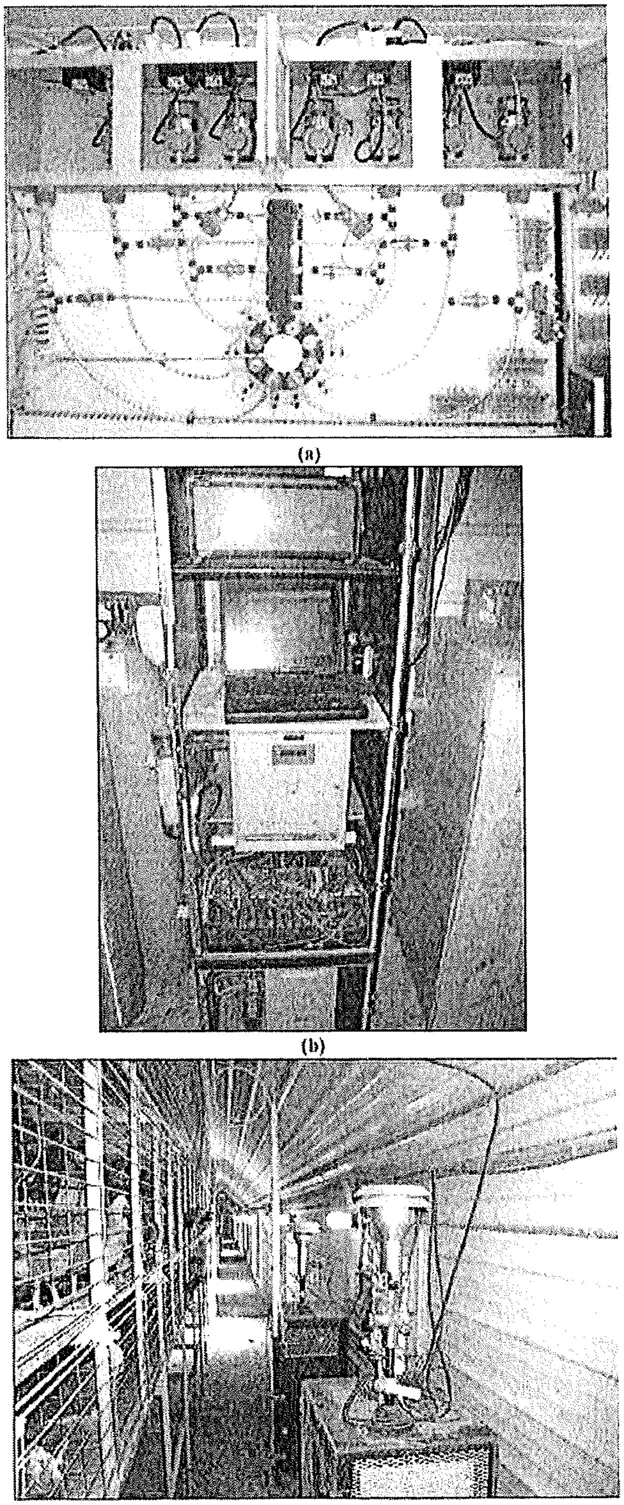

Figure 3. Gaseous and particulate matter (PM) concentration monitoring system: (a) positive-pressure gas sampling system, (b) gas analyzers, and (c) tapered element oscillation microbalance (TEOM) PM monitors.

CALCULATION OF GASEOUS AND PM EMISSIONS

With the measured gaseous or PM concentrations and building VR, the emission rate (ER) of the gas or PM from the houses to the atmosphere can be calculated according to equations 1 and 2. Daily emissions were summed from the 30 s dynamic emissions calculated over each 24 h period:

$$[\mathrm{ER}_G]_\tau = \sum_{e=1}^{2}[Q_e]_\tau\left([G]_e - \frac{\rho_e}{\rho_i}[G]_i\right) \times 10^{-6} \times \frac{w_m}{V_m} \times \frac{T_{std}}{T_a} \times \frac{P_a}{P_{std}} \quad (1)$$

$$[\mathrm{ER}_{\mathrm{PM}}]_\tau = \sum_{e=1}^{2}[Q_e]_\tau\left([\mathrm{PM}]_e - \frac{\rho_e}{\rho_i}[\mathrm{PM}]_i\right) \times 10^{-6} \times \frac{T_{std}}{T_a} \times \frac{P_a}{P_{std}} \quad (2)$$

where

$[\mathrm{ER}_G]_\tau$ = gaseous emission rate of the house at sample time τ (g house^{-1} t^{-1})

$[ER_{PM}]_\tau$ = PM emission rate of the house at sample time τ (g house^{-1} t^{-1})

$[Q_e]_\tau$ = building VR under field temperature and barometric pressure at sample time τ (m^3 house^{-1} t^{-1})

$[G]_i$ = gaseous concentration of incoming air (ppm$_v$)

$[G]_e$ = gaseous concentration of exhaust air at location e (ppm$_v$)

$[PM]_i$ = PM concentration of incoming air (μg m^{-3})

$[PM]_e$ = PM concentration of exhaust air at location e (μg m^{-3})

w_m = molar weight of the gas under consideration (g mole^{-1})

V_m = molar volume of gas under consideration at standard temperature and pressure (STP; 0°C and 1 atm) (0.022414 m^3 mole^{-1})

T_{std} = standard temperature (273.15 K)

T_a = absolúte house temperature, (°C + 273.15) K

P_{std} = standard barometric pressure (101.325 kPa)

P_a = atmospheric barometric pressure for the site elevation (kPa)

ρ_i, ρ_e = air density of incoming and exhaust air (kg dry air m^{-3} moist air).

For quality assurance, the site was visited each week. Temperature, RH, and pressure sensors were checked for reasonable values (e.g., comparing ambient dry-bulb temperature readings with local weather and inside temperature readings with the house controller's readings). If a sensor was suspected to be malfunctioning, it was checked against the reference or calibrated, as needed. Sampling pumps and valves were checked for flow or leakage and correct switching. All fans were checked for operational status, and sampling ports were checked for flow rate, with the in-line filters changed as needed. TEOM units were cleaned and restarted. The INNOVA analyzer was challenged to ensure readings of span gases as well as zero air were within a predetermined 5% of the expected values. More details on the standard operating procedures of site visits were described in the quality assurance project plan (QAPP) by Moody et al. (2008), and the current project followed the same QAPP. Section 7 of the QAPP (Moody et al., 2008) provides a table of the "sampling parameters and equipment quality control objectives" including sensor precision, quality control limits, and quality control testing timeline. This information is used in the error analysis to provide uncertainty values based on different scenarios. The calculations in the QAPP note that, with the standard operating procedures described, gaseous emission rate uncertainty is less than 10%. This 10% uncertainty also applies to PM when concentrations are 500 μg m^{-3}. Lower PM concentrations increase the uncertainty. The same types of measurement instruments and sensors as described in the QAPP were used in the current study.

Results and Discussion

In this study, the daily gaseous emission rates were considered valid for 358 and 349 days out of 546, yielding a 66% and 64% data completeness for NH_3, CO_2, and N_2O for H2 and H3, respectively. CH_4 emission rates were considered valid for 341 and 338 days out of 546, yielding a 62% and 61% data completeness for H2 and H3, respectively. Days were considered valid or complete if more than 75% of the potential 30 s averages were recorded and passed the data quality assurance check. Issues with instrument calibration, instrument malfunctioning, pump failures, power outage, and flock change accounted for the days of missing or incomplete data. The PM readings were taken for two consecutive days in each sampling interval (generally one week). A total of 56 days had both PM_{10} and $PM_{2.5}$ measurements for both houses.

Thermal Conditions and VR

Both houses (H2 and H3) held fairly constant temperatures during the winter months (fig. 4). The temperature setpoint of H2 was 1.7°C to 2.8°C lower than that of H3. The setpoint of H2 was increased in February, while the setpoint of H3 stepped up in December and again in February. RH in both houses was below 80% through most of the winter but consistently above 70%. In fall 2010 H2 had a new flock, and in fall of 2011 H3 had a new flock. VR tended to be higher in the early stage of the new flocks, as setpoint temperatures were lowered to stimulate feed intake. VR was generally between 0.6 and 11 m^3 h^{-1} bird^{-1} (fig. 4). As expected, there is a strong relationship between ambient temperature and VR (fig. 5), specifically:

$$\text{For } T_{amb} < 0.8°\text{C, VR} = 0.56\ (R^2 = 0.95) \tag{3}$$

$$\text{For } 0.8°\text{C} \le T_{amb} \le 29°\text{C, VR} = 0.008(T_{amb})^2 + 0.095(T_{amb}) + 0.478\ (R^2 = 0.91) \tag{4}$$

$$\text{For } T_{amb} > 29°\text{C, VR} = 11\ (R^2 = 0.92) \tag{5}$$

Indoor Air Quality

Ambient temperature influences VR, which in turn affects indoor gaseous concentrations. The daily mean NH_3 and CO_2 concentrations were highest in the coldest weather. The NH_3 concentrations continued to decrease with ambient temperature until the ambient temperature reached approximately 10°C, while CO_2 concentrations continued to drop until ambient temperature reached 20°C. The CH_4 concentration followed the opposite trend in that it increased with ambient temperature. Gaseous production from manure increases or remains relatively unchanged with increasing temperature (as can be seen later). However, the higher VR under warmer temperatures dilutes NH_3 and CO_2 concentrations, although the rate of CH_4 production increased more rapidly than VR (fig. 6). It is unclear to us why CH_4 emissions increased with VR. The N_2O data were excluded from the analysis and presentation due to the very low concentrations that were essentially below the detection limit of the instrument.

Diurnal trends were observed on many days. PM concentrations increased as lights were turned on, and increased again as birds were given access to the litter floor. A similar pattern was seen in CO_2 concentrations, presumably due to the increased activity level of the birds. However, NH_3 and other gaseous concentrations tended to drop

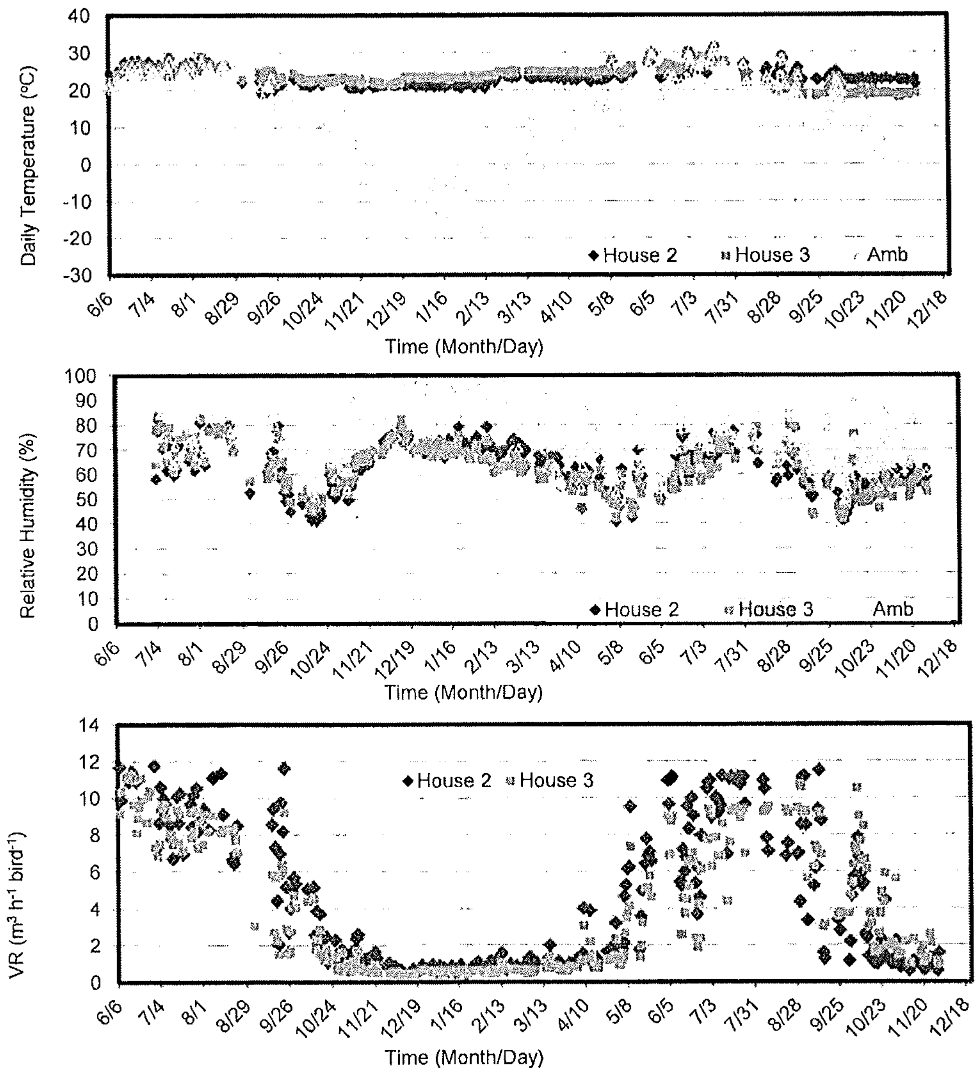

Figure 4. Daily mean ambient and indoor and temperature, ambient and indoor relative humidity, and ventilation rate (VR) of the two aviary houses monitored in 2010 and 2011.

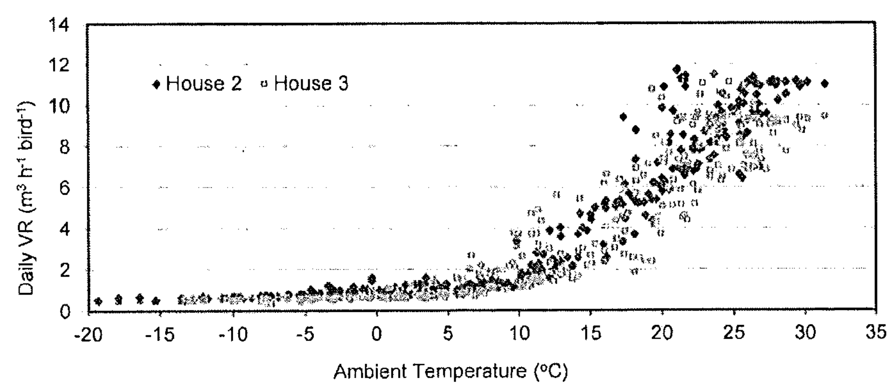

Figure 5. Relationship of daily mean building ventilation rate (VR) (m^3 h^{-1} $bird^{-1}$) vs. ambient temperature.

during the daylight hours, resulting from higher VR (fig. 7). These trends were most obvious in winter conditions when VR was fairly consistent and close to minimum over the entire day, but to a lesser extent in spring and fall. In summer, afternoon tended to have higher concentrations of all gases and PM. On these days, with the houses at maxi-

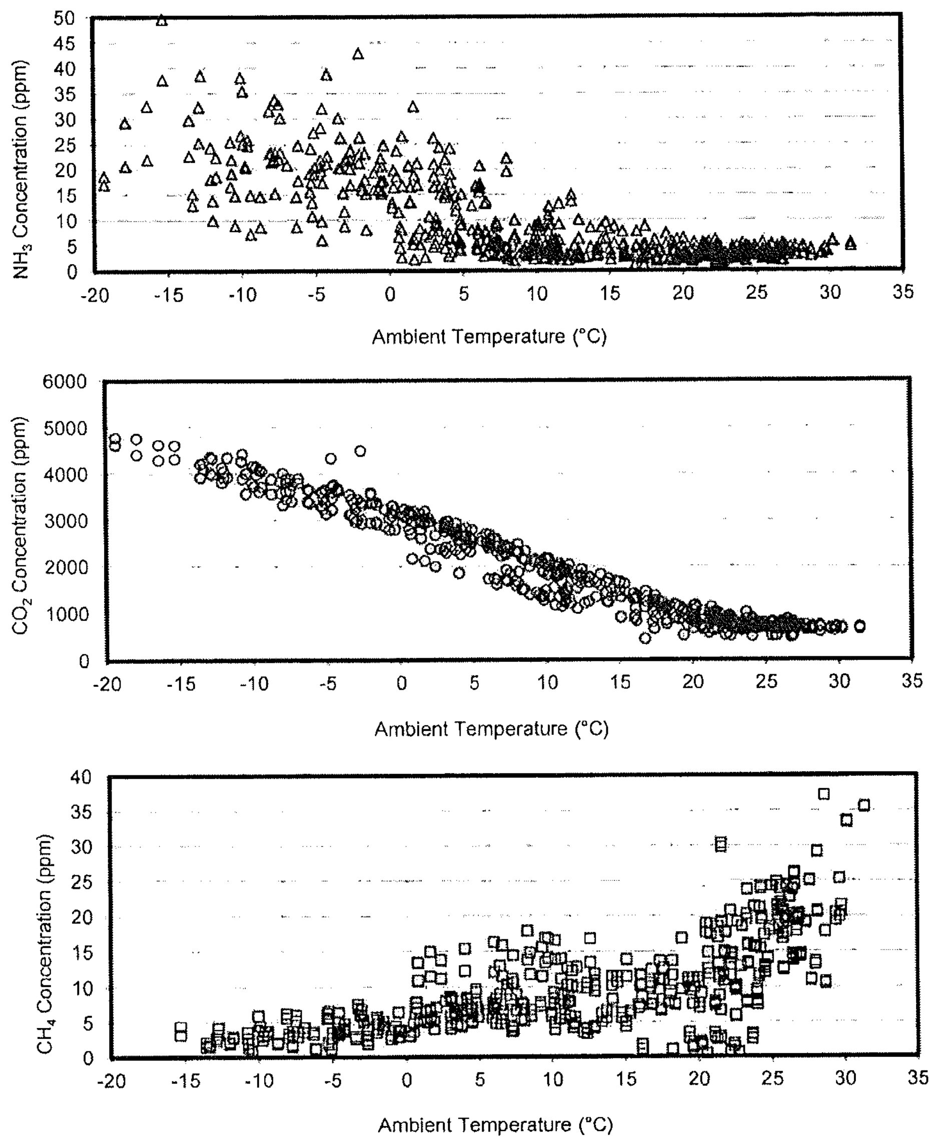

Figure 6. Relationship of daily mean gaseous concentrations (ppm) vs. ambient temperature.

mumVR, gaseous concentrations were observed to increase in the afternoon, presumably resulting from the combined effects of higher temperatures influencing thermoregulation of the birds (i.e., respiration, thus CO_2 production) and increased microbial activities within the manure.

Daily indoor gaseous and PM concentrations are important from the standpoint of both human and bird exposure. This site never exceeded the OSHA 8 h time-weighted average (TWA) CO_2 exposure limit of 10,000 ppm. The average daily NH_3 concentration exceeded 25 ppm on 24 days in H2 and on 11 days in H3, and on one day the NH_3 concentration in H2 was above the OSHA 8 h TWA exposure limit of 50 ppm. It is important to note that the unusually high NH_3 concentrations in H2 in December 2010 were due to a malfunction of the manure belt, which caused delay in manure removal. Overall average concentrations of gases during the 19 months were 8.7, 1636, and 10.0 ppm for NH_3, CO_2, and CH_4, respectively. As mentioned above, the N_2O concentrations were very low, with only a minimal number of values in an acceptable range (maximum concentration 0.45 ppm), and were therefore excluded from this presentation. The average PM_{10} and $PM_{2.5}$ concentrations during the 19 months were 2.3 and 0.25 mg m^{-3}, respectively. Although the TEOM units only ran two days per week, there were 8 days out of 153 monitored when PM_{10} concentrations were above 5 mg m^{-3}, the OSHA 8 h TWA exposure limit. Overall, H2 and H3 were not significantly different in either gas or PM concentrations. Figure 8 and table 2 summarize these data.

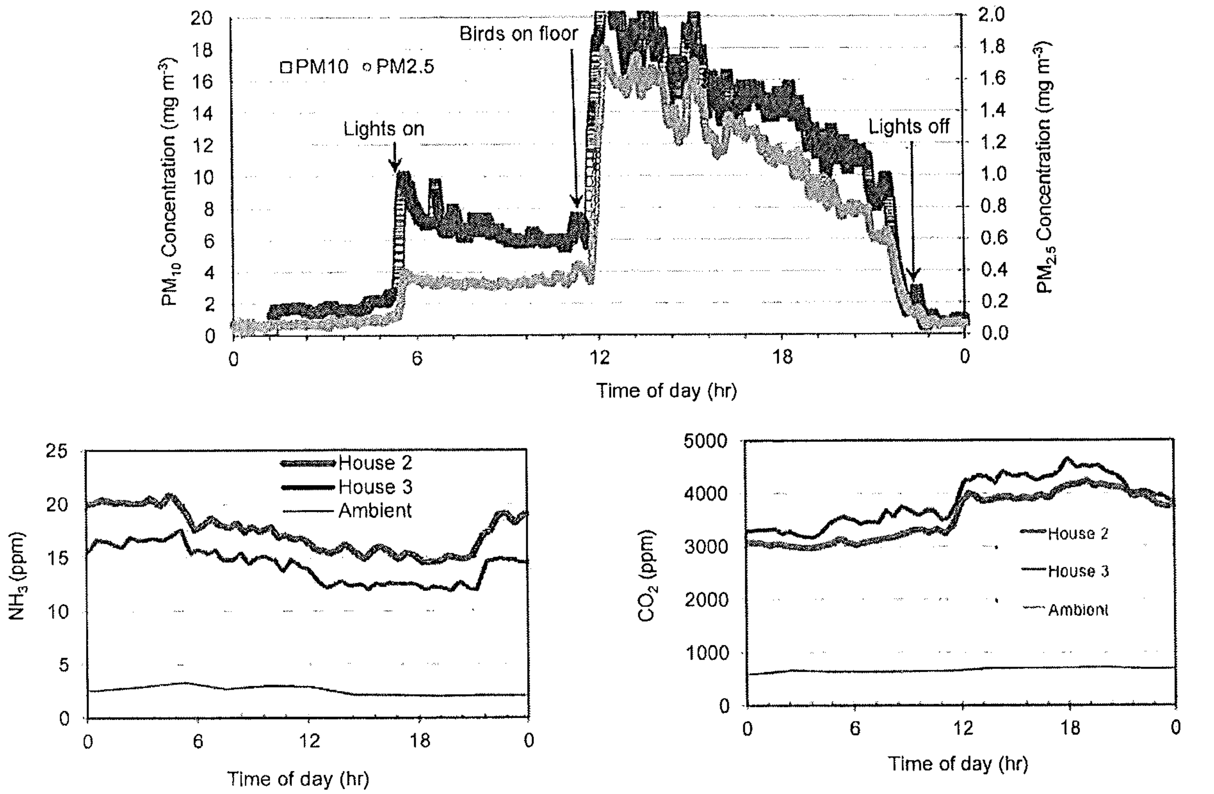

Figure 7. An example of winter diurnal patterns of PM and gaseous concentrations. The ambient temperature was -9.5°C and ventilation rate was at minimum (0.6 $m^3\ h^{-1}\ bird^{-1}$). Lights came on at 5:45 a.m.; birds were given floor access at 11:45 a.m., and lights were off at 9:45 p.m.

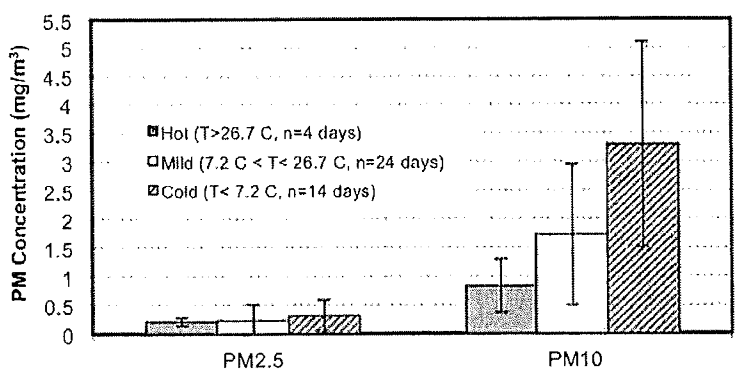

Figure 8. Daily particulate matter (PM) concentrations (mean and SD) for different ambient conditions: "hot" means temperatures >26.7°C, "mild" means temperatures of 7.2°C to 26.7°C, and "cold" means temperatures <7.2°C.

Table 2. Average daily concentrations [mean (SD)] in the two aviary houses (H2 and H3) and overall.

	Gas (ppm)			PM ($mg\ m^{-3}$)	
House	Ammonia	Carbon Dioxide	Methane	PM_{10}	$PM_{2.5}$
H2	9.0 (9.4)	1,853 (1,082)	10.1 (6.9)	2.1 (1.4)	0.24 (0.24)
H3	8.5 (7.4)	1,418 (956)	9.9 (6.7)	2.5 (1.9)	0.27 (0.28)
Overall	8.7 (8.4)	1,636 (1,022)	10.0 (6.8)	2.3 (1.6)	0.25 (0.26)

Gas and PM Emissions

The gas and PM emissions were calculated from equations 1 and 2 and are reported as quantity per house, per bird, per animal unit (AU = 500 kg live body mass), and per kg egg produced. The emissions are summarized as daily and annual amounts. The relationships of daily NH_3, CO_2, and CH_4 emissions vs. daily mean ambient temperature are presented in figure 9, whereas PM emissions are graphed based on three average daily ambient temperature ranges: hot conditions (days with ambient temperatures

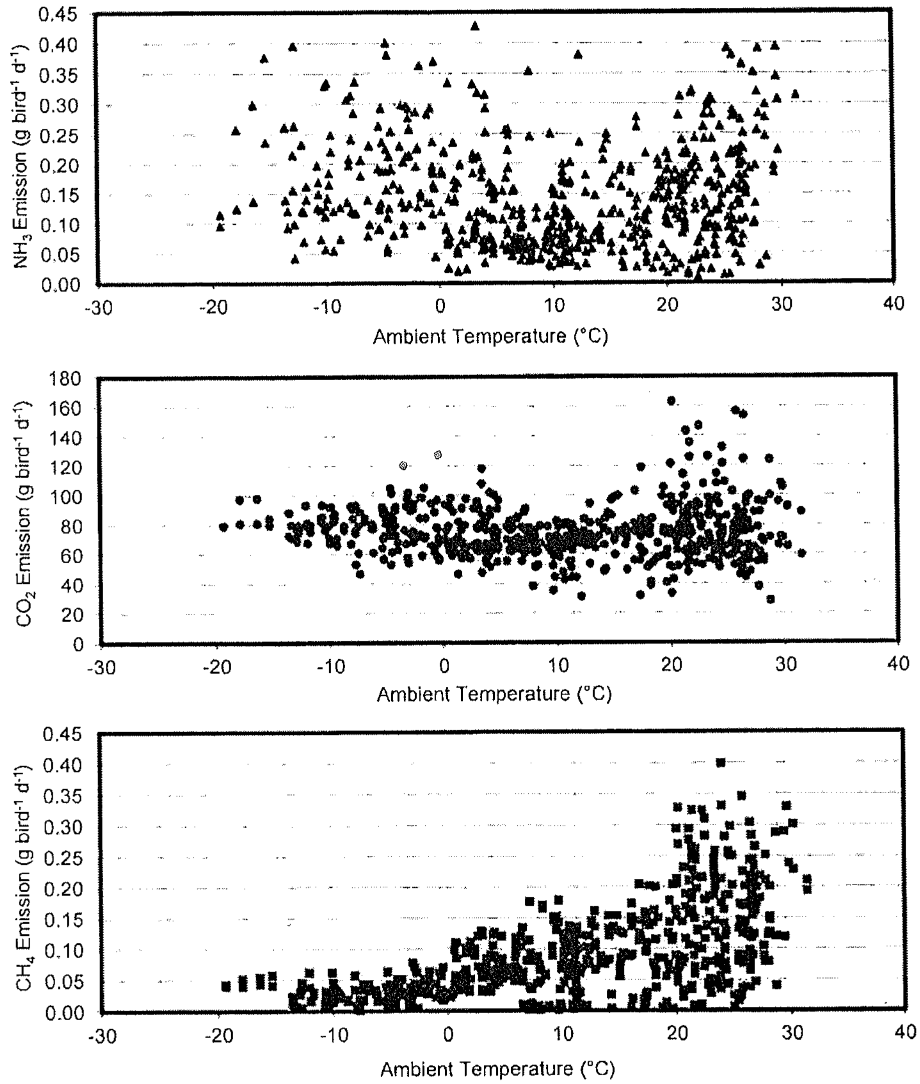

Figure 9. Relationship of daily emission rates of ammonia (NH_3), carbon dioxide (CO_2), and methane (CH_4) for both aviary hen houses vs. ambient temperature.

greater than 26.7°C), mild conditions (ambient temperature of 7.2°C to 26.7°C), and cold conditions (ambient temperature below 7.2°C) (fig. 10). As can be seen from the data in figure 9, NH_3 and CO_2 emissions showed no apparent trend of being influenced by ambient temperature. However, ambient temperature showed a positive influence on CH_4 emissions. Summaries of the average daily emission rates and annual emissions are listed in tables 3 and 4, respectively.

Overall, the results for gaseous concentrations and emissions observed in this study were within expectations. European studies revealed that ammonia concentrations in aviary housing were higher than that in manure-belt houses (Hörnig et al., 2001). Liang et al. (2003) reported that manure-belt cage hen houses in the Midwestern U.S. had NH_3 concentrations ranging from 1 to 7 ppm, while high-rise cage houses had concentrations ranging from 9 to 108 ppm at the exhaust (although the bird-level NH_3 concentrations were substantially lower, generally <25 ppm). With average NH_3 concentrations of 9 ppm, the aviary houses tended to have 2 to 8 ppm higher NH_3 concentrations than the manure-belt houses, which agreed with European findings. With the high concentrations on some winter days, it is important to use ammonia-protection masks or respirators. The study by Liang et al. (2003) also showed NH_3 emission rates of 0.05 to 0.1 g bird^{-1} d^{-1} (depending on the manure removal interval) for manure-belt cage houses and 0.95 g bird^{-1} d^{-1} for high-rise cage houses.

Ammonia emissions for the aviary houses averaged 0.15 g bird^{-1} d^{-1}, which is higher than the manure-belt system but significantly lower than the high-rise system. Two European studies demonstrated the range in NH_3 emission rates for cage-free barns as 0.27 to 0.85 g bird^{-1} d^{-1} (Groot Koerkamp et al., 1998; Müller et al., 2003). The emissions

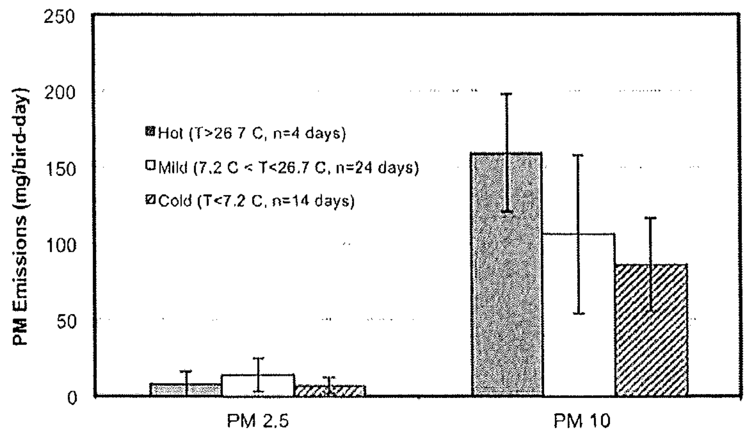

Figure 10. Daily PM emissions (mean and standard deviation) for different ambient temperature conditions: "hot" means temperatures >26.7°C, "mild" means temperatures of 7.2°C to 26.7°C, and "cold" means temperatures <7.2°C.

Table 3. Daily emission rates [mean (SD)] for the aviary hen houses (H2 and H3) monitored and overall values. Body weight of the Hy-Line brown hens averaged 1.76 kg in H2 and 1.78 kg in H3. Hen population averaged 48,250 in H2 and 47,600 in H3. AU = animal unit = 500 kg live body weight.

House	Emission Rate	Gases and Particulate Matter				
		Ammonia	Carbon Dioxide	Methane	PM_{10}	$PM_{2.5}$
H2	kg house^{-1} d^{-1}	7.9 (5.3)	3,776 (1,127)	5.4 (10.6)	3.9 (1.9)	0.24 (0.19)
	g bird^{-1} d^{-1}	0.16 (0.1)	83 (19)	0.10 (0.08)	0.08 (0.04)	0.005 (0.004)
	g AU^{-1} d^{-1}	45 (28)	23,580 (5,398)	28 (23)	23 (11)	1.4 (1.1)
	g kg^{-1} egg	3.4 (2.2)	1,738 (637)	2.5 (5.1)	1.8 (0.9)	0.10 (0.09)
H3	kg house^{-1} d^{-1}	6.2 (4.2)	3,065 (943)	4.1 (3.4)	6.2 (1.9)	0.48 (0.38)
	g bird^{-1} d^{-1}	0.13 (0.06)	67 (11)	0.08 (0.07)	0.13 (0.04)	0.011 (0.008)
	g AU^{-1} d^{-1}	37 (17)	19,034 (3,125)	23 (20)	37 (11)	2.8 (2.2)
	g kg^{-1} egg	3.1 (2.0)	1,513 (599)	2.0 (1.7)	3.1 (0.9)	0.21 (0.16)
Overall	kg house^{-1} d^{-1}	7.1 (4.8)	3,421 (1035)	4.8 (7.0)	5.1 (1.9)	0.36 (0.29)
	g bird^{-1} d^{-1}	0.15 (0.08)	75 (15)	0.09 (0.08)	0.11 (0.04)	0.008 (0.006)
	g AU^{-1} d^{-1}	41 (23)	21,307 (4,262)	25 (21)	29.5 (11)	2.1 (1.7)
	g kg^{-1} egg	3.3 (2.1)	1,626 (618)	2.3 (3.4)	2.5 (0.9)	0.16 (0.13)

Table 4. Annual emissions of the aviary hen houses. Body weight of the Hy-Line brown hens averaged 1.76 kg in H2 and 1.78 kg in H3. Hen population averaged 48,250 in H2 and 47,600 in H3. AU = animal unit = 500 kg live body weight.

House	Emission Unit	Gases and Particulate Matter				
		Ammonia	Carbon Dioxide	Methane	PM_{10}	$PM_{2.5}$
H2	kg house^{-1} year^{-1}	2,831	1,450,750	1,307	1,425	88
	g bird^{-1} year^{-1}	58	30,295	27	31	2
	kg AU^{-1} year^{-1}	16	8,606	8	9	0.6
H3	kg house^{-1} year^{-1}	2,464	1,250,163	1,130	2,262	175
	g bird^{-1} year^{-1}	52	26,436	24	46	4
	kg AU^{-1} year^{-1}	15	7,426	7	13	1.1
Overall	kg house^{-1} year^{-1}	2,647	1,350,456	1,219	1,844	132
	g bird^{-1} year^{-1}	55	28,366	26	39	3
	kg AU^{-1} year^{-1}	15	8,016	7.5	11	0.85

observed in this study were quite a bit lower. Many of the cage-free barns in Europe do not have a method of housing birds in tiered colonies where manure is collected and removed frequently, which would affect the litter amount and properties. For CO_2, the average emission rate of 75 g bird^{-1} d^{-1} is in line with reported values from manure-belt systems (70 to 85 g bird^{-1} d^{-1}) (Liang et al., 2003; Neser et al., 1997). For CH_4, the literature suggests a manure-belt system emitting between 0.08 and 0.13 g bird^{-1} d^{-1} (Groot Koerkamp et al., 1997; Monteny et al., 2001; Fabbri et al., 2007; Wathes et al., 1997). The value of 0.09 g bird^{-1} d^{-1} from the current study fell within this range. Overall, this aviary system has emission rates that relate well to a manure-belt cage house, with the exception of NH_3 emission being slightly higher.

The major difference between the aviary system and manure-belt or high-rise systems lies in the PM emissions. The literature on conventional laying-hen housing reports $PM_{2.5}$ emissions of 0.0036 to 0.014 g bird^{-1} d^{-1} (Li et al., 2011), while the current study with aviary housing averages 0.008 g bird^{-1} d^{-1}. For PM_{10}, the reported literature emission values range from 0.019 to 0.048 g bird^{-1} d^{-1} (Li et al., 2011), while this study averages 0.105 g bird^{-1} d^{-1}. The PM_{10} emissions from our study were considerably higher than those reported in the literature; however, this system had a litter floor area. A European study reported on a group of cage-free barns having a PM_{10} emission rate of 0.05 g bird^{-1} d^{-1}, with the highest value being 0.07 g bird^{-1}

d^{-1} (Takai et al., 1998). While the average in the European study was above the range of conventional housing emissions, it was well below the value found in the current study. Li et al. (2011) noted that data from conventional barns in Europe, including the Takai et al. (1998) study, were lower than similar studies in the U.S. Management of the litter (e.g., moisture content) and environmental conditions (house RH and ventilation) presumably contributed to the differences in the PM_{10} emissions.

As was mentioned above, H2 tended to have higher gaseous emissions, but PM emissions followed the opposite trend. The setpoint temperature in H2 was a few degrees lower than in H3, which led to somewhat higher VR for H2. Litter moisture content (MC) was measured monthly and was found to be slightly higher in H2 (14.4%) than in H3 (12.2%).

Overall, this aviary site ran quite well through the winter in terms of indoor air quality. There were a few days with NH_3 concentrations above the recommended 25 ppm level. RH was somewhat high on these days. A slightly higher minimum VR would have improved the situation. Gaseous emissions from the site were as expected. However, the dust concentration and emissions were quite high, emphasizing the importance of personal protection (wearing dust masks), and practical means to reduce dust generations in such housing systems should be explored.

Summary and Conclusions

Concentrations and emissions of NH_3, CO_2, CH_4, PM_{10}, and $PM_{2.5}$ for two aviary hen houses in Iowa were continually monitored for 19 consecutive months, covering two flocks from 17 to 80 weeks of age. The following observations and conclusions were made:

- Daily indoor NH_3, CO_2, CH_4, PM_{10}, and $PM_{2.5}$ concentrations (mean ±SD) were 8.7 (±8.4) ppm, 1,636 (±1,022) ppm, 10.0 (±6.8) ppm, 2.3 (±1.6) mg m^{-3}, and 0.25 (±0.26) mg m^{-3}, respectively. Concentrations of all the aerial constituents were highest at the coldest ambient conditions, except for CH_4, which increased with ambient temperature.
- Daily NH_3, CO_2, CH_4, PM_{10}, and $PM_{2.5}$ emissions (mean ±SD) were 0.15 (±0.08), 75 (±15), 0.09 (±0.08), 0.11 (±0.04), and 0.008 (±0.006) g $bird^{-1}$ d^{-1}, respectively. NH_3, CO_2, and $PM_{2.5}$ emissions were rather independent of ambient temperature, whereas CH_4 and PM_{10} emissions tended to increase with increasing ambient temperature.
- Annual gaseous and PM emissions ($bird^{-1}$ $year^{-1}$) were 55 g NH_3, 28.4 kg CO_2, 26 g CH_4, 39 g PM_{10}, and 3 g $PM_{2.5}$.

Overall, this aviary system has emission rates that relate well to a manure-belt cage house, with the exception of NH_3 being slightly higher. However, the NH_3 emissions were lower than those reported for European layer houses.

Acknowledgements

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APPENDIX C

Uncontrolled VOC Emission Factor Reference

FINAL REPORT: Quantification of Gaseous Emissions from California Broiler Production Houses

May 6, 2005

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Abstract

Methods and equipment were developed to analyze emissions from a broiler production house utilizing standard source test methods. A test stack was designed and fabricated to meet engineering testing criteria for fan exhaust air from a broiler production facility. Emissions of ammonia and organic gasses were measured periodically during the 55 day poultry production cycle including 45 days of production and 10 days between broods. Several methods were used for analysis of organic gasses and it was found that a gas chromatography/mass spectrometry analysis from samples collected in evacuated summa canisters was more useful than hydrocarbon methods for the low concentrations and complex gas mixtures encountered. An emissions factor of 0.0143 lb $bird^{-1}$ raised for ammonia and 0.0061 lb $bird^{-1}$ raised for total organic gasses is estimated. Several compounds (including acetone, dimethyl disulfide, ethanol, methanol, propane, and vinyl acetate) dominate the mass of organic gasses emitted from the house according to the mass spectrometer analysis. These may be from distinct sources within the house. The estimated emissions factor for reactive organic gasses (organic compounds with ozone forming reactivity) is 0.0037 lb $bird^{-1}$ raised.

Introduction

California has significant particulate matter and ozone air quality problems. To help solve these problems, it is necessary to estimate the emissions of air pollutants for all major industries. In the past, the livestock industry was not considered an important emissions source from an air quality perspective. To meet regulatory and public policy needs, a better understanding of livestock emissions is needed. The objective of this study was to estimate the gaseous emissions from a broiler production facility during the broiler growth cycle and develop emissions factors per bird of production.

Airborne emissions from broiler production facilities have been quantified in other studies. Ammonia emissions have received the greatest amount of attention and several researchers have quantified emissions from broiler production houses. Casey et al. (2003) reported ammonia emissions from eight broiler houses in Kentucky during the winter months ranging from 0.10 – 0.98 g day^{-1} $bird^{-1}$ for birds from 11 to 56 days old. They found that emission rate increased with bird age but appeared to be a relatively constant function of bird weight with an average emissions rate of 163±56 g day^{-1} 500 kg^{-1} live weight. The high degree of variability was attributed to different litter handling and other management practices. Lacey et al. (2003) reported ammonia emissions ranging from 0.05 – 1.90 g day^{-1} $bird^{-1}$ with an average of 0.63 g day^{-1} $bird^{-1}$ for broilers raised in central Texas over a 49 day growth cycle. The average cycle emissions were estimated as 31 g $bird^{-1}$ raised. This study found that ammonia emissions were approximately linear with live weight of birds with an average emissions rate of about 300 g day^{-1} 500 kg^{-1} live weight. This was found to be higher than reported emissions from several European studies (Wathes et al., 1997; Groot Koerkamp et al., 1998; Demmers et al., 1999; Hyde et al., 2003) but in the same order of magnitude. Climate, litter management, feed, bird weight, stocking density and measurement methodology all may contribute to differences.

Quantification of volatile organic compounds from broiler houses has received minimal attention from the research community. It has been reported that animals and their waste can emit over 130 organic compounds (O'Niell and Phillips, 1992) although an abbreviated number of these may only be important when considering mass emissions (Hobbs, 2001). Gas chromatography/ mass spectrometry (GCMS) has been used to identify odor compounds related to malodor in poultry manure (Yasuhara, 1987). These malodor compounds have very low detectable threshold for human beings with some even below the detectable limits of test equipment. A recent odor study (Chang and Chen, 2003) collected samples on sorbent tubes and analyzed them using GCMS to identify compounds from broilers produced in laboratory chambers. They tentatively identified compounds with the greatest response to include ethanol, dimethyl disulfide, 2-propanone, 2-propanal, 2-butanone, and benzene with a total of 24 distinct GCMS peaks. In another study (Hobbs et al., 1995) the headspace concentrations of compounds above manure was measured. They found that dimethyl sulfides (primarily dimethyl disulfide) were highest in poultry manure, but found relatively little of the C2 to C9 organic acids found in pig and cattle manure.

Directly emitted particulate matter emissions are also a concern from poultry production houses. Particulate matter primarily originates from litter, feed, skin and feathers that can become airborne induced by animal and air movement within the poultry facility (Grubb et al. 1965). Total suspended particulate matter (TSP) and particles with diameter less that 10 μm (PM_{10}) have been measured for tunnel-ventilated broiler facilities in Texas. Using TSP and particle size distribution samplers, a resulting emissions factor of 1.3 g PM_{10} $bird^{-1}$ of production (0.0029 lb PM_{10} $bird^{-1}$) was determined (Lacey et al. 2003). The authors compared these results to two European studies (Wathes et al., 1997; Takai et al, 1998) and found that their results were somewhat higher for TSP but the PM_{10} results were comparable with respirable particulate matter measured in the other studies. These authors speculate that the differences may be due to conditions and the sampling methodologies and technology employed. Because of the complexities of sampling particulate matter, the current study was unable to generate PM_{10} emission factors. Problems were encountered with obtaining sufficient sample for quantification using standard equipment. There are also potential problems with feathers coating equipment and collecting dust that need to be addressed.

Materials and Methods

The project approach was to perform emission tests at actively producing, mechanically-ventilated broiler houses with environmental climate controls. The majority of California broiler chickens are raised in these conditions, so the testing performed can be used to directly characterize emissions for the bulk of the industry. Also, using this type of facility simplifies the testing and analysis because of the precise control of airflow within the house. Testing can be performed under representative conditions with respect to the cycles of broiler production, animal density, animal age and size, waste handling, bedding material, litter treatments, design of poultry houses, and the diet and genetics of the animals. Testing can be performed during multiple stages of the broiler growth cycle in order to capture the emission potentials from a typical production cycle.

A typical mechanically ventilated poultry house is designed to provide optimal environmental conditions for the animal growth. Outside air is pulled through the house and expelled through a series of fans on the sides of the house to control the environment. During warm months when the broilers are 4 to 7 weeks old, air is pulled through a series of evaporative cooling pads at one end of the house and expelled through fans at the opposite end of the house (known as "tunnel" ventilation). When the broilers are young or the exterior temperatures are low, air is pulled through a series of controlled openings in the sidewalls near the roof of the house and the evaporative cooling pads are covered with curtains. During early brooding, heat must be added using heaters (propane is typical) to maintain house temperature with minimum ventilation rates to maintain sufficient moisture removal and indoor air quality. A control system monitors house temperature and regulates ventilation in response to age related, preset temperature requirements of the birds. Temperature, humidity, ventilation level, static pressure and heater status are recorded for each house.

The layout of the broiler house and ventilation system is given in Figure 1. It houses 21,000 broilers and has dimensions of 48 ft by 320 ft. The ventilations system consists of 10 fans: two 36" fans at 1/3 and 2/3 the length of the house, and a series of eight 48" fans at the end of the house opposite the evaporative cooler pads (fans are numbered as shown). The fans are constant speed with the 36" fans rated at 8,000 CFM and the 48" fans at 18,300 CFM. Ventilation rate is controlled by the number of fans operating or during early brooding by intermittent operation of one fan on a 5-minute cycle. The house is always ventilated and there are a total of 17 ventilation levels. The lowest level is operation of fan #10 for 10% of a cycle (~1,830 CFM) to the highest level with all fans operating 100% of the cycle (~146,400 CFM). After Day 28 of the growth cycle, at least some of the fans are in continuous operation all day during the spring, summer and fall, and in the afternoons in winter. Fan #10 is used in all of the ventilation modes.

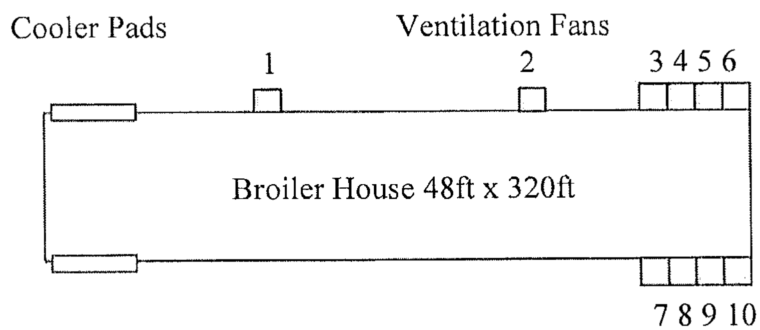

Figure 1. Components of ventilation system for mechanically-ventilated poultry house. Fans are numbered 1-10.

In order to measure airflow and concentration during a sampling cycle, a test "stack" or duct was added to the outlet of fan #10 to insure a stabilized airflow at the test equipment insertion point (Figure 2). The use of a duct is standard engineering protocol for most vent exhaust source testing methods. Airflow can be measured in the duct by performing a double transect across the diameter of the duct. A 48" diameter test duct was constructed with straightening vanes and test ports located 5 times the fan diameter from the fan with an additional 2 diameters to the opening. Pictures of the actual testing setup are given in Appendix B.

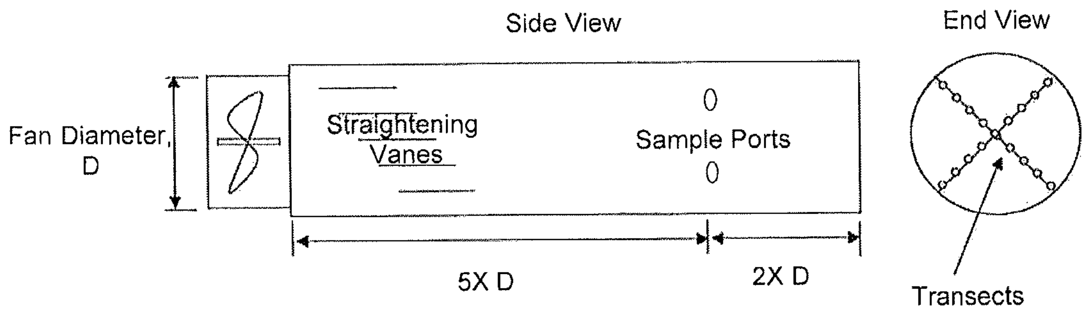

Figure 2. Schematic of test duct (not to scale) at fan outlet for insuring stabilized flow during concentration sampling. Transects of the stack are made to determine total stack airflow.

The typical daily ventilation cycle is important to consider for determining when air samples should be taken from the facility. If the ventilation levels are changing rapidly, it may be difficult to get an accurate measure of emissions because both the airflow and concentration will be changing rapidly. The ventilation system responds to outside heating load so spring, summer and fall ventilation levels increase rapidly during the morning hours from 8:00 to 12:00 and decrease rapidly from 19:00 to 23:00 in the evening. During testing the control system was set to a constant ventilation rate to control this characteristic. The house was allowed to equilibrate for several air exchanges before sampling.

Two sampling campaigns were performed, one during the late spring of 2004 and one during the fall of 2004. The first round of sampling focused on ammonia and screening level volatile organic gas evaluation using hydrocarbon methods. The second round of sampling focused on collecting more refined organic gas information. To minimize some of the environmental variables, both sample sets were performed at the same chicken house and testing was scheduled so the sampling was performed on second-run litter for both tests. The set point temperature for the house is controlled based on animal age and was similar over both tests, but ventilation rates were higher during the late spring tests due to high outdoor temperatures and the need for cooling ventilation. Propane heaters were operating to maintain house temperature during several of the sampling runs during the fall campaign. Important parameters for the broiler production house during the test sampling are given in Table 1.

Table 1. Summary of production conditions during both sampling campaigns.

House size	48' x 320'
Number of birds	~21,000
Growth cycle	45 days, 10 days between flocks
Bedding material	rice hulls
Feed	5 formulated feeds depending on bird age
Temperature	adjusted with bird age
Minimum ventilation	adjusted with bird age
Litter	second run, full removal typical after 3rd flock
Litter conditioning	floor conditioning each cycle with bedding replacement at front 1/3 of house

A goal of the project was to account for temporal differences in emissions from broiler operations as the chickens grow in size, feed intake and excretions. In California, a typical growth cycle for broiler chickens takes 45 days from the time newborn chicks enter the house to harvest. Air samples were collected and emissions evaluated several days before chicks were introduced to the house to quantify emissions from second-run litter only (called day 0). Emissions measurements were repeated on approximately the 10^{th}, 20^{th}, 30^{th}, and 40^{th} day of bird age.

Analytical Methodology

In order to determine the emissions rate of gaseous compounds from the poultry house, two elements are needed, airflow and concentration enrichment. Since ambient air may also contain pollutants, concentration measurement may be needed in inlet (ambient) and outlet (stack). This allows determination of the pollutant enrichment generated by the interior environment of the house (Figure 3). Air is sampled and concentration is determined at the ambient (C_A) and stack (C_B) locations and the difference is taken to determine enrichment. In addition, two different fan operation scenarios may exist. In the first, only the stack fan is operating and all air flows through the stack (Figure 3a). During some test runs, other fans are running because additional ventilation was needed to maintain the environment for the birds in the house (Figure 3b). To account for this additional airflow, each fan must be calibrated in relationship to the test fan. With this calibration, a ventilation level factor (VLF) can be determined for each fan configuration. The VLF is multiplied by the flow measured in the stack fan ($Flow_B$) to determine the total house flow. House emissions are determined by the following formula:

$$Emissions = (C_B - C_A) \times (Flow_B \times VLF) \quad (1)$$

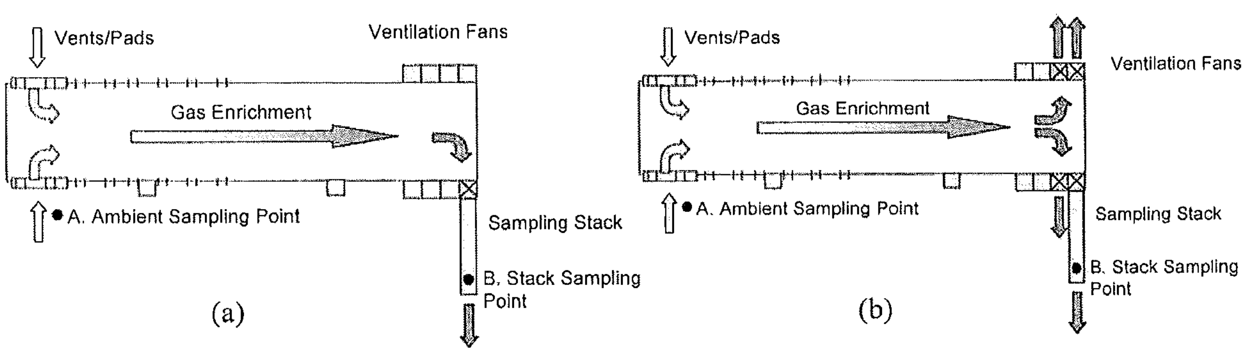

Figure 3. Schematic illustration of gas emissions enrichment from a mechanically ventilated broiler house measured with (a) only the stack fan operating, and (b) multiple fans operating.

The implicit assumption in this approach is that the concentration is the same at each fan. This assumption is reasonable because all fans are co-located at the opposite end of the house from the primary air inlets. A summary of the test methods used for flow and gas concentration is given in Table 2 and each is discussed below.

Table 2. Summary of source test methods used for flow and gaseous emissions measurement.

Measurement	*Method*	*Description*
Stack Airflow	CARB 2, CARB 4	12 point traverse of stack airspeed, temperature and humidity
Ammonia	BAAQMD Method	60 minute sample through impinger train of 0.1N HCl
Hydrocarbons	EPA Method 25A	60 minute continuous measurement with on-site FID
Hydrocarbons	EPA Method 18	Tedlar© bag collection, GC-FID for C1–C6+ compounds
Organic Gasses	EPA Method TO-15	Summa canister collection, GC-MS for 68 polar/non-polar target compounds with non-specific library search for other compounds reported relative to internal standard

Airflow Measurement

The airflow in the test stack was determined during each sampling run by using an "S" type pitot tube connected to an inclined manometer. A 12 point traverse through two ports provided average velocity and the air volumetric flow rate was determined using California Air Resources Board (CARB) Method 2. The stack temperature was determined by using a thermocouple and an indicating pyrometer. The proportion of water was determined using the wet-bulb/dry-bulb method and the dry molecular weight of the stack gas determined by CARB Method 4.

To account for this additional airflow, each fan was calibrated in relationship to the test fan with an empty house prior to the broiler cycle. The procedure used was to turn on all of the fans, set the static pressure at a high value (0.10), and measure the airflow by hand at 8 points on each fan. The procedure was repeated a low static pressure (0.05). Both a vane type and hot wire anemometer were used and gave consistent relative results. This is an abbreviated manual version of a procedure developed for quantifying absolute airflow for poultry fans (Gates et al., 2002). Since we are only interested in relative airflow we reduced the number of grid points. The relative airflow did not appear to be impacted by static pressure and the other 48 inch fans were 5-10% greater airflow than the stack fan (presumably because of the additional resistance of the stack). For the 36 inch fans the relative flow was adjusted for both the flow and the area difference of the fan.

Ammonia

Ammonia concentrations were determined according to Bay Area Air Quality Management District (BAAQMD) Method ST-1B. The exhaust gases were extracted through an impinger train containing 0.1N HCl. For each sampling run, two samples were collected at a constant rate of 0.75 cfm for approximately sixty (60) minutes. The samples were recovered in the field, placed on ice, and returned to the laboratory for analysis. The samples were sent to Calscience Environmental Laboratories for analysis. The results are reported from the laboratory as mg NH_3 sample^{-1} and converted into ppmv using the flow and sample collection period.

Organic Gasses – Hydrocarbon Methods

Two screening level hydrocarbon analyses were performed during the spring 2004 sampling campaign. Continuous total hydrocarbon (THC) monitoring was performed in the stack and in the ambient air near the air intake vents at the front of the house in accordance with EPA Method 25A. The THC samples at the outlet and in the ambient air were extracted and delivered to the analyzers through a heated Teflon line. All sampling components were stainless steel or Teflon. Calibrations were performed before and after each test-run with zero gas and propane span gas. The outlet and ambient air THC concentrations were measured utilizing a California Instruments Model 300H FID (flame ionization detection) hydrocarbon analyzer. All THC data was continuously recorded on a Linseis chart recorder. Instrument data was recorded every one (1) minute, using a data-logger, and corrected for analyzer calibration drifts with spreadsheets. The method detection limit for the THC testing is 0.5 ppmv as propane.

Calibrations for the THC tests were performed with propane calibration standards. All pre and post span calibrations were performed with EPA protocol 1 gases, directly from the bottles. Initial multipoint calibrations were performed on the FID with three (3) levels of span gas and a zero gas to demonstrate linearity throughout the measurement range. Initial calibrations and the multipoint calibrations were performed at the analyzer sample inlet. Subsequent calibrations were performed through the probe tip of the sample system, (Bias calibrations). Bias calibrations were performed before and after each test-run. The initial bias checks agreed with the pretest instrument calibrations to within 3%.

Hydrocarbons were also quantified using EPA Method 18. During the sampling run, a Tedlar bag exhaust sample was collected from the outlet of the exhaust stack. An ambient sample was also collected. The bags were stored in a dark container and transported to the laboratory for low level hydrocarbon analysis (C1–C6+ compounds) by gas chromatography utilizing a flame ionization detection system. AIRx Testing, in Ventura, California, performed the analysis. Reactive hydrocarbon concentrations are estimated by taking the sum of all detected hydrocarbons and subtracting the estimated methane (C1) and ethane (C2) contents. The minimum quantification limit for this method is 0.3 ppmv for each hydrocarbon class.

Organic Gasses – Gas Specific GCMS Method

During both the spring and fall sampling campaigns, samples were taken and analyzed for specific gas composition using EPA Method TO-15, a gas chromatograph/mass spectrometer (GCMS) method. This method was chosen because it offered low levels of detection (ppbv range) for 69 specific target compounds and the opportunity to tentatively identify and estimate other organic compounds in the samples. This method is also commonly specified for indoor air quality testing where the gas profile is unknown. The sampling train is specified to allow detection of both polar and non-polar compounds. The target species list includes alcohols and ketones that may be expected from a biological source.

Samples were collected using sanitized, evacuated summa canisters and submitted to Atmospheric Analysis & Consulting for analysis by EPA Method TO-15. The results are reported in units of ppbv. The laboratory also performed a non-target compound library search to tentatively identify other compounds present in the canister sample. The confidence level in the identification was computed along with the total area of the peak. This area was compared with the internal calibration to estimate the concentration of the tentatively identified compound in ppbv.

Quality Assurance/ Quality Control

All samples were taken following the aforementioned standard procedures by a licensed emissions testing firm (AirX Testing) that operates within the San Joaquin Valley Unified Air Pollution Control District. Standard sample handling and record keeping practices were maintained for all samples collected during the two sampling campaigns. Fan operations data was recorded by the house control system and verified in the field at the time of sampling. Complete reports including all measurements, calibrations and laboratory analysis were generated by AirX Testing and a list of these reports is contained in Appendix C. As an additional assurance, the California Air Resources Board, Monitoring and Laboratory Division performed a review of the field collection and laboratory practices used during the second sampling run for volatile organic gasses. This review is included in Appendix D.

Results and Discussion

The measured concentrations of ammonia in the test stack during the testing are shown in Table 3. Ammonia results showed an increase in ammonia emissions with broiler age ranging from 0.48×10^{-4} lb day^{-1} $bird^{-1}$ (0.02 g day^{-1} $bird^{-1}$) on day 17 to 10.9×10^{-4} lb day^{-1} $bird^{-1}$ (0.49 g day^{-1} $bird^{-1}$) on day 43. This is in a reasonably consistent but somewhat lower than the range reported in other recent studies on broiler emissions of ammonia in the United States mentioned above (Casey et. al., 2003; Lacey et. al., 2003).

Table 3. Concentration and flow data for ammonia during spring sampling campaign.

Bird Age (days)	Date	Time	Ammonia Conc. (ppmv)	House Flow (dscfm)	House Emissions (lb/hr)
0 (litter)	4/26	11:28	5.9	15,743	0.25
0 (litter)	4/26	12:00	6.3	15,907	0.27
0 (litter)	4/26	13:37	6.5	16,070	0.28
18	5/17	10:23	0.8	18,098	0.04
18	5/17	13:03	0.7	29,071	0.06
28	5/27	6:15	2.2	27,464	0.16
28	5/27	8:32	1.6	43,739	0.19
28	5/27	11:05	0.8	65,394	0.14
28	5/27	13:00	0.4	104,591	0.12
42	6/11	6:00	3.4	67,394	0.61
42	6/11	11:08	2.5	131,269	0.90
42	6/11	13:10	2.4	128,910	0.82

The amount of ammonia emission appears to correlate to the size and amount of excretion of the broilers as discussed above. An exponential expression is used to fit this growth related phenomenon. Figure 4 shows the emissions rate per animal relative to age along with the equations for the best fit. Integrating under the exponential curve gives a cycle emission of 0.0112 lb $bird^{-1}$ (5.1 g $bird^{-1}$) during the growth cycle. Ammonia emissions from the litter continue after the birds are removed until the litter is either dried during house heating for the next broiler cycle or when the litter is cleaned and removed from the house. Using the day 0 data, the estimated daily emissions for the second run litter tested before the birds were placed was 3.13×10^{-4} lb day^{-1} $bird^{-1}$ (0.14 g day^{-1} $bird^{-1}$) giving an estimated 55 day production cycle ammonia emissions of 0.0143 lb $bird^{-1}$ (6.5 g $bird^{-1}$). This is lower than the 31 g $bird^{-1}$ reported by Lacey et al. (2003) for broiler houses in Texas, but these authors found that their results were higher than several European studies of poultry emissions. Differences may be attributable to cycle length, litter management, feed, climate and other process factors along with differences in methodology. As noted by the National Research Council (NRC, 2003), further work is needed to determine how these process factors affect emissions.

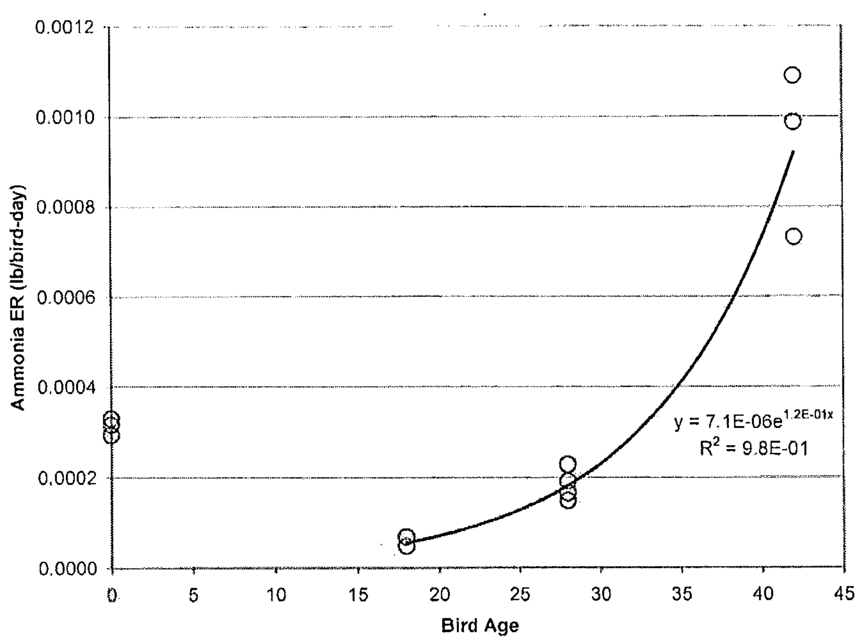

Figure 4. Ammonia emissions rate as a function of bird age for with exponential curve fit. Note that day 0 data represents emissions between cycles before litter is dried during initial house heating, not included in fit.

The results of the hydrocarbon analyses from the spring sampling run are shown in Table 4. All concentrations measured were near the minimum quantification limit of the method. For EPA Method 25A, the stack results were typically somewhat larger than the ambient for most sampling runs. For EPA Method 25A, the C1 (methane) response was detected for all samples but was often greater in the ambient air than in the stack air. One conclusion would be that methane emissions do not appear to be significant for poultry production. A C4 response was present in both the stack and ambient on the day 0 (litter only) sampling run and a C2 response in both on the day 18 sampling run. For all other compounds and runs the response was non-detect above the minimum quantification limit for the method of 0.3 ppmv.

Table 4. Concentration and flow data for hydrocarbons during spring sampling campaign.

				Method>	EPA25A THC	EPA18* C1	C2	C4
				CalGas>	Propane	Methane	Ethane	Butane
BirdAge (days)	Date	Time	House Flow (dscfm)	MQL>	0.5 (ppmv)	0.3 (ppmv)	0.3 (ppmv)	0.3 (ppmv)
0 (litter)	4/26	12:15	15,743	Stack	*NS*	2.4		0.6
				Ambient	*NS*	3.6		2.0
0 (litter)	4/26	14:15	16,070	Stack	2.0	2.2		2.3
				Ambient	2.0	4.1		1.9
18	5/17	12:00	18,098	Stack	4.6	2.1	1.0	
				Ambient	2.0	2.1	0.4	
18	5/17	13:30	29,071	Stack	4.8	1.6	0.4	
				Ambient	1.2	2.0	0.6	
28	5/27	6:40	27,464	Stack	1.7	2.3		
				Ambient	1.3	1.7		
28	5/27	8:32	43,739	Stack	1.7	2.0		
				Ambient	1.3	2.9		
43	6/11	10:00	67,394	Stack	1.4	2.8		
				Ambient	1.1	4.3		
43	6/11	14:00	128,910	Stack	0.6	2.5		
				Ambient	1.3	3.0		

*Non-detect is indicated by blank space. C3, C5, C6, C6+ compounds were not detected (MQL = 0.3 ppmv) for all sampling runs and are not shown.
MQL = Minimum quantification limit
NS = Not sampled during this run

An estimate of total organic gas emissions was made based on this screening analysis by subtracting the ambient concentration from the stack concentration and using the house flow and mass properties of the calibration gas to estimate emissions. Figure 5 shows the results for house emissions. The trend between the EPA Method 25A and EPA Method 18 appears to correspond somewhat, but Method 18 shows negative emissions because of greater response in the ambient air than the stack air. This phenomenon is difficult to explain, but the low level of detection indicates that these hydrocarbon methods may have limited suitability for this type of testing. It appears that these methods may not be sensitive enough to detect the compounds or low concentrations present in the poultry air.

Additionally, these methods assume that the response of the flame ionization detector to the compound mix is comparable to a standard hydrocarbon compound like methane or propane. This may not be the case for the compounds in the poultry air. This makes the results only semi-quantitative and may not provide useful information on total mass emissions. Because of these shortcomings, efforts after the spring sampling run concentrated on the more sensitive and specific EPA Method TO-15.

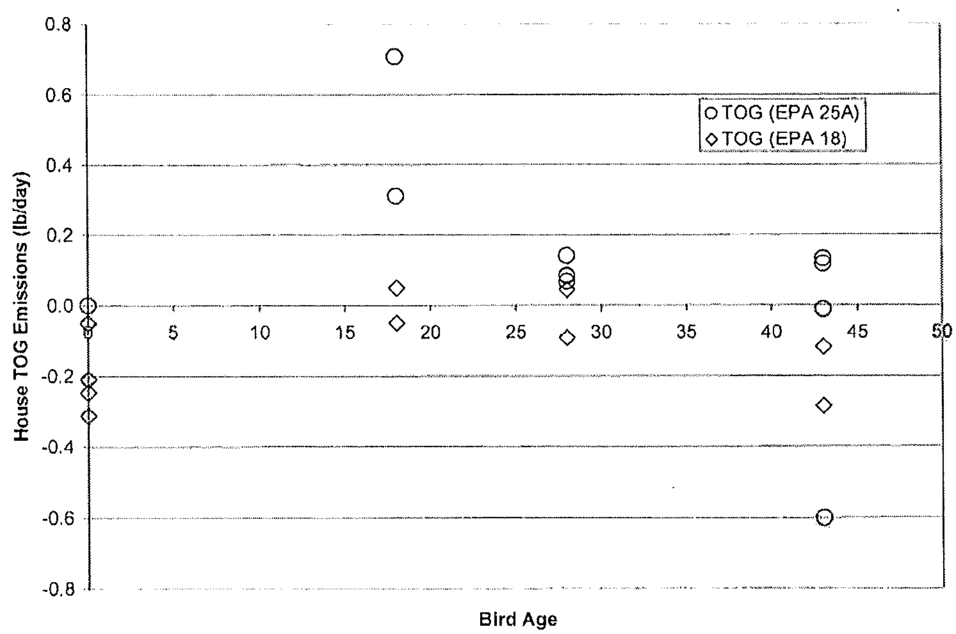

Figure 5. Broiler house total organic gas emissions as estimated by EPA Method 25A and EPA Method 18 reported as lb/day. Results may not be quantitative.

The EPA Method TO-15 utilizing GCMS has much higher sensitivity and can identify specific compounds in the air mixture, alleviating some of the problems with the hydrocarbon methods. Only a limited number of TO-15 samples were collected during the spring run and ambient samples were not always taken to correct for compounds in the outside air. An additional run in the same house under the same litter conditions was performed in the fall to collect additional organic gas data. Results are shown in Table 5 including the ambient and stack concentrations of the target compounds and the tentatively identified compounds that were positively detected during the sampling campaigns. Only the detected target compounds are shown on Table 5. A complete list of the target compounds and detection limits from the calibration standard are shown in Appendix A. It should be noted that the identification and quantification of the tentatively identified compounds is approximate because the GCMS response is compared to an internal standard and not a calibration standard for the specific gas.

Table 5. Organic gas concentrations from broiler house quantified using EPA Method TO-15 (concentrations in ppbv).

			Stack									Ambient					
		Date>	5/17	5/27	6/11AM	6/11PM	10/15	10/29	11/9	11/18	11/29	6/11	10/15	10/29	11/9	11/18	11/29
		Bird Age (days)>	18	28	43	43	0	9	20	29	40	43	0	9	20	29	40
		Flowrate (dscfm)>	18,098	27,280	67,392	128,810	14,305	16,031	15,264	26,451	28,222	67,392	14,305	16,031	15,294	26,451	28,222
Chemical Compound	Molecular Wt.	MDL															
Methanol	32.04	20.0	379	171	91	78			391	393			77				
Propylene	42.06	0.5					17				3.1		4.3				4.7
Ethanol	46.07	2.5	114		27	17		46	114	43	10		59	9.4		3.8	8.2
Acetone*	58.08	1.0	50	1194	20		13	1313	60	50	0.5		13	22	18		5.0
Isopropyl Alcohol	60.1	1.0					2.6										
Carbon Disulfide	76.2	0.5		2.9						0.5							
Benzene	78.1	0.5					1.6						7.8				1
Cyclohexane	84.2	0.5											3.4				
Methylene Chloride*	84.9	1.0		11			1.4	12	6		0.9		1.4	5.6		2.6	1.4
Vinyl Acetate	86.06	0.5	173	27		5	1.2	14	62	35	5.3		1.8			1.6	1.3
Hexane	86.14	0.5	5.2	4.1			1.5	10	6.3	3.8	0.7		2				1
Chlorodifluoromethane*	86.46	1.0											1				
Toluene	92.08	0.5	2.5	2.1			3.2	4.6					6.2				3.7
Heptane	100.2	0.5											1.4				
m- & p-Xylenes	106.2	0.5											1.5				1.4
4-Methyl-2-Pentanone (MIBK)	110.2	0.5					1.3										
Dichlorodifluoromethane*	120.93	0.5	2.3	2.2	2	4						3.3	1.1				
Ethylene Oxide	44	TIC				11											
Acetaldehyde	44.05	TIC	99		6.0				24				23		13	9.3	6.5
Propane	44.1	TIC	24	53					919	340					855	31	
2-methyl-1-propene	56.08	TIC															3.4
Isocyanomethane	57.05	TIC		83													
Propanal	58.06	TIC	11														
Isobutane	58.12	TIC	11		13	14	17		277		4.4	4397			280		
Butane	58.12	TIC					20		42		4.7	87			44		4
Methyl Formate	60.1	TIC	7.0														
Dimethyl Sulfide	62.13	TIC	7.5														
nitromethane	64.06	TIC													8.9	4.5	
2-Butanone	72.1	TIC							6.2		0.7						
Pentanone (Pentane)	72.15	TIC											13				
2,2-dimethyl-Propane	72.17	TIC														29	
2-methylbutane	72.2	TIC			4		28		20		4.3		37		24		3.9
Methyl acetic Acid	74.1	TIC	5.8														
Thiourea	76.1	TIC														3.6	
1-hexene	84.16	TIC										54					
Methylcyclopentane	84.2	TIC											17				
2-methylpentane	86.18	TIC	5.1														
3-methylpentane	86.2	TIC											7.5				
2,2-dimethylbutane	86.2	TIC							10								
Dimethyl disulfide	94.2	TIC	22		46	19				237	16						
3-Furanmethanol	98.1	TIC								51							
Methylcyclohexane	98.19	TIC											12				
2-Methylhexane	100.2	TIC											3.1				
3-Methylhexane	100.2	TIC											3.9				
Heptanal	114.2	TIC				5.9											
2,2,3,3,tetramethylbutane	114.28	TIC															5.1
A-pinene	136.16	TIC											3.1				
Trichloromonofluoromethane*	137.7	TIC											8.3				
decamethyl hexamethylsiloxane	102	TIC				3.1											
Hydrogen sulfate 0-methylisourea	172.15	TIC	8.9														
Hexamethyl Cyclotrisiloxane*	222.54	TIC				28										19	

*Compound is exempt (not Reactive Organic Gas). TIC = Tentatively Identified Compound. MDL = Method Detection Limit; blank space indicates compound at less than MDL.
EPA TO-15 target compounds with no detections were omitted from table. See Appendix A for complete target list.

Total organic gas was calculated as the sum of all of the identified target compounds and the tentatively identified compounds for each sampling run. Figure 6 shows the total organic gas emitted from the house from the spring and winter runs without correction for ambient concentrations. The corrected fall data is given in Figure 7 subtracting ambient from house concentration. To compute the emissions factor per bird produced the average emissions rate for the five sampling runs was multiplied by the number of days of production (55 total including 45 days with growing birds in the house and 10 days between cycles) and divided by the number of birds produced. An average total organic gas (TOG) emissions rate of 0.095 lb hr^{-1} for the house is obtained and a production cycle emissions of 0.0061 lb $bird^{-1}$ (2.83 g $bird^{-1}$) is estimated.

The types of gasses detected were fairly consistent and were dominated by a few compounds. The average emissions rate for organic gasses that showed positive emissions over the cycle are shown in Table 6. Total organic gas and the reactive organic gas are also computed from each sampling run and the average from the 5 sampling runs is reported in Table 6. The mass composition of the organic gas generated in the house is also determined. Note that the quantification and identification of the compounds in italics are tentative because they were detected by GCMS but not part of the available TO-15 target standard.

Some of the compounds detected as part of TOG are excluded compounds in terms of ozone formation and regulation. Because the TOG species are identified we can readily determine from the speciation profile the reactive portion or the reactive organic gasses (ROG) as named by the California Air Resources Board. Here the average house ROG emission for the fall is 0.057 lb hr^{-1} with estimated production cycle emissions of 0.0037 lb $bird^{-1}$ (1.70 g $bird^{-1}$).

The key compounds in terms of mass emissions that were part of the TO-15 standard were acetone, methanol, vinyl acetate, and ethanol. Dimethyl disulfide, and propane were tentatively identified during multiple sampling runs by GCMS analysis. The compound 3-Furanmethanol was tentatively identified in a large quantity on only one sampling event and may not be a reliable result. Figure 8 shows the house emissions rates for some of the consistently detected compounds over both sampling campaigns.

The source of the compounds detected in the house was not investigated but may not exclusively be from birds or manure. Many of the organic compounds detected have been noted in other studies that focused on odors from birds and manure (Chang and Chen, 2003; Hobbs et al., 1995). Propane heaters, feed and supplements, and off gassing from house materials and equipment are other potential sources of emissions. Propane and vinyl acetate, not noted in the odor studies, may come from these other sources.

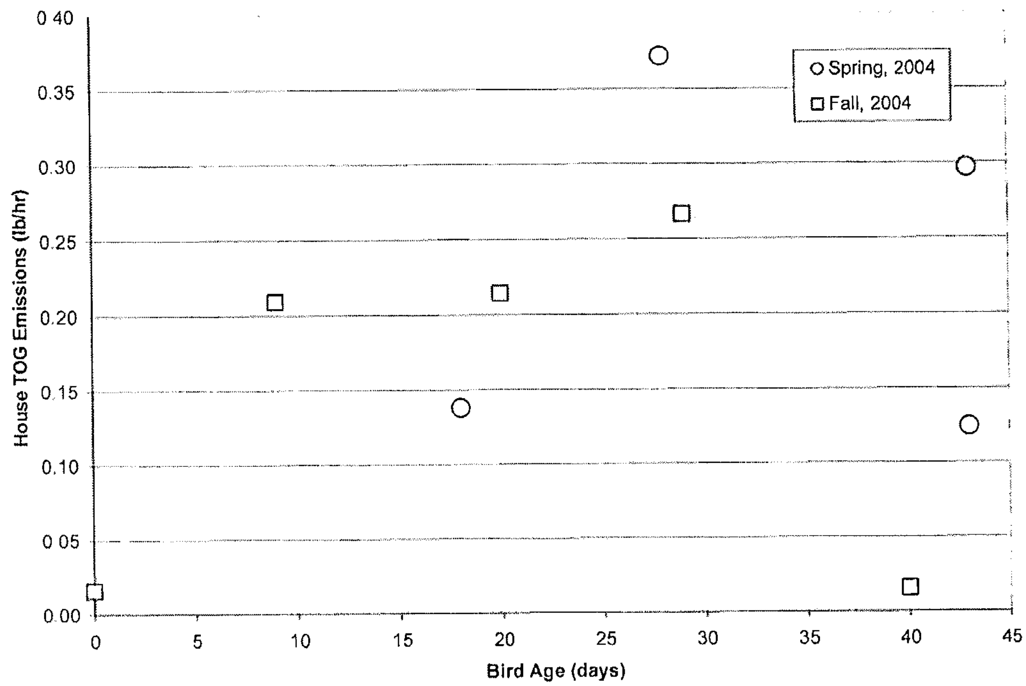

Figure 6. House total organic gas emissions as estimated from EPA Method TO-15 for spring and fall sample runs (not corrected for ambient concentrations).

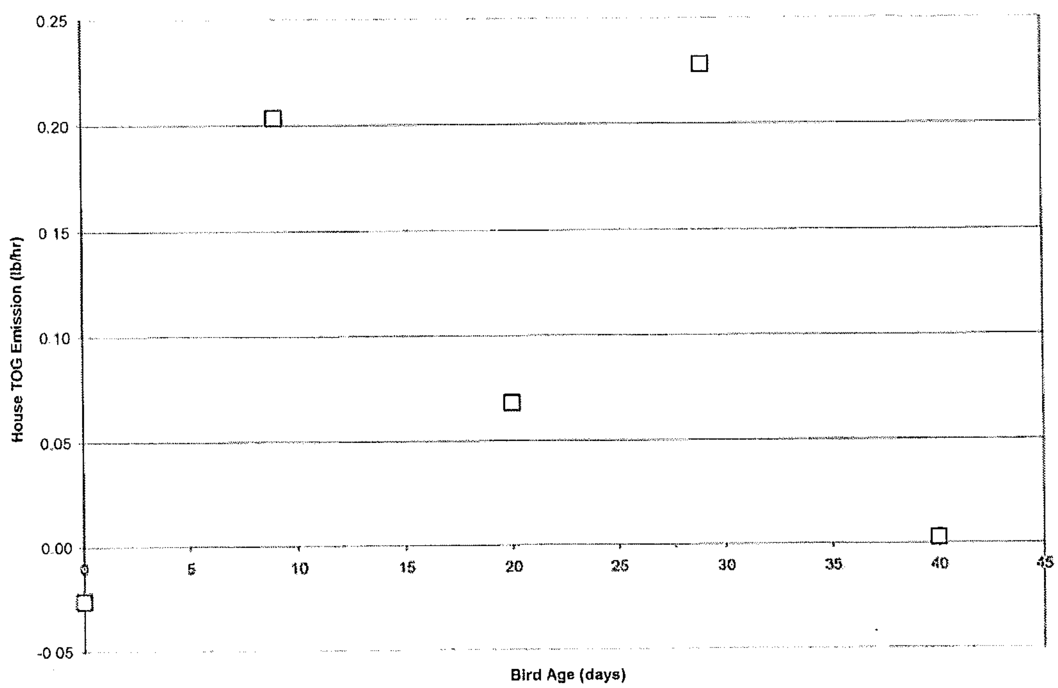

Figure 7. Ambient corrected house organic gas emissions as estimated by EPA Method TO-15 for fall sample run.

Table 6. Average organic gas emissions rate per unit of production during a 55-day broiler cycle (Fall 2004). As detected by EPA Method TO-15 with tentatively identified and quantified compounds in italics.

Organic Compound	**Average (g/bird)**	**St. Dev. (g/bird)**	**Speciation (% mass)**
Acetone*	1.246	2.467	39.3
Methanol	0.419	0.722	13.2
Vinyl Acetate	0.175	0.182	5.5
Ethanol	0.111	0.212	3.5
Hexane	0.035	0.044	1.1
Carbon Disulifde	0.012	0.028	0.4
Methylene Chloride*	0.009	0.029	0.3
Propylene	0.006	0.017	0.2
Isopropyl Alcohol	0.002	0.005	0.1
4-Methyl-2-Pentanone (MiBK)	0.002	0.005	0.1
Dimethyl disulfide	*0.595*	*1.222*	*18.7*
Propane	*0.379*	*0.740*	*12.0*
3-Furanmethanol	*0.124*	*0.278*	*3.9*
Butane	*0.020*	*0.046*	*0.6*
Isobutane	*0.018*	*0.032*	*0.6*
2,2-dimethylbutane	*0.012*	*0.028*	*0.4*
2-Butanone	*0.008*	*0.014*	*0.2*
Total Organic Gas	**2.83**	**3.43**	
Reactive Organic Gas	**1.70**	**3.08**	

Averages of five measurements taken over a 55-day broiler cycle in Fall 2004.
Compounds with negative enrichment are not shown or included in speciation.
* signifies exempt compounds (not ROG)

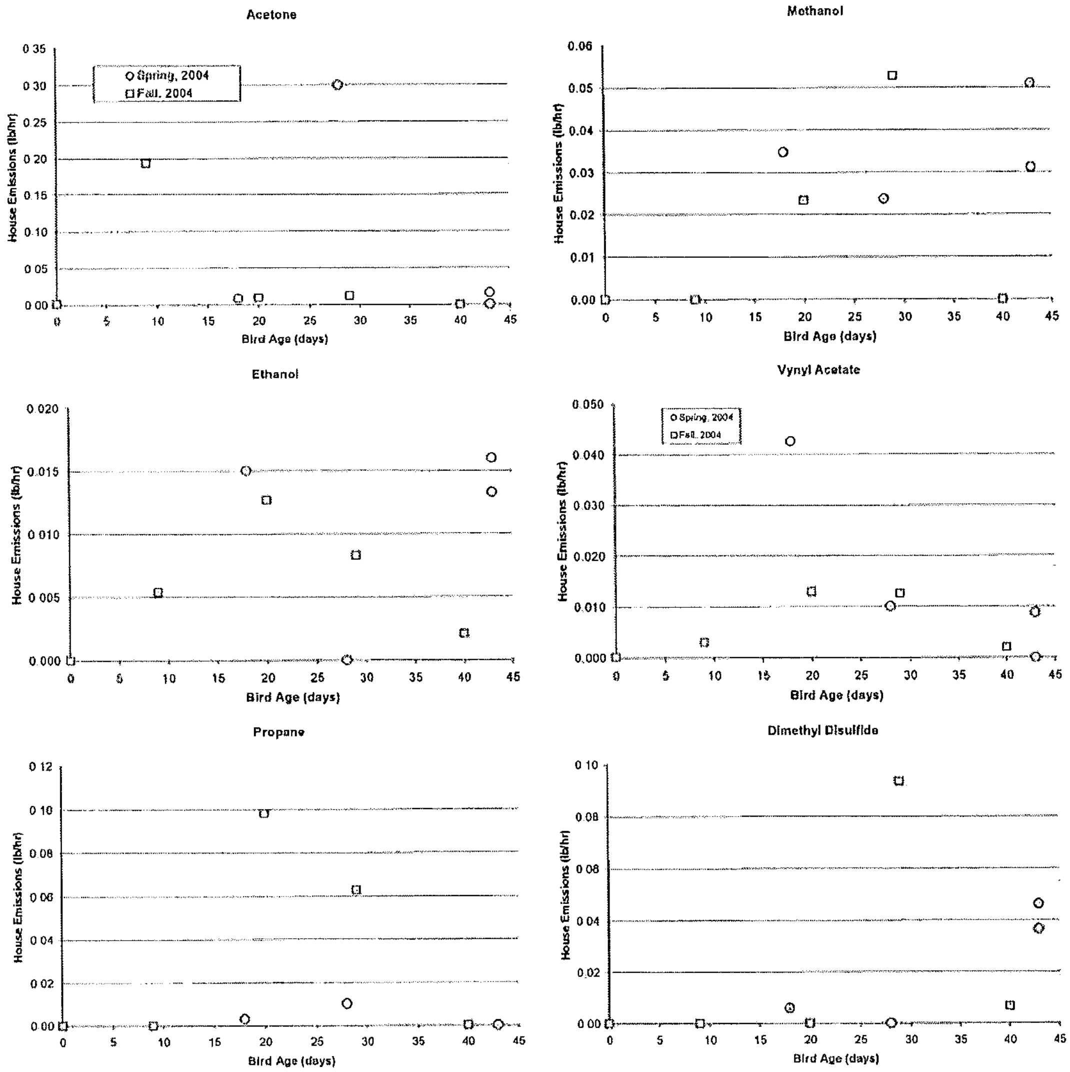

Figure 8. Broiler house emissions of key organic gasses detected by GCMS (EPA TO-15) as a function of bird age for spring and fall campaigns. Note that emissions rates are not corrected for ambient concentrations.

Conclusion

This study was able to generate ammonia and organic gas emissions estimates for a typical broiler production cycle, expressed on a per bird of production basis. The study did not look at the effects of location, seasonal variability or other parameters on cycle emissions. However, annual emissions factors are needed in order to calculate the facility emissions of California broiler facilities given their capacity. Annualized emissions factors for broiler production in California can be estimated from the cycle emissions developed in this study. To achieve this, the emissions measured during the spring and fall campaigns of this study are assumed to represent the entire year. Cycle time was a total of 55 days (45 days of broiler growth and 10 days between broods) so the house has the potential of raising 6.7 broods per year. The annual emissions factor is therefore 6.7 times the per bird estimates. A summary of emissions factors for broiler production developed in this study is given in Table 7 including the production and annual capacity estimates.

Table 7. Gas emissions factors for broiler production as estimated by this study.

Compound	Production Emission Factor (lb bird^{-1})	Capacity Emission Factor (lb bird^{-1} yr^{-1})
Ammonia	0.0143	0.096
Total Organic Gas*	0.0061	0.041
Reactive Organic Gas	0.0037	0.025

*Gas speciation profile is given in Table 6 and includes tentatively identified compounds.

Acknowledgements

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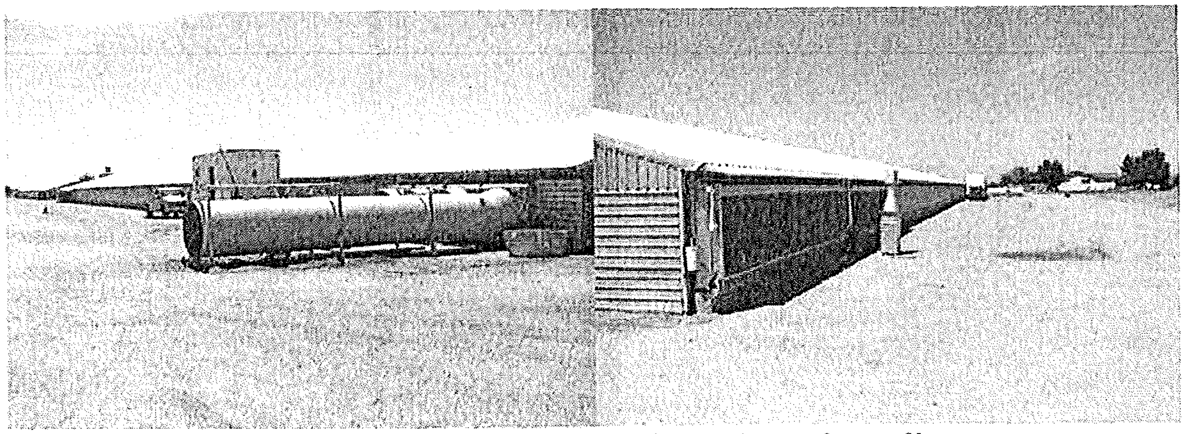
Appendices

Appendix A. Target compounds for EPA Method TO-15 Analysis

Chemical Compound	*Method Detection Limit*
Chlorodifluoromethane	1.0
Propylene	0.5
Dichlorodifluoromethane	0.5
Chloromethane	0.5
1,2-Dichloro-1,1,2,2-Tetrafluoroethane	0.5
Vinyl Cloride	0.5
Methanol	20.0
1,3-Butadiene	0.5
Bromomethane	0.5
Chloroethane	0.5
Dichlorofluoromethane	0.5
Ethanol	2.5
Vinyl Bromide	0.5
Acetone	1.0
Trichlorofluoromethane	0.5
Isopropyl Alcohol	1.0
Acrylonitrile	0.5
1,1-Dichloroethylene	0.5
Methylene Chloride	1.0
Allyl Chloride (Chloroprene)	0.5
Carbon Disulifde	0.5
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.5
t-1,2-Dichloroethylene	0.5
1,1-Dichloroethane	0.5
MTBE	0.5
Vinyl Acetate	0.5
2-Butanone (MEK)	1.0
cis-1,2-Dichloroethene	0.5
Hexane	0.5
Chloroform	0.5
Ethyl Acetate	0.5
Tetrahydrofuran	0.5
1,2-Dichloroethane	1.0
1,1,1-Trichloroethane	0.5
Benzene	0.5
Carbon Tetracloride	0.5
Cyclohexane	0.5
1,2-Dichloropropane	0.5
Bromodichloromethane	0.5
1,4-Dioxane	1.0
Trichloroethene	1.0
2,2,4-Trimethylpentane	0.5
Heptane	0.5
cis-1,3-Dichloropropene	0.5
4-Methyl-2-Pentanone (MiBK)	0.5
t-1,3-Dichloropropene	0.5
1,1,2-Trichloroethane	0.5
Toluene	0.5
2-Hexanone	1.0
Dibromochloromethane	0.5
1,2-Dibromoethane	0.5
Tetrachloroethylene	0.5
Chlorobenzene	0.5
Ethylbenzene	0.5
m- & p-Xylenes	0.5
Bromoform	0.5
Styrene	0.5
1,1,2,2-Tetrachloroethane	0.5
o-Xylene	0.5
4-Ethyltoluene	0.5
1,3,5-Trimethylbenzene	0.5
1,2,4-Trimethylbenzene	0.5
Benzyl Cloride	1.0
1,3-Dichlorobenzene	0.5
1,4-Dichlorobenzene	0.5
1,2-Dichlorobenzene	0.5
1,2,4-Trichlorobenzene	1.0
Hexachlorobutadiene	1.0

Appendix B. Photos of field testing setup

Figure A1. Broiler production house showing sampling stack attached to Fan#10 at back



of house and ambient sampling at evaporative cooler/vent inlets at front of house.

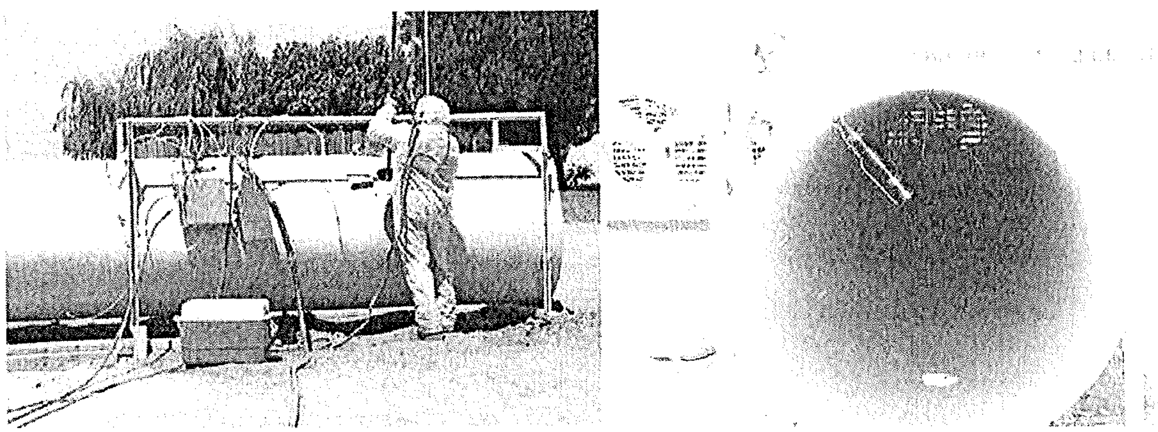


Figure A2. Sampling stack shown during airflow measurement and sampling.

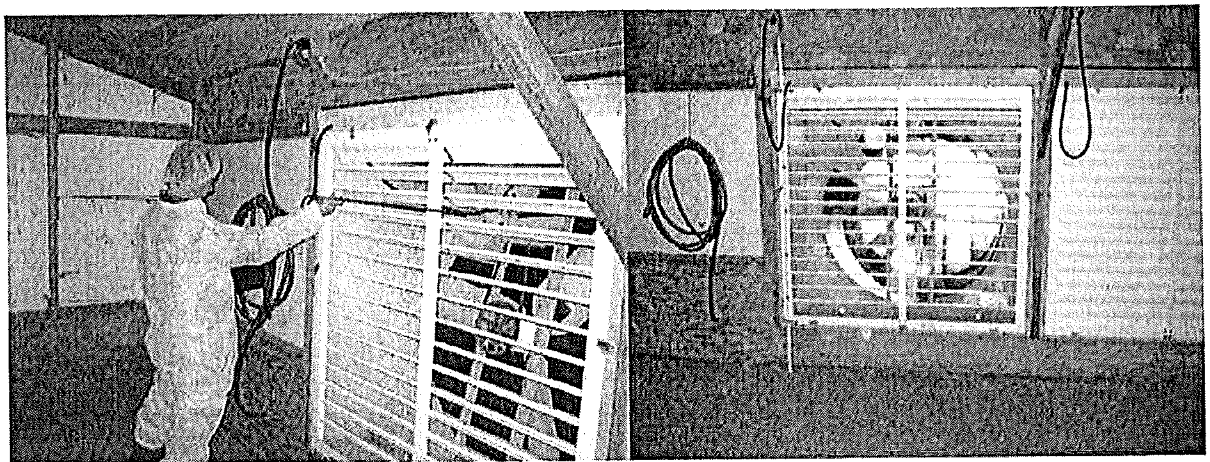


Figure A3. Calibration of fans in interior of house to determine ventilation level factor.

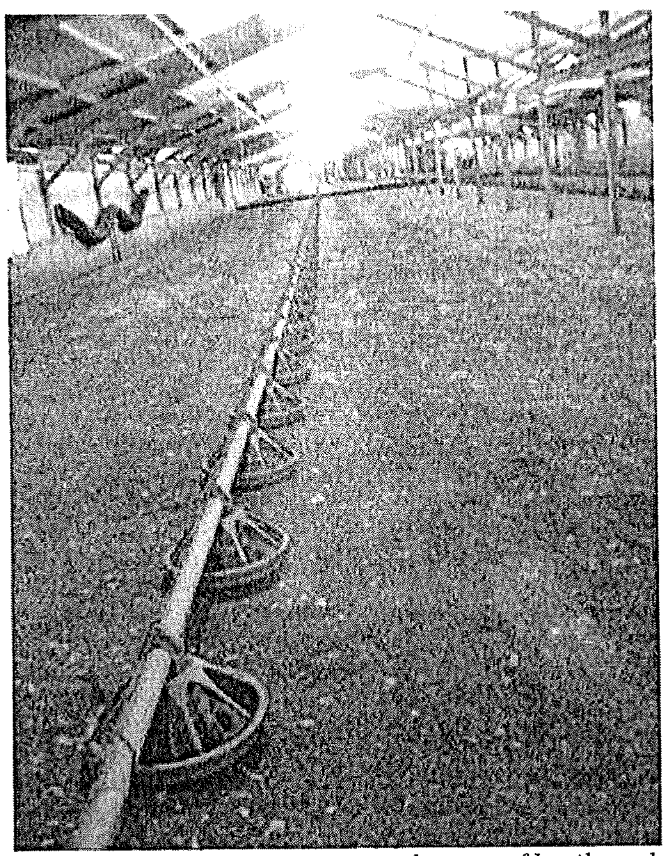


Figure A4. Interior of poultry house prior to introduction of broilers showing bedding, animal feeders, and open vents along roofline.

Appendix C. Source test reports

Complete list of data and quality assurance reports referenced by this study. Reports were prepared by:

AIRx Testing
P.O. Box 1077
17331 Sharon Blvd.
Madera, CA 93639

- Engineering Testing of Chicken House Stack
Tested On: April 26, 2004
- Engineering Testing of Chicken House Stack
Tested On: May 17, 2004
- Engineering Testing of Chicken House Stack
Tested On: May 27, 2004
- Engineering Testing of Chicken House Stack
Tested On: June 11, 2004
- Engineering Testing of Chicken House Stack
Tested On: October 15, 2004
- Engineering Testing of Chicken House Stack
Tested On: October 29, 2004
- Engineering Testing of Chicken House Stack
Tested On: November 9, 2004
- Engineering Testing of Chicken House Stack
Tested On: November 18, 2004
- Engineering Testing of Chicken House Stack
Tested On: November 29, 2004

Appendix D. VOC sampling and analysis audit

Attachment.

APPENDIX D

Ammonia Emission Control from Dietary Restriction Reference Articles

Dietary Manipulation to Reduce Ammonia Emission from High-Rise Layer Houses

Y. Liang[1], H. Xin[2], H. Li[2], R. Gates[3], E. Wheeler[4], K. Casey[5], B. Behrends[6] and D. Burnham[7]
[1] University of Arkansas, Fayetteville, AR; [2]Iowa State University, Ames, IA; [3]University of Kentucky, Lexington, KY; [4]Pennsylvania State University, University Park, PA; [5]Texas AgriLife Research, Amarillo, TX; [6]Agri-Tech, a Sparboe Company, Litchfield, MN; [7]Aviagen, Huntsville, AL

Species: Poultry (Layers)
Use Area: Animal Housing
Technology Category: Diet Modification
Air Mitigated Pollutants: Ammonia

Description:

Ammonia (NH_3) generation from poultry production is a result of microbial decomposition of uric acid and undigested nitrogen (N) in bird feces. Ammonia emission is associated with N content of the feces, which is influenced by feed composition and feed conversion efficiency of the bird. To reduce N content in feces, ration may be formulated with reduced dietary crude protein (CP) and supplemented with limiting amino acids (AA) to match bird dietary requirements, thereby improving digestive conversion efficiency. A dietary manipulation experiment with hens fed properly formulated lower CP diets was conducted for a full year to evaluate NH_3 emission from commercial layer houses.

Mitigation Mechanism:

The lower CP diet (LCP) was tested against an industry standard or control (Ctrl) diet in four high-rise (HR) laying-hen (Hy-Line W-36) houses at a commercial layer facility in Iowa to study the effect of diet manipulation on NH_3 emissions. Two of the HR houses received a standard CP ration (Ctrl) and the other two received a LCP ration supplemented with amino acids (AA). Hence, the experiment had two dietary regimens with two replicates each.

In general, the LCP diet had 0.4 to 1.2% lower CP than the Ctrl diet during various feeding phases. Soy content was reduced in the LCP diet, and crystalline AA DL-methionine, L-lysine.HCL and L-threonine were supplemented so that these essential AA were at the same levels in both diets for each corresponding feeding phase. Tryptophan and isoleucine in the LCP diet were slightly lower than those in the Ctrl diet (difference ranged from 0.02% to 0.06%).

Daily NH_3 emission rate (ER) for houses with the LCP diet averaged 0.80 g d^{-1} hen^{-1} (annual ER: 292 g hen^{-1}), as compared with 0.90 g d^{-1} hen^{-1} (Annual ER: 329 g hen^{-1}) for the Ctrl diet houses (Table 1). Hence, NH_3 ER decreased by 11% with up to 1.2% reduction in dietary CP. No significant difference was found between the two diets in weekly hen-day egg production (80.3% for Ctrl vs. 80.2% for LCP) (Fig. 1) or case weight (47.7 lb $case^{-1}$ for Ctrl vs. 48.3 lb $case^{-1}$ for LCP). Therefore, the results indicate that dietary manipulation provides a viable means to reduce NH_3 emission from laying hen operations.

Applicability:

This mitigation technology was tested with Hy-Line W-36 laying hen birds from 20 to 108 weeks of age.

Limitations:

Crude protein (amino acids) in the diet can only be reduced to the level where the next essential amino acids becomes limiting, otherwise it will adversely affect bird performance. The discussed study utilized diets ranging from 0.4 to 1.2% lower CP than the standard or Ctrl diet during various feeding phases to achieve approximately 11% of ammonia emission reduction.

Table 1. Effect of lower crude protein (LCP) diet on ammonia emission rate (ER) from HR layer houses in Iowa

NH_3 ER in g/d-hen (range)		NH_3 ER reduction by the LCP diet
Standard (Ctrl) diet	Lower CP (LCP) diet	
0.90 (0.24 – 1.60)	0.80 (0.19 – 1.37)	11%

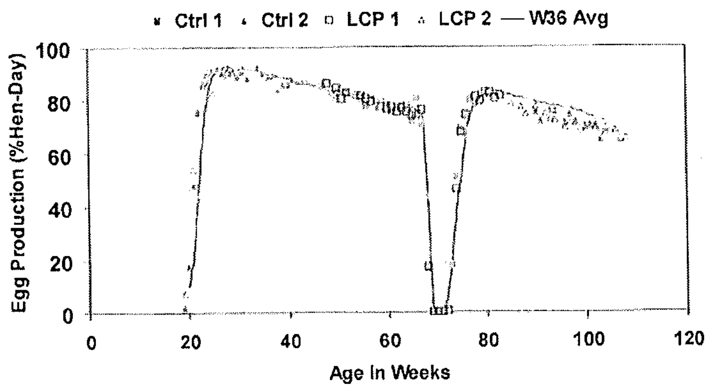


Figure 1. Egg production of birds receiving Standard (Ctrl) or lower CP (LCP) diets. Solid line represents average production performance of Hy-Line W-36 birds.

Cost:

Table 2 lists the cost comparison of a sample dietary formulation of the LCP and Ctrl diets. When the study was conducted in 2003, the costs of 1000 kg of feed were $115.75 and $116.22 for the LCP and Ctrl rations, respectively, based on an estimated corn and soybean prices of $116 and $210 /1000kg. The cost of the same LCP dietary formulation is 1.2% less (2008 prices) than that of the standard dietary formulation due to reduced grain portions, which is especially relevant with the current higher grain costs (corn, soybean, etc.). The costs of 1000 kg of feed are $235.44 and $238.47 for the sample LCP and Ctrl rations based on the 2008 prices, respectively.

Implementation:

Sample dietary formulation of the LCP and Ctrl diets and their nutrient compositions are provided in Tables 2 and 3.

Table 2. Sample dietary formulations of the lower crude protein (LCP) and standard (Ctrl) diets and cost comparison (February 2008 cost basis).

Ingredient	Weight (kg)		Unit price ($/1000kg)	Formulated Cost ($)	
	LCP	Ctrl		LCP	Ctrl
Corn	581.787	552.333	195.00	113.45	107.70
Soybean 48	248.262	275.039	380.00	94.34	104.51
Feed fat	40.840	45.153	255.00	10.41	11.51
Alimet	2.155	1.941	1,820.00	3.92	3.53
Limestone	98.997	98.973	19.00	1.88	1.88
Dicalcium phosphate	21.086	20.850	225.00	4.74	4.69
Salt	4.116	4.111	40.00	0.16	0.16
Vit+min premix	1.100	1.100	3,098.79	3.41	3.41
Choline chloride	0.250	0.250	648.79	0.16	0.16
Natuphos	0.250	0.250	3,578.79	0.89	0.89
L-lysine HCl	0.727		1,600.00	1.16	
L-threonine	0.429		2,100.00	0.90	
Total weight (kg)	1,000.000	1,000.000			
Total Cost of 1000kg of feed ($)				235.44	238.47

Table 3. Dietary nutrient composition of the sample formula for the lower CP (LCP) and standard or control (Ctrl) diets (%, unless otherwise noted)

Nutrient	LCP	Ctrl
Dry matter	89.952	90.038
Crude protein	16.666	17.610
Fat	6.966	7.340
Ash	14.571	14.662
Crude fibre	2.405	2.480
Nitrogen	2.714	2.863
AMEn (kCal/kg)	2,925.000	2,925.000
TMEn (kCal/kg)	3,047.290	3,048.971
Lysine	0.950	0.966
Methionine	0.466	0.460
Methionine+cystine	0.750	0.757
Cystine	0.284	0.297
Threonine	0.680	0.680
Isoleucine	0.700	0.749
Tryptophan	0.191	0.206
Arginine	1.084	1.164
Valine	0.785	0.832
Glycine	0.698	0.743
Glycine+serine	1.538	1.635
Histidine	0.467	0.493
Leucine	1.524	1.592
Phenylalanine	0.845	0.898
Phenyl.+tyrosine	1.488	1.580
Serine	0.839	0.892
Tyrosine	0.643	0.683
TEAA	10.907	11.413
Calcium	4.250	4.250
Phosphorous	0.703	0.709
Avail. phosphorous	0.480	0.480
Sodium	0.190	0.190

Technology Summary:

Utilization of lower crude protein with supplemented essential amino acids is a source reduction method to mitigate ammonia emission from laying hen production facilities. Lower N excretion in the bird feces due to lower total N intake can result in lower NH_3 emission from the production system. The 0.4 to 1.2% lower CP than the Standard diet during various feeding phases used in the above study resulted in about 11% ammonia emission reduction. Formulation based on nutritional requirement at different feeding phases is required to achieve emission reduction without affecting bird performance, i.e. egg production and case weight. The cost of using the lower CP diet is about 1% lower than that of using the standard diet.

Additional Resources:

Y. Liang, H. Xin, E. F. Wheeler, R. S. Gates, H. Li, J. S. Zajaczkowski, P. A. Topper, K. D. Casey, B. R. Behrends, D. J. Burnham, F. J. Zajaczkowski 2005. Ammonia emissions from U.S. laying hen houses in Iowa and Pennsylvania. Trans. ASABE. 48(5):1927-1941.

Acknowledgments:

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NRI Air Quality Extension & Education
Iowa Farm Bureau Federation
Iowa Egg Council
Iowa Pork Industry Center
Iowa Pork Producers Association
U.S. Pork Center of Excellence

Dietary Manipulations to Lower Ammonia Emission from Laying-Hen Manure

S.A. Roberts[1], H. Xin[1], H. Li[1], R.T. Burns[1], K. Bregendahl[1], and E.C. Hale[2]
Iowa State University, Ames, Iowa[1], Rose Acre Farms, Seymour, Indiana[2]

Species: Poultry (Layers)
Use Area: Animal Housing
Technology Category: Dietary Modification
Air Mitigated Pollutants: Ammonia

Description:

Ammonia emission is a major environmental concern for egg producers. The nutrient composition and chemical characteristics of an animal's diet influence nutrient composition and characteristics of the manure and research has shown that adjusting the laying hens' diet can lower ammonia emission from the manure. The dietary manipulation techniques considered in this paper include:

- Reduced crude protein diets;
- Inclusion of high-fiber ingredients (e.g., corn distiller's dried grains with solubles [DDGS], wheat middlings, or soybean hulls); and
- Inclusion of EcoCal™—a proprietary mixture of calcium sulfate (gypsum) and zeolite.

Mitigation Mechanism:

Diets with reduced crude protein contents have been used successfully to lower ammonia emission from pig manure (van der Peet-Schwering et al., 1996) and laying hen manure (Liang et al., 2005). Animals can only perform (whether egg production or muscle growth) to the level of the first limiting amino acid in their diet. Amino acids supplied above the level of the first-limiting amino acid cannot be used and the nitrogen is therefore excreted in the urine. A reduced crude protein diet is typically formulated by including crystalline amino acids such that the inclusion of protein-supplying ingredients (e.g. soybean meal) can be decreased while still maintaining a nutritionally adequate diet. This technique allows the amino acid content of the diet to more closely resemble the amino acid requirement of the animal, thereby limiting the amount of excess nitrogen that must be excreted. In a field-scale study reported by Liang et al. (2005), laying hen diets were formulated to contain one percentage unit lower crude protein compared to a control diet and resulted in a 10% decrease in ammonia emission (Table 1). The study involved 4 high-rise laying-hen houses, each containing approximately 75,000 hens. Two houses were assigned to a standard diet and two houses were assigned to a reduced crude protein diet and emissions were measured over one year.

High-fiber ingredients are typically not included in diets for monogastric animals (i.e., pigs and poultry). However, research in Europe showed that including fiber in pig diets lowered ammonia emission from manure slurry (Kruezer and Machmuller, 1993; Tetens et al., 1996; Cahn et al., 1996; Shriver et al., 2003). Our group conducted an experiment to evaluate the effect of including high-fiber ingredients (i.e., corn DDGS, wheat middlings, or soybean hulls) in laying-hen diets on ammonia emission and found that high-fiber ingredients led to a decrease in ammonia emission from laying-hen manure (Roberts et al., 2007). Including 10% corn DDGS caused a 41% decrease in ammonia emission, 7.3% wheat middlings caused a 38% decrease in ammonia emission, and 4.8% soybean hulls caused a 27% decrease in ammonia emission from the manure. Our hypothesis of this mechanism is two-fold: 1. fiber provides energy to bacteria in the lower gastrointestinal tract where the bacteria use nitrogen, that would otherwise be excreted as uric acid, for bacterial protein synthesis; and 2. the bacterial metabolism produces short-chain fatty acids that lower manure pH, thereby shifting ammonia (NH_3) to ammonium (NH_4^+), which is less volatile. The results of the experiment showed that the manure pH was lower from the fiber-fed hens, but it was not clear if nitrogen repartitioning from uric acid to bacterial protein occurred. This laboratory-scale study involved 128 cages of hens (2 hens per cage), each assigned to a control, corn DDGS, wheat middlings, or soybean hulls diet. Further research is continuing to investigate the effects of corn DDGS on ammonia emission from laying-hen manure and to elucidate the mechanism.

Our research group is currently working on two separate field-scale studies, each involving multiple high-rise houses, to determine the effect of dietary corn DDGS on ammonia emission under commercial production conditions. EcoCaltm is a proprietary mixture of calcium sulfate (i.e., gypsum) and zeolite. Calcium sulfate is added to the diet as an acidifier, replacing part of the dietary calcium carbonate (i.e., limestone). As described in the previous paragraph, lower manure pH shifts ammonia to ammonium, which is less volatile and will tend to stay in the manure rather than escaping to the air. Zeolite is a binder that traps the ammonium in the manure, thereby lowering volatilization. Unpublished research from our group indicates the 3.5% dietary inclusion of EcoCaltm led to a 23% decrease in ammonia emission from laying-hen manure during the winter months (December to May) in the Midwest. This study involved two high-rise laying-hen houses, each containing approximately 250,000 hens. Hens in one house were fed a standard diet while hens in the other house were fed a diet containing 3.5% EcoCaltm.

Table 1 shows the ammonia decrease observed in various experiments conducted by our group. Emission rates are affected by many variables such as season, which may influence the actual reduction that is realized at a specific farm. Choice of dietary manipulation should be made by the egg producer based not only on anticipated ammonia reduction but also on ingredient cost, availability, and logistics of changing the diet.

Table 1. Comparison of diets

Item	Ammonia Decrease %	Inclusion Rate %	Diet cost[1] ¢/kg ($/2,000 lb)
Standard corn, soy, meat and bone meal diet	–	–	26.6 (241)
One percentage unit lower crude protein[2,3]	10	–	26.1 (237)
Corn distiller's dried grains with solubles (DDGS)[4]	41	10.0	25.5 (231)
Wheat middlings[4]	38	7.3	26.7 (242)
Soybean hulls[4]	27	4.8	27.6 (250)
EcoCal[TM,5]	23	3.5	27.6 (250)

[1]Ingredient costs used were those reported for Midwest United States markets for April 2008 (see text). EcoCal[TM] cost from personal communication: E.C. Hale, III (April 15, 2008).

[2]In the study performed by Liang et al. (2005) and in the sample diet used for cost comparisons, DL-methionine, L-lysine, and L-threonine were added to meet the methionine + cystine, lysine, and theonine requirements, respectively, and soybean meal was added to meet the fourth-limiting amino acid requirement.

[3]Ammonia decrease was based on a one-year study by Liang et al. (2005) under commercial production involving 4 high-rise laying hen houses.

[4]Ammonia decrease was based on a 10-month study by Roberts et al. (2007) that involved 256 hens.

[5]Ammonia decrease was based on a 6-month study under commercial production involving 2 high-rise laying hen houses.

Applicability:

The research described herein focuses on lowering ammonia emission from laying hens using dietary manipulation. Some work has been done using these methods in pigs and the mechanisms should hold true for other types of poultry (i.e., broiler chickens and turkeys). However, these discussions are only directly relevant for laying hens.

Limitations:

Livestock producers should consult a qualified nutritionist prior to making changes in any diets to assure optimum nutritional status and animal performance.

Care should be taken when formulating reduced crude protein diets. The amino acid requirements of the animals must be precisely known for the specific production situation considered. Inclusion of dietary amino acids above the animals' requirements is costly and contributes to nitrogen excretion, thereby decreasing the overall effectiveness of the ammonia-lowering regimen. Furthermore, the digestible amino acid contents of all ingredients in the diet must be known, so that the diet can be balanced with amino acid contents closely resembling the requirements of the animal. If the animals' amino acid requirements are not precisely known or the amino acid contents of feed ingredients are overestimated, the diet may be deficient in one of more amino acids, which will decrease production and indirectly increase ammonia excretion. If the animal has an amino acid deficiency, it will excrete the nitrogen from all amino acids fed above the level of the deficient amino acid.

There are a few points to consider when including high-fiber feed ingredients in laying-hen diets. The nutrient content and digestibility of the "new" ingredient should be evaluated so the diet formulation can take full advantage of those nutrients. High-fiber ingredients tend to have a lower amino acid digestibility compared to corn and soybean meal, so diets should be formulated on a digestible amino acid basis. Furthermore, high-fiber ingredients usually have low energy content, which may make such ingredients unsuitable for nutrient-dense pullet or peaking diets. As with any feed ingredients, producers should secure a consistent, high-quality supply for optimum diet quality and animal production.

EcoCaltm is added at either 3.5 or 7.0% of the diet, replacing equal parts of calcium from calcium carbonate. The mixture of calcium sulfate and zeolite is adjusted according to the desired addition. The calcium in the product can be considered in the total diet formulation, lowering the inclusion of calcium carbonate (i.e., limestone). When feeding EcoCaltm, egg producers should be aware of a potential increase in hydrogen sulfide emission stemming from the sulfur in the calcium sulfate. While feeding 3.5% dietary EcoCaltm caused a 23.2% decrease in ammonia emission from laying hens, a 134% increase in hydrogen sulfide was observed (1.82 ± 0.07 mg/d per hen for control-fed hens and 4.38 ± 0.20 mg/d per hen for the EcoCaltm fed hens) over a 173-d experiment conducted by our research group (unpublished data). Hydrogen sulfide concentrations were maintained below 200 ppb or 0.2 ppm at the exhaust fans in the treatment house. Although significant increases in hydrogen sulfide concentrations and emissions were observed, the levels remain low and should not cause worker or hen health concerns or trigger reporting thresholds. For instance, the emergency planning and community right to know act (EPCRA) requires reporting of hydrogen sulfide releases greater than 45 kg (100 lb) per day. At the observed, elevated hydrogen sulfide emission rate of 4.38 mg/d per hen, it would take 10.3 million hens to emit 100 lb per day.

Cost:

To compare cost differences between mitigation strategies, example diets were formulated and costs calculated (Table 1). Ingredient costs published in Feedstuffs magazine April 14, 2008 for Chicago markets were used. The following ingredients' prices are not published by Feedstuffs and were set as listed: calcium carbonate 3.2¢/kg ($29/2,000 lb), l-lysine HCl $2.20/kg ($2,000/2,000 lb), dl-methionine $2.55/kg ($2,313/2,000 lb), l-threonine $2.82/kg ($2,560/2,000 lb), and EcoCaltm 16.5¢/kg ($150/2,000 lb). Ingredient nutrient values published by NRC (1994) were used for all ingredients except corn DDGS nutrient values (not including energy) taken from University of Minnesota (UMN, 2008) and soybean hulls and wheat middlings values published by Hy-Line (2006). A value of 2,805 kcal/kg (1,272 kcal/lb) was used for the metabolizable energy content of the corn DDGS (Dakota Gold, 2008). Calcium content of EcoCaltm was assumed to be 17.14%. Diets were formulated to contain 2,850 kcal/kg (1,293 kcal/lb) metabolizable energy. Total lysine was set at 0.80% of the diet and other amino acid inclusions were calculated using the ideal amino acid profile reported by Bregendahl et al. (2008). For all other nutrients, recommendations published by NRC (1994) were used.

Diets were formulated by including dl-methionine to meet the methionine + cystine requirement and adding soybean meal to meet the second-limiting amino acid requirement. Meat and bone meal was added to meet the requirement for available phosphorus. The reduced-protein diet was formulated by including dl-methionine, l-lysine, and l-threonine to meet the methionine + cystine, lysine, and threonine requirements, respectively, and including soybean meal to meet the fourth-limiting amino acid requirement. EcoCaltm, corn DDGS, soybean hulls, and wheat middlings inclusion rates were set at the inclusion used in the respective experiment (3.5%, 10%, 4.8%, and 7.3%, respectively). All nutrient contributions from each ingredient were considered in the formulations. For the example diets prepared, the cost of the standard diet was $241/2,000 lb. The corn DDGS diet was $10/2,000 lb less expensive while the reduced protein diet was $4/2,000 lb less expensive compared to the standard diet. The wheat middlings diet was $1/2,000 lb more expensive and the EcoCaltm and soybean hulls diets were each $9/2,000 lb more expensive compared to the standard diet.

Implementation:

Producers should use care when reformulating diets to assure that all nutrient requirements of the hens are met. Feed ingredients should be sourced from a reputable company with high-quality, consistent products and should be analyzed to determine nutrient content of the ingredients prior to diet formulation to ensure optimal performance of the hens. Ingredient costs may vary greatly for different egg producers based on the proximity to the supplier and private contracting (including volume discounts)

Technology Summary:

Dietary manipulations can lower ammonia emission from laying-hen manure. Options discussed in this report include:

- Reduced crude protein diets;
- Including high-fiber ingredients (e.g., corn DDGS, wheat middlings, or soybean hulls); or
- Including EcoCal™.

Each different dietary manipulation technique offers positive and negative aspects that will fit differently into individual production systems. Producers should work closely with a qualified nutritionist to decide which diet would be best suited for their operation and to implement the changes such that all diets are nutritionally balanced and optimal egg production is achieved. Cost comparisons should be evaluated as the cost of the total diet and calculated for each individual production situation.

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Iowa Egg Council
Iowa Pork Industry Center
Iowa Pork Producers Association
U.S. Pork Center of Excellence

APPENDIX E

BACT Guideline

San Joaquin Valley
Unified Air Pollution Control District

Best Available Control Technology (BACT) Guideline 5.7.2*

Last Update: 02/05/2013

Poultry Layer House

Pollutant	Achieved in Practice or contained in the SIP	Technologically Feasible	Alternate Basic Equipment
VOC	19% control - completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; belt manure aeration/drying and removal system with manure removal at least twice per week; all birds fed in accordance with NRC or other District-approved guidelines; and all mortality removed from houses once per day.	1) 98% control - Thermal Incineration 2) 95% control - Catalytic Incineration 3) 95% control - Carbon Adsorption 4) 80% control – Biofiltration	
PM10	50% control - completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; and belt manure aeration/drying and removal system with manure removal at least twice per week.	1) 99% control - Electrostatic Precipitator 2) 99% control - Baghouse 3) 95% control - Wet Scrubber 4) 60% control - High Efficiency Cyclones	
NH3	55% control - completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; belt manure aeration/drying and removal system with manure removal at least twice per week; all birds fed in accordance with NRC or other District-approved guidelines; and all mortality removed from houses once per day.	1) 99% control - Wet Scrubber 2) 80% control - Biofiltration	

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in s a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

***This is a Summary Page for this Class of Source**

APPENDIX F

BACT Analysis

I. Top Down BACT Analysis for VOC Emissions from Laying Hen Houses and Pullet Houses

a. Step 1 - Identify all control technologies

BACT Guideline 5.7.2 lists the following control technology options:

1) 98% Control – Thermal Incineration (Technologically Feasible)
2) 95% Control – Catalytic Incineration (Technologically Feasible)
3) 95% Control – Carbon Adsorption (Technologically Feasible)
4) 80% Control - Biofiltration (Technologically Feasible)
5) 19% Control - Layer House Design and Management Practices (Achieved in Practice), including:
   a. Animals fed in accordance with National Research Council (NRC) or other District accepted guidelines utilizing routine nutritional analysis for rations.
   b. Completely enclosed mechanically ventilated layer housing
   c. Mortality removed at least once per day
   d. Evaporative cooling pads to regulate house temperature
   e. Mixing fans
   f. Belt manure aeration/drying and removal system with manure removal at least twice per week

b. Step 2 - Eliminate technologically infeasible options

There are no technologically infeasible options to eliminate from step 1.

c. Step 3 - Rank remaining options by control effectiveness

VOC Emission Control Technology Rankings			
Rank	Control Technology	Control Efficiency	Status
1	Thermal Incineration	98%	Technologically Feasible
2	Catalytic Incineration	95%	Technologically Feasible
3	Carbon Adsorption	95%	Technologically Feasible
4	Biofiltration	80%	Technologically Feasible
5	Layer House Design and Management Practices	19%	Achieved in Practice

d. Step 4 - Cost Effectiveness Analysis

Options 1 and 2 – Thermal and Catalytic Incineration (98% Control):

The following cost analysis demonstrates that the cost of the control equipment alone, not including installation labor and materials and operational costs, causes incineration to exceed the District's VOC cost effectiveness threshold.

According to the applicant, each of the proposed cage-free laying hen houses will be equipped with 48 ventilation fans each rated at 26,200 cfm. Each of the proposed pullet houses will be equipped with 38 ventilation fans each rated at 26,200 cfm. The number of fans running at any one time varies, depending mostly on ambient temperature and other weather factors. Assuming that under extreme weather conditions all fans will be running (for a pullet house as the most conservative estimate), the maximum air flow rate from each house will be 995,600 cfm (38 fans x 26,200 cfm/fan).

Because there is no thermal oxidizer available for handling such a large air flow rate, exhaust concentrators must be used to reduce the volume of air to be treated. According to the estimates obtained by the District[5], four concentrators, each at a capital cost of $2.5 million, would be required to reduce the air flow rate from the layer house ten-fold to about 80,000 cfm. The concentrated air flow rate can then be treated using two 40,000 cfm oxidizers, each at a capital cost of $450,000.

The estimate obtained by the District shows the expected total capital costs as follows:

4 exhaust concentrators @ $2,500,000 = $10,000,000
2 oxidizers @ $450,000 = $900,000
Total = $10,900,000

Annualized Capital Cost

Pursuant to District Policy APR 1305, Section X (11/09/99), the incremental capital cost for the purchase of the fuel cell system will be spread over the expected life of the system using the capital recovery equation. The expected life of the entire system will be estimated at 10 years. A 10% interest rate is assumed in the equation and the assumption will be made that the equipment has no salvage value at the end of the ten-year cycle.

$$A = [P \times i(I+1)^n]/[(I+1)^n-1]$$

Where: A = Annual Cost
P = Present Value
I = Interest Rate (10%)
N = Equipment Life (10 years)
A = $[\$10,900,000 \times 0.1(1.1)^{10}]/[(1.1)^{10}-1]$
= $1,773,925/year

[5] Estimate provided by Curt Jordan of Catalytic Products International (Telephone: (847) 438-0334; url: http://cpilink.com/).

VOC Emission Reductions

Pursuant to the District's Revised BACT Cost Effectiveness Thresholds (May 2008), the methodology for determining the emission reduction used in cost effectiveness analyses is calculated as follows:

Emission Reductions = District Standard Emissions - Emissions with Tech Feasible BACT

District Standard Emissions:

District Standard Emissions serve as a baseline from which to estimate potential emissions reductions achievable by technologically feasible controls. According to the District's office memorandum for revised BACT cost effectiveness thresholds, if there is no SJVAPCD prohibitory rule emission limit that applies to the particular new emission unit or if the existing emission unit does not have permitted emission limits, District standard emissions for the unit are equal to the emissions from similar equipment that is commonly available in the District. In no case shall the emissions used be higher than that allowed by State or Federal requirements. If insufficient information is available to make a determination regarding emissions from common available equipment in the District, District standard emissions will be estimated based on EPA's Compilation of Air Pollutant Emission Factors (AP-42), or other references as determined by the SJVAPCD to be appropriate.

Rule 4570 applies to the proposed poultry facility and requires mitigation measures to be performed. Therefore, the District Standard emissions will be equal to the controlled VOC emissions from the proposed cage-free poultry houses. The controlled VOC emissions from the proposed cage-free poultry houses are discussed in Section VII of this evaluation. These emissions already include the control efficiency for the Achieved in Practice BACT option.

Thus:

District standard emissions for the proposed poultry layer houses = 4,818 lb-VOC/house-year (as calculated in Section VII.C.2 of the application review)

Annual VOC Emission Reductions = PE x 0.98
= 4,818 lb-VOC/year x 0.98
= 4,722 lb-VOC/year
= 2.36 tons-VOC/year

Cost Effectiveness Calculation:

Cost of Reduction ($/ton) = Annual O&M Cost / VOC Reductions
= $1,773,925/yr ÷ (2.36 tons-VOC/year)
= $751,663/ton

The analysis demonstrates that the initial capital cost of thermal or catalytic incineration, not including the operation and maintenance costs, will exceed the District's BACT Cost Effectiveness Threshold for VOC of $17,500/ton. Therefore, these options are not cost-effective and will not be required for the proposed project.

Option 3 – Carbon Adsorption (95% Control):

Carbon adsorption occurs when air that contains pollutants is blown through an activated carbon unit and the pollutants are adsorbed onto the surfaces in the pores of the activated carbon particles.

The following cost analysis demonstrates that the cost of activated carbon and the annual labor costs cause carbon adsorption to exceed the District's cost effectiveness threshold.

In addition to controlling VOC emissions, treated activated carbon can also control ammonia emissions. Although this technology can control both pollutants, a cost effectiveness threshold has not been established for ammonia. Therefore, only achieved-in-practice options will be considered for ammonia at this time and a multi-pollutant cost effectiveness analysis for VOC and ammonia will not be performed.

Amount of Activated Carbon Required for VOC Control

Carbon can adsorb 20% of its weight in VOCs[6].

Carbon required = (4,818 lb-VOC/year x 0.95) x 1 lb-Carbon/0.2 lb-VOC
= 22,886 lb-carbon/year

Cost of Activated Carbon Required for VOC Control

On May 18, 2016, Rebecca Alward of Calgon Carbon Corporation provided a price estimate of $1.35 per lb of carbon plus freight for District Project N-1143210.

Per the EPA Air Pollution Control Cost Manual, Sixth Edition (January 2002), freight costs for the carbon will be estimated as 5% of the carbon capital cost.

This facility is going to be located in Kern County, which has a current sales tax rate of 7.5%. However, pollution control equipment may qualify for CA tax partial exemption[7]. The exemption rate is 4.1875%, so the reduced sales tax rate for Kern County equals 3.3125% (7.5% - 4.1875%).
Total Carbon cost = 22,886 lb-carbon/yr x $1.35/lb x 1.083125$_{\text{(taxes and freight)}}$ = $33,464/house-year

Annual Labor Costs for Activated Carbon System

The annual labor costs for the carbon adsorption system are estimated based on information from the EPA Air Pollution Control Cost Manual, Sixth Edition (January 2002), Section 3.1: VOC Recapture Controls, Chapter 1: Carbon Adsorbers (September 1999)[8] and is summarized in the table below.

[6] District GEAR 9 - Soil Remediation Project Utilizing an Activated Carbon System.
[7] http://www.boe.ca.gov/sutax/manufacturing_exemptions.htm#Purchasers
[8] EPA Air Pollution Control Cost Manual, Seventh Edition (November 2017), Section 3.1: VOC Recapture Controls, Chapter 1: Carbon Adsorbers (September 1999). United States Environmental Protection Agency Office of Air

Carbon Adsorption Annual Labor Costs			
Direct Annual Costs (DAC)			
Operating Labor			
Operator	½ hr per shift	$18.50/hr x 0.5 hr/shift x 3 shift/day x 365 days/year	$10,129
Supervisor	15% of operator		$1,519
Maintenance			
Labor	½ hr per shift	$18.50/hr x 0.5 hr/shift x 3 shift/day x 365 days/year	$10,129
Maintenance Materials	100% of labor		$10,129
Total Annual Labor Costs			**$31,906**

VOC Emission Reductions

District standard emissions for the proposed poultry layer houses = 5,490 lb-VOC/house-year (as calculated in Section VII.C.2 of the application review)

Annual VOC Emission Reductions = PE x 0.95
= 4,818 lb-VOC/year x 0.95
= 4,577 lb-VOC/year
= 2.33 tons-VOC/year

Cost Effectiveness Calculation:

Cost of Reduction ($/ton) = Annual O&M Cost / VOC Reductions
= ($33,464 + 31,906)/yr ÷ (2.33 tons-VOC/year)
= $28,056/ton

The analysis demonstrates that the annual costs of the purchase of carbon and the annual labor costs, not including the initial capital cost for the system, will exceed the District's BACT Cost Effectiveness Threshold for VOC of $17,500/ton. Therefore, this option is not cost-effective and will not be required for the proposed project.

Option 4 – Biofilter (80% Control):

Biofiltration is a method of reducing pollutants in which exhaust air that contains contaminants is blown through a media (e.g., soil, compost, wood chips) that supports a microbial population. The microbes utilize the pollutants such as VOCs and ammonia as nutrients and oxidize the compounds as they pass through the filter. Although biofiltration can control both VOC and ammonia emissions, a cost effectiveness threshold has not been established for ammonia. Therefore, only achieved-in-practice options will be considered for ammonia at this time and a multi-pollutant cost effectiveness analysis for VOC and ammonia will not be performed.

Quality Planning and Standards. Research Triangle Park, North Carolina 27711. EPA/452/B-02-001. http://epa.gov/ttn/catc/dir1/cs3-1ch1.pdf

The following cost analysis demonstrates that the capital cost of biofiltration alone, not including installation labor and materials and operational costs, causes incineration to exceed the District's VOC cost effectiveness threshold.

Cost of Biofiltration:

The cost of a biofilter includes the cost of the blowers, pretreatment systems such as humidifiers, air treatment media, ductwork, plenums, and labor.

Based on case studies of biofilters already in operation the U.S. EPA, Clean Air Technology Center (CATC) technical bulletin "Using Bioreactors to Control Air Pollution" (September 2003)[9] lists capital costs ranging from $2.35 per cfm to $7.74 per cfm, not including the installation of duct work, for biofilters with capacities of 50,000 cfm or greater and lists capital costs of $20.20 per cfm and $30.00 per cfm for Biotrickling filters, excluding the more expensive Hyperion unit, which was intended to be used as a research device.

For purposes of this analysis, the lowest capital cost value for biofilters given in the EPA document of $2.35 per scfm will be used for the most conservative estimate. Adjusting for inflation, $2.35/scfm (2003 dollars) is equivalent to $3.21/scfm (current 2018 dollars) (US Bureau of Labor Statistics, http://www.bls.gov/data/inflation_calculator.htm)

As previously discussed the maximum air flow rate for each poultry house is 1,257,600 cfm (48 fans x 26,200 cfm/fan).

The capital cost of the biofilter is calculated as follows:

$3.21/cfm x 1,257,600 cfm = $4,036,896

Pursuant to District Policy APR 1305, Section X (11/09/99), the cost for the purchase of the biofilter will be spread over the expected life of the system using the capital recovery equation. Although the biofilter media (e.g., soil, compost, wood chips) must be replaced after 3-5 years, this additional cost will not be considered in this analysis. Therefore, the expected life of the system (fans, ductwork, plenum, etc.) is estimated at 10 years. A 10% interest rate is assumed in the equation and the assumption will be made that the equipment has no salvage value at the end of the ten-year cycle. The cost is annualized as follows:

$$A = [P \times i(I+1)^n]/[(I+1)^n-1]$$

Where: A = Annual Cost
P = Present Value
I = Interest Rate (10%)
N = Equipment Life (10 years)

$$A = [\$4{,}036{,}896 \times 0.1(1.1)^{10}]/[(1.1)^{10}-1]$$
$$= \$660{,}121/\text{year}$$

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[9] U.S. Environmental Protection Agency, Clean Air Technology Center (CATC), "Using Bioreactors to Control Air Pollution" EPA-456/R-03-003, (E143-03), September 2003, http://www.epa.gov/ttn/catc/dir1/fbiorect.pdf.

VOC Emission Reductions

District standard emissions for the proposed poultry layer houses = 4,818 lb-VOC/house-year (as calculated in Section VII.C.2 of the application review)

Annual VOC Emission Reductions = PE x 0.80
= 4,818 lb-VOC/year x 0.80
= 3,854 lb-VOC/year
= 1.93 tons-VOC/year

Cost Effectiveness Calculation:

Cost of Reduction ($/ton) = Annual O&M Cost / VOC Reductions
= $660,121/yr ÷ 1.93 tons-VOC/year
= $342,032/ton

The analysis demonstrates that the initial capital cost of biofiltration, not including the operation and maintenance costs, will exceed the District's BACT Cost Effectiveness Threshold for VOC of $17,500/ton. Therefore, this option is not cost-effective and will not be required for the proposed project.

Option 5 – Poultry Layer House Design and Management Practices (19% Control):

The only remaining control option in step 3 above has been deemed AIP for this class and category of source and per the District BACT policy is required regardless of the cost. In addition, the applicant has proposed this option. Therefore, a cost effectiveness analysis is not required.

e. Step 5 - Select BACT

BACT for VOC for this operation is poultry layer house design and management practices consisting of the following: completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; belt manure aeration/drying and removal system with manure removal at least twice per week; all birds fed in accordance with NRC or other District-approved guidelines; and all mortality removed from houses at least once per day. The applicant has proposed these requirements for the poultry houses. Therefore, BACT is satisfied.

II. Top Down BACT Analysis for PM_{10} Emissions from Laying Hen Houses and Pullet Houses

a. Step 1 - Identify all control technologies

BACT Guideline 5.7.2 list the following control technology options:

1) 99% Control - Electrostatic Precipitator (Technologically Feasible)
2) 99% Control – Baghouse (Technologically Feasible)
3) 95% Control - Wet Scrubber (Technologically Feasible)
4) 60% Control - High Efficiency Cyclones (Technologically Feasible)
5) 50% Control - Completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; and belt manure aeration/drying and removal system with manure removal at least twice per week (Achieved in Practice)

b. Step 2 - Eliminate technologically infeasible options

Option 2 (Baghouse) will be eliminated from consideration as a technologically feasible control option. Previous BACT determinations have concluded that this option is not practical for poultry facilities because feathers adhere strongly to the filter media and, unlike dust or other granular materials, cannot be dislodged using the available bag cleaning technologies such as mechanical shaking and reverse pulse jets.

c. Step 3 - Rank remaining options by control effectiveness

PM10 Emission Control Technology Rankings			
Rank	Control Technology	Control Efficiency	Status
1	Electrostatic Precipitator	99%	Technologically Feasible
2	Wet Scrubber	95%	Technologically Feasible
3	High Efficiency Cyclones	60%	Technologically Feasible
4	Completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; and belt manure aeration/drying and removal system with manure removal at least twice per week	50%	Achieved in Practice

d. Step 4 - Cost Effectiveness Analysis

Option 1 - Electrostatic Precipitator (99% Control):

The following cost analysis demonstrates that the annual operating & maintenance (O&M) costs alone, not including the initial capital costs, causes the electrostatic precipitator to exceed the District PM_{10} cost effectiveness threshold.

According to the EPA-CICA Air Pollution Control Technology Fact Sheet on Dry Electrostatic Precipitator (ESP) – Wire-Plate Type (EPA-452/F-03-028)[10], the annual O&M cost for a Wire-Plate Type ESP ranges from $3 to $35 per scfm (in 2002 dollars)

For purposes of this analysis, the lowest O&M cost value given of $3 per scfm will be used for the most conservative estimate.

Annual O&M cost = $3/scfm (in 2002 dollars)

Adjusting for inflation, $3/scfm (2002 dollars) is equivalent to $4.20/scfm (current 2018 dollars) (US Bureau of Labor Statistics, http://www.bls.gov/data/inflation_calculator.htm)

The air flow rate is conservatively assumed to be 628,200 acfm/house[11] (the temperature was not specified so assume that acfm = scfm).

Annual O&M cost per house = 628,200 scfm x $4.20/scfm-year = $2,638,440/year

PM_{10} Emission Reductions:

Pursuant to the District's Revised BACT Cost Effectiveness Thresholds (May 2008), the methodology for determining the emission reduction used in cost effectiveness analyses is calculated as follows:

Emission Reductions = District Standard Emissions - Emissions with Tech Feasible BACT

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[10] http://www.epa.gov/ttncatc1/products.html#aptecfacts

[11] Each proposed house will be equipped with 48 exhaust fans, each with an air flow rate of 26,200 cfm. The number of fans running at any one time may vary. However, the applicant has stated that during summer months, all of the fans would need to be operating in order to maintain each house at an optimal temperature. However, for more conservative BACT calculations, it will be assumed 50% of the fans will be in operation (24 x 26,200 cfm = 628,800 cfm/house).

District Standard Emissions:

There are no prohibitory rule emission limits applicable to layer houses. Therefore, the District Standard emissions will be equal to the uncontrolled PM_{10} emissions from the proposed cage-free poultry houses. The uncontrolled PM_{10} emissions from the proposed cage-free poultry houses are discussed in Section VII of this evaluation. These emissions already include the control efficiency for the Achieved in Practice BACT option.

Thus:

PM_{10} Emission Reductions = District Standard Emissions - Emissions with Tech Feasible Controlled Emissions

District standard emissions = 327,000 bird/house x 0.2271 lb-PM_{10}/bird-day x 365 days/year = 27,105 lb-PM_{10}/year/house

PM_{10} Emission Reductions

Annual PM_{10} Emission Reductions = PE x 0.99
= 27,106 lb-PM_{10}/year x 0.99
= 26,835 lb-PM_{10}/year
= 13.42 tons-PM_{10}/year

Cost Effectiveness Calculation:

Cost of Reduction ($/ton) = Annual O&M Cost / PM_{10} Reductions
= $2,638,440/yr ÷ 13.42 tons-PM_{10}/year
= $196,605/ton

The analysis demonstrates that the operation and maintenance cost of an electrostatic precipitator, not including the initial capital cost, will exceed the District's BACT Cost Effectiveness Threshold for PM_{10} of $11,400/ton. Therefore, this option is not cost-effective and will not be required for the proposed project.

Option 2 – Wet Scrubber (95% Control):

The following cost analysis demonstrates that the annual operating & maintenance (O&M) costs alone, not including the initial capital costs, causes the wet scrubber to exceed the District PM_{10} cost effective threshold.

According to the EPA-CICA Air Pollution Control Technology Fact Sheet on Venturi Scrubbers (EPA-452/F-03-017)[12], the annual O&M cost for a Venturi wet scrubber ranges from $4.4 to $120 per scfm (in 2002 dollars)

[12] http://www.epa.gov/ttncatc1/products.html#aptecfacts

For purposes of this analysis, the lowest O&M cost value given of $4.4 per scfm will be used for the most conservative estimate.

Annual O&M cost = $4.4/scfm (in 2002 dollars)

Adjusting for inflation, $4.4/scfm (2002 dollars) is equivalent to $6.16/scfm (current 2018 dollars) (US Bureau of Labor Statistics, http://www.bls.gov/data/inflation_calculator.htm)

As previously calculated, the proposed air flow rate is conservatively assumed to be 646,000 acfm/house (the temperature was not specified so assume that acfm = scfm).

Annual O&M cost per house = 628,800 scfm x $6.16/scfm-year = $3,873,408/year

PM_{10} Emission Reductions

Annual PM_{10} Emission Reductions = PE x 0.95
= 27,106 lb-PM_{10}/year x 0.95
= 25,751 lb-PM_{10}/year
= 12.88 tons-PM_{10}/year

Cost Effectiveness Calculation:

Cost of Reduction ($/ton) = Annual O&M Cost / PM_{10} Reductions
= $3,873,408/yr ÷ 12.88 tons-PM_{10}/year
= $300,730/ton

The analysis demonstrates that the operation and maintenance cost of a wet scrubber, not including the initial capital cost, will exceed the District's BACT Cost Effectiveness Threshold for PM_{10} of $11,400/ton. Therefore, this option is not cost-effective and will not be required for the proposed project.

Option 3 – High Efficiency Cyclones (60% Control):

The following cost analysis demonstrates that the annual operating & maintenance (O&M) cost alone, not including the initial capital cost, causes the cyclones to exceed the District PM10 cost effective threshold.

According to the EPA-CICA Air Pollution Control Technology Fact Sheet on Cyclones (EPA-452/F-03-005)[13], the annual O&M cost for a cyclone ranges from $0.70 to $8.50 per scfm (in 2002 dollars)

For purposes of this analysis, the lowest O&M cost value given of $0.70 per scfm will be used for the most conservative estimate.

[13] http://www.epa.gov/ttncatc1/products.html#aptecfacts

Annual O&M cost = $0.70/scfm (in 2002 dollars)
Adjusting for inflation, $0.70/scfm (2002 dollars) is equivalent to $0.98/scfm (current 2018 dollars) (US Bureau of Labor Statistics, http://www.bls.gov/data/inflation_calculator.htm)

As previously calculated, the proposed air flow rate is conservatively assumed to be 646,000 acfm/house (the temperature was not specified so assume that acfm = scfm).

Annual O&M cost per house = 628,800 scfm x $0.98/scfm-year = $616,224/year

PM_{10} Emission Reductions

Annual PM_{10} Emission Reductions = PE x 0.60
= 27,106 lb-PM_{10}/year x 0.60
= 16,264 lb-PM_{10}/year
= 8.13 tons-PM_{10}/year

Cost Effectiveness Calculation:

Cost of Reduction ($/ton) = Annual O&M Cost / PM_{10} Reductions
= $616,224/yr ÷ 8.13 tons-$PM_{10}$/year
= $75,796/ton

The analysis demonstrates that the operation and maintenance cost of high efficiency cyclones, not including the initial capital cost, will exceed the District's BACT Cost Effectiveness Threshold for PM_{10} of $11,400/ton. Therefore, this option is not cost-effective and will not be required for the proposed project.

Option 4 – Completely Enclosed Mechanically Ventilated Layer Housing and Belt Manure System with Manure Removed Twice per Week (50% Control):

The only remaining control option in step 3 above has been deemed AIP for this class and category of source and per the District BACT policy is required regardless of the cost. In addition, the applicant has proposed this option. Therefore, a cost effectiveness analysis is not required.

e. Step 5 - Select BACT

BACT for PM_{10} for this operation is completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; and belt manure aeration/drying and removal system with manure removal at least twice per week. The applicant has proposed these requirements for each of the poultry houses. Therefore, BACT is satisfied for PM_{10} emissions.

III. Top Down BACT Analysis for NH_3 Emissions from Laying Hen Houses and Pullet Houses

a. Step 1 - Identify all control technologies

The control technology options include:

1) 99% Control – Wet Scrubber (Technologically Feasible)
2) 80% Control – Biofiltration (Technologically Feasible)
1) 55% Control - Poultry Layer House Design and Management Practices (Achieved in Practice), including:
   a. Animals fed in accordance with National Research Council (NRC) or other District accepted guidelines utilizing routine nutritional analysis for rations.
   b. Completely enclosed mechanically ventilated layer housing
   c. Mortality removed at least once per day
   d. Evaporative cooling pads to regulate house temperature
   e. Mixing fans
   f. Belt manure aeration/drying and removal system with manure removal at least twice per week

b. Step 2 - Eliminate technologically infeasible options

A cost effectiveness threshold has not been established for ammonia. Therefore, only options that meet the District's definition of Achieved-in-Practice controls will be evaluated and wet scrubber and biofiltration will be removed from consideration as control alternatives for the purposes of this top down BACT analysis.

c. Step 3 - Rank remaining options by control effectiveness

NH_3 Emission Control Technology Rankings			
Rank	Control Technology	Control Efficiency	Status
1	Poultry Layer House Design and Management Practices	55%	Achieved in Practice

d. Step 4 - Cost Effectiveness Analysis

The applicant has proposed the only control option from step 3 above; therefore a cost effectiveness analysis is not required.

e. Step 5 - Select BACT

BACT for NH_3 for this operation is poultry layer house design and management practices consisting of the following: completely enclosed mechanically ventilated layer housing with evaporative cooling pads, mixing fans, and a computer control system; belt manure aeration/drying and removal system with manure removal at least twice per week; all birds fed in accordance with NRC or other District-approved guidelines; and all mortality removed from houses at least once per day. The applicant has proposed these requirements for the poultry houses. Therefore, BACT is satisfied.

APPENDIX G

Greenhouse Gas (GHG) Analysis

<u>Greenhouse Gas Emissions Impacts</u>:

On December 17, 2009, the San Joaquin Valley Air Pollution Control District (District) adopted *District Policy APR 2005 — Addressing Greenhouse Gas (GHG) Emission Impacts for Stationary Source Projects Under CEQA When the District is Serving as the Lead Agency.* The policy was developed to assist Lead Agencies, project proponents, permit applicants, and interested parties in assessing and reducing the impacts of project specific GHG emissions on global climate change. The District policy uses an approach intended to streamline the process of determining if project specific GHG emissions would have a significant effect.

The District Policy for GHG emissions states a project is considered to have a less than significant impact for GHG emissions when:

1. The project is exempt from CEQA.

2. The project equipment is designed and operated in accordance with Best Performance Standards (BPS) established by the District. BPS are adopted by the District after review and consideration of possible environmental effects. The District has determined that the operation of equipment that includes BPS results in less than significant cumulative impacts.

3. The project is designed to achieve a 29% reduction in GHG emissions compared to the business as usual (BAU) design case. The District has determined that projects that achieve a 29% reduction in GHG emissions compared to BAU design case result in less than significant cumulative impacts.

4. The project complies with an approved GHG emission reduction plan or GHG mitigation program. The District has determined that such plans or programs result in less than significant cumulative impacts.

BPS has not been established for poultry operations. Therefore, a 29% GHG emission reduction compared to BAU will be calculated.

The California Air Resources Board (ARB) used its emission inventory to establish a three-year average for GHG emissions occurring by sector during the baseline period of 2002-2004. This three-year average baseline emissions inventory was projected to the year 2020 using assumptions about potential growth. CARB designated the baseline emissions inventory projected to the year 2020 as BAU. Therefore, BAU is considered the baseline period if Central Valley Eggs was operating from 2002-2004.

Thus, the percent reduction in GHG emissions is calculated as follow:

$$\%\ \text{Reduction in GHG emissions} = \frac{(2002-2004\ \text{baseline GHG emissions}) - (\text{Proposed project GHG emissions})}{2002-2004\ \text{baseline GHG emissions}} \text{x}100\%$$

Project GHG Emissions:

In order to determine a 29% reduction in GHG emissions, the GHG from the proposed project will first be calculated.

Basis and Assumptions

- The maximum number of hens that will be kept in each of the seven poultry houses proposed under this project is 327,000 hens, resulting in a total of 2,289,000 hens for the seven houses (proposed by the applicant).
- The maximum number of pullets that will be kept in each of the three pullet houses proposed under this project is 350,000, resulting in a total of 1,050,000 pullets for the three houses (proposed by the applicant).
- Emission factors are based on the documentation for ARB's 2015 Edition of the GHG Emission Inventory (Released June 2015):
    - *Emission factor for CH_4 = 647 g of CO_2eq/head of hens 1+ yr*[14]
    - *Emission factor for N_2O = 1,070 g of CO_2eq/head of hens 1+ yr*[15]
- Emission factors for pullets will be determined using similar assumptions to the PM_{10}, VOC and NH_3 emission rates in Section VII.B above (uncontrolled emission factors) that pullets will generate approximately 61.8% of the emissions that adult laying hens generate (comparison of an uncontrolled emission factors between laying hens and the sum of chick starters plus pullet growers).

Calculations

Total Laying Hen Emissions (CH_4+N_2O) = 647 + 1,070 g of CO_2eq/head of hens/year
= 1,717 g of CO_2eq/head of hens/year
= 1.717 kg of CO_2eq/head of hens/year

Total Pullet Emissions (CH_4+N_2O) = 1.717 kg of CO_2eq/head of hens/year x 0.618 kg-pullet/kg-hen
= 1.061 g of CO_2eq/head of pullets/year

Proposed GHG Emissions = Number of hens x 1.717 kg of CO_2eq/head of hens/year + Number of Pullets x 1.061 kg of CO_2eq/head of pullets/year

Proposed GHG Emissions = 2,289,000 hens x 1.717 kg of CO_2eq/head of hens/year + 1,050,000 pullets x 1.061 kg of CO_2eq/head of pullets/year

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[14] http://www.arb.ca.gov/cc/inventory/doc/docs3/3a2i_manuremanagement_poultrywobedding_livestockpopulation_hens1+yr_ch4_2013.htm

[15] http://www.arb.ca.gov/cc/inventory/doc/docs3/3a2i_manuremanagement_poultrywobedding_livestockpopulation_hens1+yr_n2o_2013.htm

Proposed GHG Emissions = 5,044,263 kg of CO_2eq/year

Converting to Metric Ton = 5,044,263 kg of CO_2eq/year x 1 metric ton/1,000 kg

Total Proposed GHG emissions = 5,044 metric ton of CO_2eq/year

Baseline GHG Emissions:

The baseline GHG emissions from an operating period of 2002-2004 will now be calculated.

On November 4, 2008, California voters passed ballot Proposition 2, known as the Standards for Confining Farm Animals initiative[16]. Proposition 2 required calves raised for veal, egg-laying hens, and pregnant pigs be confined in ways that allow these animals to lie down, stand up, fully extend their limbs and turn around freely[17].

In response, the California Department of Food and Agriculture adopted Section 1350 (Shell Egg Food Safety) of Title 3 of the California Code of Regulations which lists stocking density guidelines for all chickens whose eggs are sold in California[18].

# of Hens	1	2	3	4	5	6	7	8	≥9
Square Inches/Hen	322	205	166	146	135	127	121	117	116

Central Valley Eggs is designed in accordance with the stocking densities required by Section 1350, which went into effect on January 1, 2015. However, if the facility were operating between the baseline period of 2002-2004, the facility would not be subject to current stocking density requirements. Therefore, the facility would be able to house more birds in the same amount of space.

The University of California Cooperative Extension, California Poultry Workgroup publication "Animal Care Series: Egg-Type Layer Flock" (May 1998)[19] indicates that 72 in^2 of floor space per hen was associated with the highest egg production but that with good management, 50-60 in^2 of floor space per hen can give comparable results. Assuming the average value of the required floor space range given for laying hens in this document (50-72 in^2 per bird), results in approximately 61 in^2 per hen. This value is 47% less than the minimum space requirement required by Section 1350 of Title 3 of the California Code of Regulations and can be used to calculate the number of hens that the proposed houses would have been capable of housing before this regulation became effective.

[16] http://elections.cdn.sos.ca.gov/sov/2008-general/ssov/10-ballot-measures-statewide-summary-by-county.pdf
[17] http://vig.cdn.sos.ca.gov/2008/general/text-proposed-laws/text-of-proposed-laws.pdf#prop2
[18] http://ucanr.edu/sites/CESonomaAgOmbuds/files/174478.pdf
[19] https://www.cdfa.ca.gov/ahfss/mpes/pdfs/eggsafetyrule.pdf

Based on the typical floor space requirements for laying hens that were in effect prior to California Proposition 2 and Section 1350 of Title 3 of the California Code of Regulations, it is estimated that each of the proposed hen houses at Central Valley Eggs would have been capable of housing approximately 777,886 hens (based on 329,521 ft^2 of total space for laying hens in each cage-free house, 145.11 in^2 of space per bird, as provided by the applicant), for a total of 5,445,202 hens in the seven proposed poultry houses. Pursuant to information provided from the applicant, the pullet houses are not subject to California Proposition 2 requirements. Therefore, it will be assumed that the three pullet houses would have been capable of housing the same number of birds in 2002-2004 that they are proposing to house in this project, 1,050,000 pullets.

Basis and Assumptions

- Laying hen capacity is 5,445,202 hens (estimated based on the housing area of the proposed facility and pre-Proposition 2 housing practices).
- The pullet houses are not required to comply with Proposition 2 requirements. Therefore, the maximum number of pullets that will be kept in each of the three pullet houses will be set equal to the numbers proposed by Central Valley Eggs under this project, 350,000, resulting in a total of 1,050,000 pullets for the three houses (proposed by the applicant).
- Emission factors for hens are based on the documentation for ARB's 2015 Edition of the GHG Emission Inventory (Released June 2015):
    - *Emission factor for CH_4 = 647 g of CO_2eq/head of hens 1+ yr*
    - *Emission factor for N_2O = 1,070 g of CO_2eq/head of hens 1+ yr*
- Emission factors for pullets will be determined using similar assumptions to the PM_{10}, VOC and NH_3 emission rates in Section VII.B above (uncontrolled emission factors) that pullets will generate approximately 61.8% of the emissions that adult laying hens generate (comparison of an uncontrolled emission factors between laying hens and the sum of chick starters plus pullet growers).

Calculations

Total Laying Hen Emissions (CH_4+N_2O) = 647 + 1,070 g of CO_2eq/head of hens/year
= 1,717 g of CO_2eq/head of hens/year
= 1.717 kg of CO_2eq/head of hens/year

Total Pullet Emissions (CH_4+N_2O) = 1.717 kg of CO_2eq/head of hens/year x 0.618 kg-pullet/kg-hen
= 1.061 g of CO_2eq/head of pullets/year

Baseline GHG Emissions = Number of hens x 1.717 kg of CO_2eq/head of hens/year + Number of Pullets x 1.061 kg of CO_2eq/head of pullets/year

Baseline GHG Emissions = 5,445,202 hens x 1.717 kg of CO_2eq/head of hens/year + 1,050,000 pullets x 1.061 kg of CO_2eq/head of pullets/year

Baseline GHG Emissions = 10,463,461 kg of CO_2eq/year

Converting to Metric Ton = 10,463,461 *kg of CO_2eq/year x 1 metric ton/1,000 kg*

Total Proposed GHG emissions = 10,463 metric ton of CO_2eq/year

Reduction in GHG Emissions:

As calculated above,

- Proposed Project GHG Emissions = 5,044 metric tons of CO_2eq/year
- 2002-2004 Baseline GHG Emissions = 10,463 metric tons of CO_2eq/year

Therefore, the percent reduction in GHG emissions is calculated as follows:

$$\%\ \text{Reduction in GHG emissions} = \frac{(10{,}463\ \text{tons - CO2e/yr}) - (5{,}044\ \text{tons - CO2e/yr})}{10{,}463\ \text{tons - CO2e/yr}} \times 100\%$$

% Reduction in GHG Emissions = 51.8%

As calculated above, the proposed project results in GHG emissions reductions of 51.8% compared to BAU. Therefore, the project is considered to have a less than significant impact for GHG emissions.

APPENDIX H

Health Risk Assessment (HRA) and Ambient Air Quality Analysis (AAQA) Summaries

San Joaquin Valley Air Pollution Control District
Risk Management Review

To:	Dustin Brown – Permit Services
From:	Kyle Melching – Technical Services
Date:	August 24, 2016
Facility Name:	Central Valley Egg
Location:	Gun Club Rd & Hannawalt Ave., Wasco
Application #(s):	S-8841-1-0 thru 15-0
Project #:	S-1161654

A. RMR SUMMARY

Chicken Egg Production w/ Diesel-fired IC Engines	Prioritization Score	Acute Hazard Index	Chronic Hazard Index	Maximum Individual Cancer Risk	T-BACT Required?	Special Permit Conditions?
1-0	>1	0.89	0.41	3.08E-06	See Conclusion	No
2-0	N/A[1]	N/A[1]	N/A[1]	N/A[1]	No	No
3-0	>1	N/A[2]	0.00	5.92E-08	No	Yes
4-0	>1	N/A[2]	0.00	5.97E-08	No	Yes
5-0	>1	N/A[2]	0.00	5.24E-08	No	Yes
6-0	>1	N/A[2]	0.00	5.26E-08	No	Yes
7-0	>1	N/A[2]	0.00	4.63E-08	No	Yes
8-0	>1	N/A[2]	0.00	4.67E-08	No	Yes
9-0	>1	N/A[2]	0.00	4.16E-08	No	Yes
10-0	>1	N/A[2]	0.00	1.35E-07	No	Yes
11-0	>1	N/A[2]	0.00	1.23E-07	No	Yes
12-0	>1	N/A[2]	0.00	9.60E-08	No	Yes
13-0	>1	N/A[2]	0.00	4.19E-08	No	Yes
14-0	>1	N/A[2]	0.00	9.31E-08	No	Yes
15-0	>1	N/A[2]	0.00	8.18E-08	No	Yes
Project Totals	**>1**	**0.89**	**0.41**	**4.01E-06**		
Facility Totals	**>1**	**0.89**	**0.41**	**4.01E-06**		

[1]Emission factors from the manure storage are built into the emission factors for the hen and pullet houses. Therefore, the risks from this unit will be captured in (Unit 1-0) chicken housing.
[2]Acute and Chronic Hazard Indices were not calculated since there is no risk factor, or the risk factor is so low that the risk has been determined to be insignificant for this type of unit.

Proposed Permit Requirements

To ensure that human health risks will not exceed District allowable levels; the following shall be included as requirements for:

Units # 3-0 thru 14-0

1. The PM10 emissions rate shall not exceed 0.07 g/bhp-hr based on US EPA certification using ISO 8178 test procedure.
2. The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction.
3. This engine shall be operated only for testing and maintenance of the engine, required regulatory purposes, and during emergency situations. Operation of the engine for maintenance, testing, and required regulatory purposes shall not exceed 50 hours per calendar year.

Units # 15-0

1. The PM10 emissions rate shall not exceed 0.08 g/bhp-hr based on US EPA certification using ISO 8178 test procedure.
2. The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction.
3. This engine shall be operated only for testing and maintenance of the engine, required regulatory purposes, and during emergency situations. Operation of the engine for maintenance, testing, and required regulatory purposes shall not exceed 50 hours per calendar year.

B. REPORT

I. Project Description

Technical Services received a request on June 22, 2016, to perform an Ambient Air Quality Analysis and a Risk Management Review for the installation of 7 new layer hen houses (barns) and three pullet houses (barns) consisting of a total of 3,339,000 birds in all. In addition, the facility will be permitting one manure storage unit, twelve 464 BHP diesel-fired emergency standby IC engines, and one 755 BHP diesel-fired emergency standby IC engine.

II. Analysis

RMR

VOC toxic emissions for this proposed unit were calculated using emission factors generated from a 2004 source test conducted on a Broiler House in the District. PM based toxic emissions factors from Livestock Dust were calculated using emission factors generated from using the worst case composite of the 1997 EPA speciation of Kern County feedlot soil. The toxic emissions were input into the San Joaquin Valley APCD's Hazard Assessment and Reporting Program (SHARP). In accordance with the District's Risk Management Policy for Permitting New and Modified Sources (APR 1905, May 28, 2015), risks from the proposed unit's toxic emissions were prioritized using the procedure in the 1990 CAPCOA Facility Prioritization Guidelines. The prioritization score for the facility is greater than 1.0 (see RMR Summary Table). Therefore, a refined health risk assessment was required. The AERMOD model was used, with the parameters outlined below and meteorological data for 2007-2011 from Wasco to determine the dispersion factors (i.e., the predicted concentration or X divided by the normalized source strength or Q) for a receptor grid. These dispersion factors were input into the SHARP Program, which then used the Air Dispersion Modeling and Risk Tool (ADMRT) of the Hot Spots Analysis and Reporting Program Version 2 (HARP 2) to calculate the chronic and acute hazard indices and the carcinogenic risk for the project. Each modeled barn PM10 emission's used was a variable emission factor (by month/hour/day). This emission factor was derived to reflect the operations of the exhaust fans utilization rate based on the temperature outside; which utilizes met data temperature values. For the acute risk, a refined ammonia (NH3) analysis was ran since it was determined the ammonia accounted for over 99% of the total acute risk. Hourly lb/ammonia toxicity was modeled from each barn to determine the refined acute risk associated with the project.

The following parameters were used for the review:

Unit ID	Unit Description	PM10 Emissions (lb/hr)	PM10 Emissions (lb/yr)	NH3 Emissions (lb/hr)	NH3 Emissions (lb/yr)	Increase # of Hen*
1-0 (LH1)	Hen Housing	0.31	2,711	6.87	60,152	327,000
1-0 (LH2)	Hen Housing	0.31	2,711	6.87	60,152	327,000
1-0 (LH3)	Hen Housing	0.31	2,711	6.87	60,152	327,000
1-0 (LH4)	Hen Housing	0.31	2,711	6.87	60,152	327,000
1-0 (LH5)	Hen Housing	0.31	2,711	6.87	60,152	327,000
1-0 (LH6)	Hen Housing	0.31	2,711	6.87	60,152	327,000
1-0 (LH7)	Hen Housing	0.31	2,711	6.87	60,152	327,000
1-0 (PHA)	Pullet Housing	0.14	903	4.1	26,319	350,000
1-0 (PHB)	Pullet Housing	0.14	903	4.1	26,319	350,000
1-0 (PHC)	Pullet Housing	0.14	903	4.1	26,319	350,000
3-0	LHDICE1	0	4	N/A	N/A	N/A
4-0	LHDICE2	0	4	N/A	N/A	N/A
5-0	LHDICE3	0	4	N/A	N/A	N/A
6-0	LHDICE4	0	4	N/A	N/A	N/A
7-0	LHDICE5	0	4	N/A	N/A	N/A
8-0	LHDICE6	0	4	N/A	N/A	N/A
9-0	LHDICE7	0	4	N/A	N/A	N/A
10-0	PHDICEA	0	4	N/A	N/A	N/A
11-0	PHDICEB	0	4	N/A	N/A	N/A
12-0	PHDICEC	0	4	N/A	N/A	N/A
13-0	DICE13	0	4	N/A	N/A	N/A
14-0	FIREWDICE	0	4	N/A	N/A	N/A
15-0	OFFICEICE	0	7	N/A	N/A	N/A

*Number of head account for VOC TAC emissions

Modeled Source ID	Unit Description	Release Height (m)	Length of Side (m)	Initial Lat. Dim. (m)	Initial Vert. Dim. (m)
LH1 thru LH7	Barns 1-7 Emissions	5.3	2.89	0.67	4.96
PHA thru PHC	Barns A-C Emissions	5.3	2.89	0.67	4.96

Modeled Source ID	Unit Description	Release Height (m)	Diameter (m)	Velocity (m/s)	Temperature (K)
Units 3-0 thru 14-0	464 BHP Diesel ICE	3.66	0.15	55.6	777
Unit 15-0	755 BHP Diesel ICE	3.66	0.2	53	755

AAQA. In addition to the RMR, Technical Services performed modeling for the criteria pollutants associated with the project.

The results from the Criteria Pollutant Modeling for the **engines** are as follows:

Diesel ICE's	1 Hour	3 Hours	8 Hours.	24 Hours	Annual
CO	NA[1]	X	NA[1]	X	X
NO_x	NA[1]	X	X	X	Pass
SO_x	NA[1]	NA[1]	X	NA[1]	Pass
PM_{10}	X	X	X	NA[1]	Pass[2]
$PM_{2.5}$	X	X	X	NA[1]	Pass[2]

*Results were taken from the attached PSD spreadsheet.
[1]The project is an intermittent source as defined in APR-1920. In accordance with APR-1920, compliance with short-term (i.e., 1-hour, 3-hour,8-hour and 24-hour) standards is not required.
[2]The criteria pollutants are below EPA's level of significance as found in 40 CFR Part 51.165 (b)(2).

The results from the Criteria Pollutant Modeling for the **barns** are as follows:

Each layer barn's maximum hourly emission rate is 0.31 lb-PM_{10}/hr. Each pullet barn maximum hourly emission rate is 0.14 lb-PM_{10}/hr. PM10 from the barns were modeled with a variable emission factor (by month/hour/day). This emission factor was derived to reflect the operations of the exhaust fans utilization rate based on the temperature outside; which utilizes met data temperature values.

$PM_{10\ \&\ 2.5}$ Pollutant Modeling Results*
Values are in µg/m^3

Category	24 Hours	Annual
Net Value	7.96	1.78
Interim Significance Level	10.4[1&2]	2.08[1&2]
Result	Pass	Pass

[1]Per District 1925 the SIL threshold for fugitive dust sources is 10.4 µg/m3 for the 24-hour average concentration and 2.08 µg/m3 for the annual concentration.
[2]On January 22, 2013, the United States Court of Appeals for the District of Columbia Circuit (Court) granted a request from the Environmental Protection Agency (EPA) to vacate and remand to the EPA the portions of two Prevention of Significant Deterioration (PSD) PM2.5 rules (40 CFR 51.166 and 40 CFR 52.21) addressing the Significant Impact Levels (SILs) for PM2.5 so that the EPA could voluntarily correct an error in these provisions. Until EPA establishes new SILs for PM2.5, the District will consider compliance with the PM10 standards as a surrogate for compliance with the PM2.5 standards.

III. Conclusion

Unit 1-0 Barns

The acute and chronic indices are below 1.0 and the cancer risk factor associated with each barn is less than 1.0 in a million. **In accordance with the District's Risk Management Policy, the project is approved without Toxic Best Available Control Technology (T-BACT).**

Unit 3-0 thru 15-0 Engines

The cancer risk associated with each proposed diesel IC engine is less than 1.0 in a million. In accordance with the District's Risk Management Policy, the project is approved without Toxic Best Available Control Technology (T-BACT) for PM10.

To ensure that human health risks will not exceed District allowable levels; the permit requirements listed on page 1 of this report must be included for this proposed unit.

These conclusions are based on the data provided by the applicant and the project engineer. Therefore, this analysis is valid only as long as the proposed data and parameters do not change.

The emissions from the proposed equipment will not cause or contribute significantly to a violation of the State and National AAQS.

The ambient air quality impacts from PM_{10} emissions from the poultry ranch do not exceed the District's 24-hour or Annual interim threshold for fugitive dust sources.

IV. Attachments

A. RMR request from the project engineer
B. Additional information from the applicant/project engineer
C. Prioritization score w/ toxic emissions summary.
D. Facility Summary
E. Variable Emission Rates

APPENDIX I

Quarterly Net Emissions Change (QNEC)

Quarterly Net Emissions Change (QNEC)

The Quarterly Net Emissions Change is used to complete the emission profile screen for the District's PAS database. The QNEC shall be calculated as follows:

QNEC = PE2 - PE1, where:

QNEC = Quarterly Net Emissions Change for each emissions unit, lb/qtr.
PE2 = Post-Project Potential to Emit for each emissions unit, lb/qtr.
PE1 = Pre-Project Potential to Emit for each emissions unit, lb/qtr.

Using the values in Sections VII.C.2 and VII.C.1 in the evaluation above, quarterly PE2 and quarterly PE1 can be calculated as follows:

$PE2_{quarterly} = PE2_{annual} \div 4$ quarters/year

$PE1_{quarterly} = PE1_{annual} \div 4$ quarters/year

S-8841-1-1 or -1-2:

Quarterly NEC [QNEC]			
Pollutant	**PE2 (lb/qtr)**	**PE1 (lb/qtr)**	**QNEC (lb/qtr)**
NO_X	0	0	0
SO_X	0	0	0
PM_{10}	5,404	0	5,404
CO	0	0	0
VOC	9,634.5	0	9,634.5