

APPENDIX B

SMP CA1B
SITE MONITORING PLAN FOR BROILER RANCH IN CALIFORNIA

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Site Description

The University of California-Davis (UCD), with assistance from Purdue University, will measure emissions from two broiler barns at a 16-barn broiler ranch in Stanislaus County, California. The overall layout of the site is provided in Fig. 1. The broiler site is located 163 km (102 mi) driving distance from the UCD and 3,565 km (2,228 mi) driving distance from Purdue.

The barns are oriented E-W and spaced 12.2 m (40 ft) apart (Fig. 1). The barn roofs have a 4:12 slope. Each barn is 125 m (410 ft) long x 12.2 m (40 ft) wide and houses 21,000 birds that grow from 0.05 to 2.41 kg (1.1 to 5.3 lb). Six to seven batches of birds are raised in each barn every year, and all barns are on the same growth cycle.

Average monthly climatic data for the site is presented in Table 1. Average daytime high temperatures range from the mid-50's (°F) (~12°C) in the winter to mid-90's (~35°C) in the summer. Average overnight lows (°F) range from the mid-30's (~3°C) in winter to the low 60's (~16°C) in summer. Prevailing winds are from the SE in the winter, and W to WNW during the rest of the year.

Birds are fed a pelleted diet consisting of 62% corn, 22% soybeans, 19.5% protein, and 3% poultry fat. Feed is delivered by auger. All litter is removed from the barn after three batches, and is taken off-site (to a fertilizer plant) within 2-3 d on average. Prior to being removed from the site, manure may remain in piles by the road (to the W of the barns) for 2-3 days. Between each batch, the top 20 to 25% of the litter is removed the entire length of the barn in a decaking operation using a Lewis Brothers Housekeeper. After decaking, the remaining litter at the front of the barn is moved to the back of the barn and 34.4-m³ (45-yd³) of rice hulls are placed in the front using a 3.8-m³ (5-yd³) Carry-All Soil Mover.

Ventilation air enters the barn through pressure-adjusted baffled air inlets at the eaves (Fig. 2). The air is exhausted out the W end of the barn where there are ten, 1.2-m. (48-in) diameter belted exhaust fans (Model 48318-235, Chore-Time, Milford, IN) located in banks of five fans on the north and south sidewalls. The fans on the N and S walls are 0.2 m (8 in) apart. The fan motors for the 1.2-m (48-in) fans are 1 Hp (Model # 5KCR49UN0462AT). The five fans located on the north sidewall (Fig. 3) are numbered 3 through 7 (Fig. 4), and the five fans located on the S wall (Fig. 5) are numbered 8 through 12 (Fig. 4). In addition, there is one 0.9-m (36-in) diameter belted exhaust fan (Model AT365Z1CP, Aerotech, Mason, MI) located on the W wall at the back of the barn. This fan is designated as Fan #2, and has a 1/2-Hp motor (Model # 177509-01). Finally, there is one other 0.9-m (36-in) diameter belted exhaust fan (Model AT365Z1CP, Aerotech, Mason, MI), designated Fan #1, located on the E wall; however, this fan is inactive, and will remain so throughout the study. The barn has six temperature sensors. Fan relay control regimes are dependent upon the age of the birds; a total of 8 different schemes are used (Table 2), depending on two factors – namely, the age of the birds and the maximum

temperature (with 75°F being the transition point between schemes). Eight of the 10 fan relays control single fans, while two (relays 6 and 10) each control two of the 48-in fans (Fig. 4).

During cooler weather, the front half of the barn is heated by 14 LP Radiant Brooders (42,000 Btu/h), while the rest of the barn is heated by 3 LB White Convection LP heaters (180,000 Btu/h). During warmer conditions, supplemental cooling is provided by evaporative pads, which are located at the E ends of the barns (Fig. 6). These are Munters pads made of a paper product, and are four feet high, eight inches deep, and 12 inches wide. The lights are shut off for several hours each night. Water consumption is recorded by an automatic water meter. Daily mortalities are recorded manually.

The farm follows a strict biosecurity policy, which requires that visitors not have been on another broiler or layer farm for at least 48 h prior to coming onsite. Persons are required to shower and wear clean protective clothing (bodysuits, hairnets, and boots), and instruments and equipment are required to be disinfected before being brought onsite. Access to the farm by outside vehicles is restricted; the farm requires personnel and equipment to be brought onsite using the farm's golf cart. Advance notice of site visits is thus required.

Other potential pollution sources near the farm include a hatchery just over one mile W of the ranch, another 10-house broiler ranch approximately $\frac{3}{4}$ mi to the NNW, and a large dairy about $\frac{1}{2}$ mi to the NW.

This site was selected for monitoring for the National Air Emissions Monitoring Study for the following reasons:

1. It is owned by Foster Farms, the top broiler producer in California.
2. The site represents the type of barns that Foster Farms uses in California.
3. The site meets the criteria for site selection.

Monitoring Plan

The barns selected for measurement are barns 10 and 12, which are part of a complex of 16 barns (Fig. 1) that was built in the 1960s and remodeled in 2002. Figs. 7 and 8 show schematics of the monitoring plan for the barns, and Table 3 lists the locations at which the various samples will be collected. It is intended that data collection will commence at the beginning of one of the growth cycles that is started after a full removal of litter from the barn. The on-farm instrument shelter (OFIS, SOP U1) will be positioned at the far W end of the space (Fig. 9) between barns 10 and 12 (Fig. 7), with a N/S orientation to minimize interference with vehicle traffic along the driveway W of the barns. The OFIS will be positioned somewhat off-center in the space between the barns, so as to leave enough space to one side for vehicle access (note that positioning the OFIS on-center in the space would have left approximately 2.5 m (8 ft) on either side, which was judged to be insufficient to allow access). Heated raceways (SOP U3) will be used to connect the OFIS with each barn, to avoid condensation in the sampling lines during cold weather.

Three gas sampling probes will be placed in the W end of each barn, near the exhaust fans at a height equal to the fan hubs (Fig. 7). One gas sampling probe (A) is located in front of the inlet of fan 2, and between fans 5 and 10. Gas sampling probes B and C are located 3 m (10 ft) from each sidewall, in a cross-sectional plane that is 1 m (3 ft) E of fans 7 and 12. Each sampling location will be sampled individually with one tube using a PAAQL gas sampling system (GSS, SOP G1). The inlet air sampling location will be located at approximately the midpoint (lengthwise) of the barns, near one of the two barns. Except for the 2-3 day stockpiling of litter just outside the far end of the barns, there are no outdoor manure storages or lagoon to contribute to inlet contaminant concentrations, and these are expected to be relatively low and stable.

All sampling locations will be connected to the GSS using Teflon tubing. The control sequence for the six barn locations during each 60-min sampling cycle is given in Table 4. The ambient location will be monitored for 30 min twice daily. Thus, there will be 23 samples taken per location every day, unless calibration or other interruption of sampling occurs.

One set of gas analyzers in the OFIS will be used to sequence through all the GSLs. A TE Model 450C fluorescence-based analyzer (SOP G5) will be used to measure H₂S. Ammonia and CO₂ will be measured with an INNOVA Model 1412 Photoacoustic IR multi-gas monitor (SOP G7). The INNOVA Model 1412, will also measure methane, methanol, and non-methane VOC concentrations, the last of these by measuring total VOC and subtracting methane and methanol.

Continuous inlet PM measurements will be taken using a Beta-Gage monitor (SOP P4), which will be located at the inlet gas-sampling location of barn 10 (Fig. 7), enclosed in a protective outdoor enclosure. This location for the inlet PM monitor is very close to the ventilation inlet air entrances, and the closest possible contaminant sources – the exhaust fans at the W end of the barns – are more than 60 m (200 ft) away, although they will be downwind approximately $\frac{3}{4}$ of the time (Table 1). The driveway around the complex is paved, so vehicle traffic should not stir up much dust; however, the area between the barns is neither paved nor vegetated. Vehicle traffic through this area could cause “spikes” of dust to the inlet PM monitor; however, such traffic is infrequent. TEOMs will continuously sample exhaust PM₁₀ (SOP P1), and will be located about 6 m (19 ft) in front of fan 7, which is denoted as the primary representative exhaust fan (PREF) for each barn, as shown in Fig. 7. This places the TEOM at approximately the midpoint of a line connecting fans 7 and 12. The PM₁₀ inlet head on the TEOMs and Beta-Gage will be replaced with PM_{2.5} heads for two, two-week periods over the course of the study. The first of these is scheduled for December 5-20, 2007; the second, for June 15-30, 2008. TSP inlet heads will be placed on the TEOMs and Beta-Gage for one week every 8 weeks, beginning with the first week of data collection.

Capacitance-type relative humidity and temperature probes (SOP E2) will be located at the W end of each barn, near the TEOM (Fig. 7). A solar radiation shielded (SOP E3) RH/temperature probe (SOP E2) and a wind anemometer (SOP E4) will be attached to a 1-m (3-ft) aluminum tower (SOP E5) located on the ridge of Barn 10 near the OFIS.

Thermocouples (TC) will be used to measure temperatures (SOP E1) at each sampling point, and will also be distributed with equal spacing along the center of each barn. These will be attached

to the 4"x 4" support posts which run down the center of the barn at 10' intervals (Fig. 10). Two TC will be located next to the two brooders closest to the OFIS, and two will be located at the center of the evaporative pads (Fig. 7). Thermocouples will also be located in the heated raceway between the barn and OFIS (SOP U3). Two TC will be located in the OFIS; one will measure the temperature of the OFIS, and one will measure the temperature of the instrument rack.

Barn static pressure will be measured (SOP A5) in the barn across the N, S, and W walls (Fig. 7). The outside port will be located against the outside wall near the ventilation fans of the north, south, and west walls. These pressures will be different with northerly, southerly, and westerly winds. Static pressure in the OFIS will also be measured, to ensure that positive pressure is maintained.

Fan operation will be monitored using RPM sensors mounted on the 11 active fans in each barn. No sensors will be mounted on the inactive fan #1 at the E end of the barns. The Hall-effect RPM sensors will be mounted to detect the rotational speed (RPM) of either the fan shaft, a fan blade, or the fan pulley. The digital signal from the RPM sensor will be converted into a frequency measurement with a counter module in the data acquisition system. Impeller anemometers (SOP A3) will be mounted on the PREF (fan 7) in each barn, and on one of the infrequently-used 36-in fans (fan #2 in Barn 12).

The FANS analyzer (SOP A2) will be used to test fans in the barns. If there are any fans that are inaccessible to the FANS analyzer, the traversing method (SOP A8) will be used to test these fans.

Relays that control lights, brooders and feeders will also be monitored in each barn, using auxiliary contacts in 5-VDC circuits, in conjunction with the digital inputs of the data acquisition system (SOP S4). Activity sensors (SOP S3) will be located to monitor movement of birds and workers in the barn (Fig. 7); as with the thermocouples, these will be mounted to the support posts along the center axis of the barn (Fig. 10). Activity sensors will also be used to monitor researcher presence in the OFIS.

An initial characterization study of barn VOCs will be conducted on one day during the first month of data collection. While total VOC emissions are continuously monitored using the INNOVA 1412, along with building airflow rate, VOCs will be sampled with duplication at fan 7 (the primary representative exhaust fan) in each barn, using sorbent tubes (SOP V1) and Silcosteel canisters (SOP V2) for phenols and volatile fatty acids (VFAs), and all-glass bubblers (SOP V3) for linear and cyclic amines. Each phenol/VFA sample (sorbent tubes or canisters) will be evaluated using gas chromatography – mass spectrometry (GC-MS) (SOP V4 or V6, respectively, for sorbent tubes and canisters), while amines collected in the bubblers will be analyzed by ion chromatography (IC) (SOP V5). Any single analyte that contributes more than 5% of the total VOC mass (as determined by the PIR) will be identified during this initial characterization study. Whichever individual sampling method(s) (sorbent tubes, canisters, and/or bubblers) best captures these analytes will be employed for the remainder of the study. VOC samples will be collected through the GSS, and will be collected from GSL-C at fan 7 (1 m

E of fan 7 and 3 m from the S wall of the barn – Table 3) in each of the two barns. This subsequent VOC sampling will be conducted on a quarterly basis.

Litter on the floor of the barns will be sampled (SOP M1) six times per year; one sampling run will be conducted each season, and will be timed to take place near the middle of a brood cycle. At each time point, 16 samples will be collected from each of the two barns; collection points will be chosen such that 8 are taken in the portion of the barn with relatively fresh litter (the front), and 8 from the portion with the older litter (the back). Apart from this specification, sample locations will be randomly selected. Thus, the two groups together will give a representative picture of the barn as a whole. At each sampling point, all litter in a 2-ft radius will be brought to the center of the sampling location and mixed for a composite sample. These samples will be analyzed for pH (SOP M2) and solids content (SOP M3), and will provide the primary data for correlating these manure (litter) properties with emissions.

The material removed from the barn during each full cleanout (those after each second or third brood) will also be sampled. Three of these events would occur in the first year of the study, and two or three in the second, with the last occurring near the conclusion of the two-year data collection period). During each of these events, 12 samples will be taken from the blended litter pile before it is removed from the site, and 4 samples of the new incoming bedding will be collected. To compare the composition of the litter removed during the full cleanouts with litter removed after the decaking operations, three of these events will also be sampled. Six samples will be taken from the blended pile. Analysis of samples taken from the litter removed during the full cleanout and from litter removed during decaking will provide data for the N mass balance for the facility (SOP S5). The samples will be analyzed for total (Kjeldahl) nitrogen (SOP M4), ammoniacal nitrogen (SOP M5), pH (SOP M2) and solids content (SOP M3). Incoming bedding and feed will be analyzed for Kjeldahl N (SOP S6). Analytical data for feed will be compared with that provided by the producer (SOP S1). Manure production per barn (for the full cleanouts and the decaking operations) will be estimated by determining the total volume of manure removed off-site from cleanout or decaking operations, and dividing by the number of barns (16).

Data on animal inventory, mortalities and weight will also be provided by the producer, and will be verified quarterly by the study personnel (SOP S2). Hatchery and slaughterhouse counts (SOP S2) will also be obtained as additional checks on the accuracy of the counts. Water will be evaluated with several samples of the water provided to the animals. The producer also records daily mortalities (SOP S2), and will provide this data (SOP S1). Nitrogen content of the animals themselves (mortalities, birds sent to slaughter) will be determined from the literature.

OFIS Electrical Power Supply

The OFIS will be supplied with 3-wire, single-phase, mid-point neutral, 120/240-volt, 100 A at 240 V (SOP U1) power by the farm. The electrical lines will be run from the power supply control box situated on the W side between Barns 8 and 10, across Barn 10 to reach the external pullout switch at the OFIS. The outdoor section of power line will be protected by electric PVC

conduit. The section run through the open ground will be buried. A copper ground rod will be installed at the location of the OFIS and connected to the OFIS ground.

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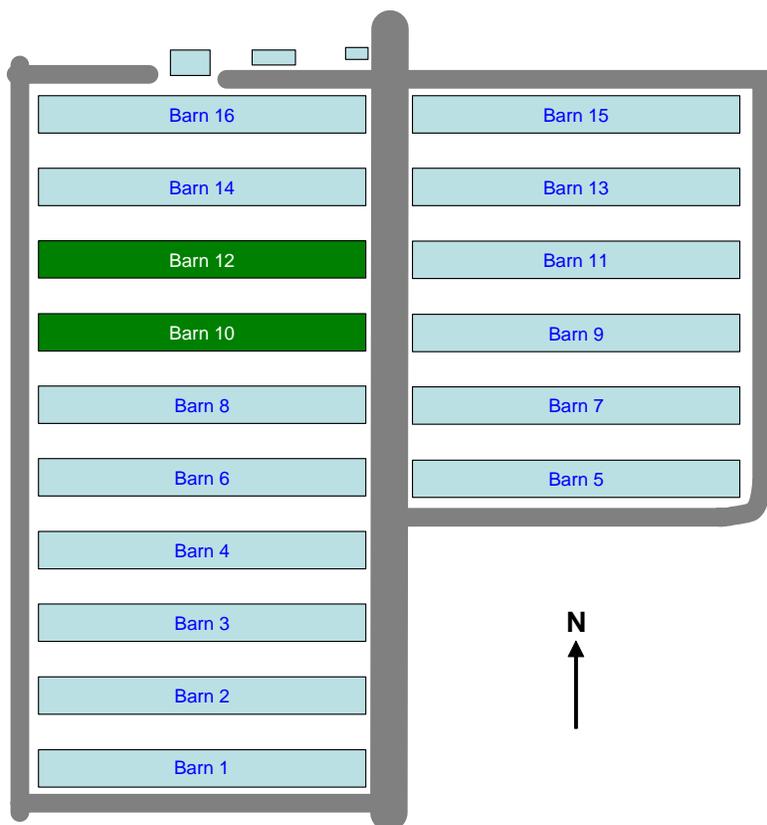


Figure 1. Layout of the facility. Continuous emissions will be measured at barns 10 and 12.

Table 1. Monthly averages for weather conditions at the site*.

Month	Temperature		Precipitation		Wind Speed	Wind Direction
	High (°F / °C)	Low (°F / °C)	Rain (in / mm)	Snow (in / cm)	Mph / kmh	(From)
January	53 / 12	37 / 3	2.84 / 72.1	0.0 / 0.0	8 / 13	SE
February	61 / 16	40 / 5	1.97 / 50	0.0 / 0.0	8 / 13	SE
March	65 / 19	43 / 6	2.17 / 55.1	0.0 / 0.0	9 / 15	WNW
April	73 / 23	46 / 8	1.08 / 27.4	0.0 / 0.0	10 / 15	WNW
May	82 / 28	52 / 11	0.26 / 6.6	0.0 / 0.0	11 / 17	W
June	89 / 32	58 / 14	0.08 / 2.0	0.0 / 0.0	11 / 18	W
July	94 / 35	61 / 16	0.06 / 1.5	0.0 / 0.0	10 / 16	WNW
August	93 / 34	61 / 16	0.07 / 1.8	0.0 / 0.0	9 / 15	WNW
September	88 / 31	58 / 14	0.35 / 8.9	0.0 / 0.0	9 / 14	WNW
October	78 / 26	51 / 10	0.79 / 20.1	0.0 / 0.0	7 / 12	WNW
November	63 / 17	43 / 6	2.17 / 55.1	0.0 / 0.0	7 / 12	SE
December	53 / 12	37 / 3	2.11 / 53.6	0.0 / 0.0	8 / 13	SE

*<http://www.weatherunderground.com>



Figure 2. Air inlet in the eave of the barn.



Figure 3. The bank of 48-in fans in the N sidewall of barn 10.

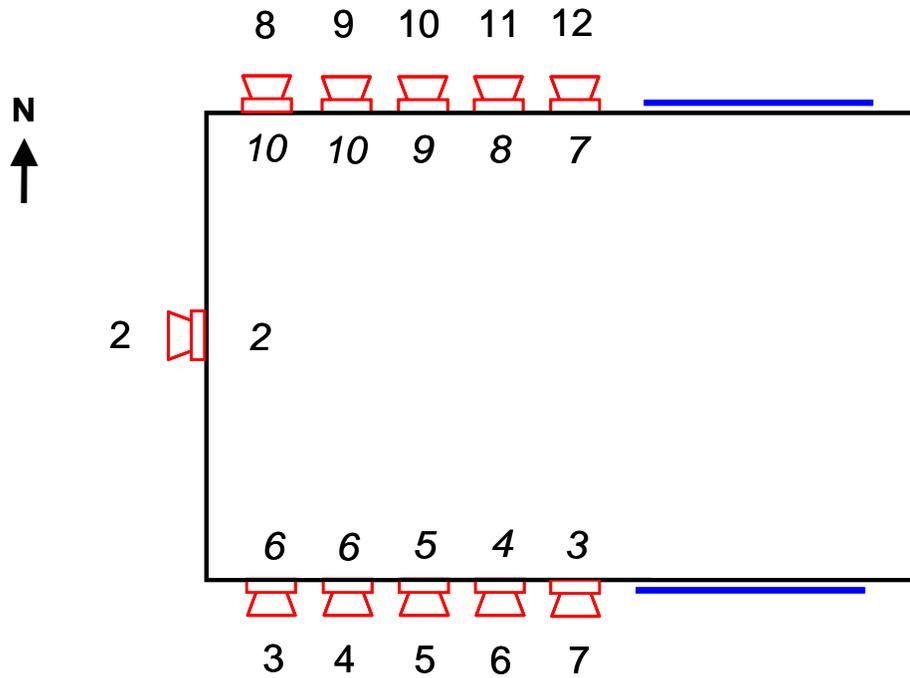


Figure 4. Fan assignments to control relays. Fan numbers are on the outside; relay numbers are on the inside. Note that relays 6 and 10 each control two adjacent fans.



Figure 5. The bank of 48-in fans in the S sidewall of barn 10, as seen from the outside.

Table 2. Fan relay control for the various stages of the 8 temperature control regimes used at the California broiler farm site.

Fan relays running	Timer relays	% on	Scheme ¹								Fan relays running (proposed) ²
			1	2	3	4	5	6	7	8	
<u>Tunnel Ventilation</u>											
3,4,5,6,7,8,9,10											3,4,5,6,7,8,9,10
3,4,5,6,7,10											3,4,5,6,7,10
3,4,5,6,7,8											3,4,5,6,7,8
3,4,5,7,8,9											3,4,5,7,8,9
3,4,5,7,8											3,4,5,7,8
3,4,7,8											3,4,7,8
3,4,7											3,4,7
3,7											3,7
3,2											3,2
<u>Power Ventilation</u>											
3,4,5,7,8											3,4,5,7,8
3,4,5,6											3,4,5,6
3,4,7,8											3,4,7,8
3,4,7,2											3,4,7,2
3,4,7											3,4,7
3,4,5											3,7,5
3,4,2											3,7,2
3,7,2											3,7,2
3,7											3,7
3,4	3,4	100									3,7
3,4	3,4	80									3,7
3,7	3,7	80									3,7
3,7	3,7	60									3,7
3,2	3,2	100									3,2
3,2	3,2	80									3,2
3,2	3,2	75									3,2
3,2	3,2	50									3,2
3,2	3,2	35									3,2
3,2	3,2	20									3,2
3,2	3,2	10									3,2
3,2	2	50									3,2
3,2	2	30									3,2
3	3	100									3
3	3	75									3
3	3	50									3
3	3	35									3
3	3	20									3
3	3	10									3

¹Scheme numbers: 1 = Days 1-9, 2 = Days 10-28, 3 = Days 28-ship, 4 = Days 1-9 (T>75), 5 = Days 10-14 (T>75), 6 = Days 15-24 (T>75), 7 = Days 25-29 (T>75), 8 = Days 29-ship (T>75).



Figure 6. Evaporative cooling pads in the sidewall near the E end of one of the barns.

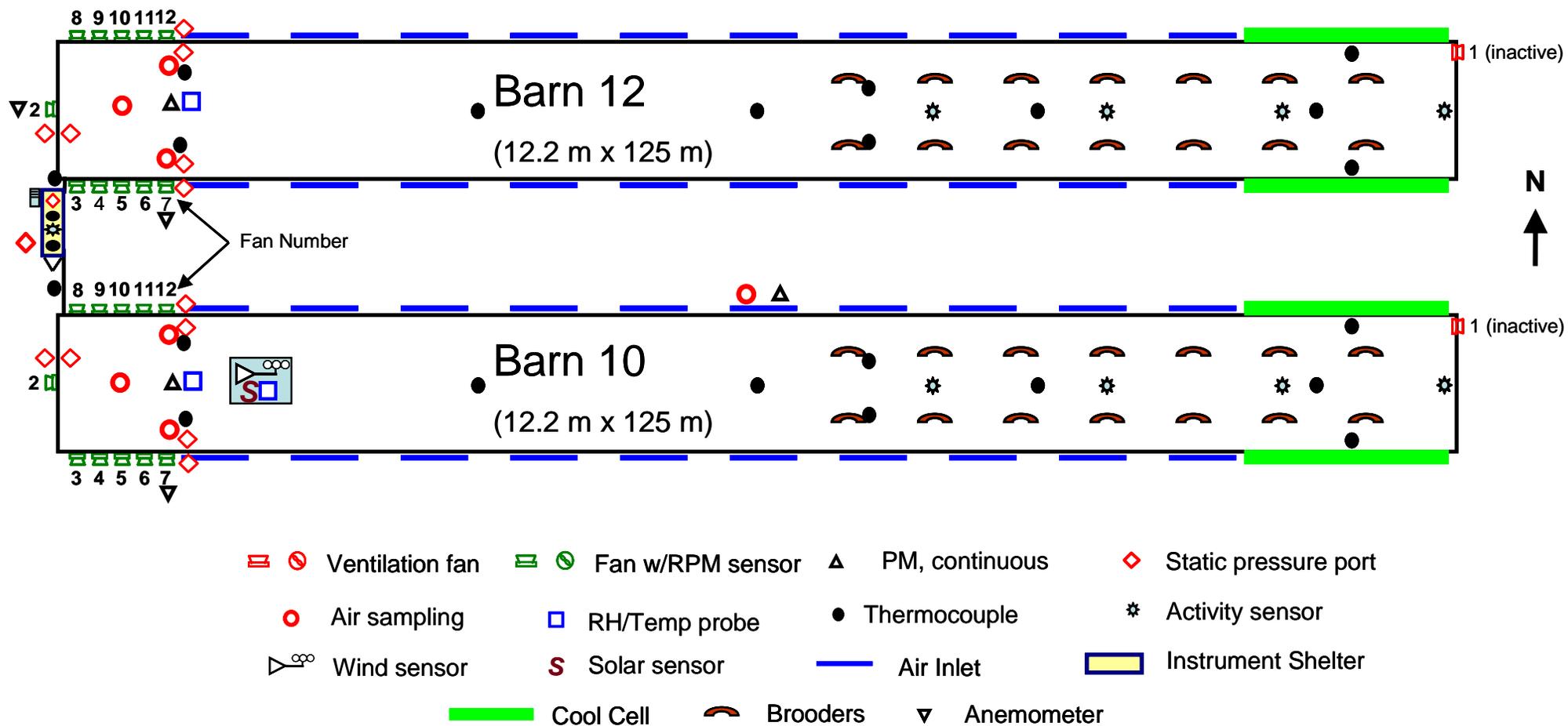


Figure 7. Overhead view of the barn schematics, showing the site monitoring plan for continuous air emission testing at barns 10 and 12.

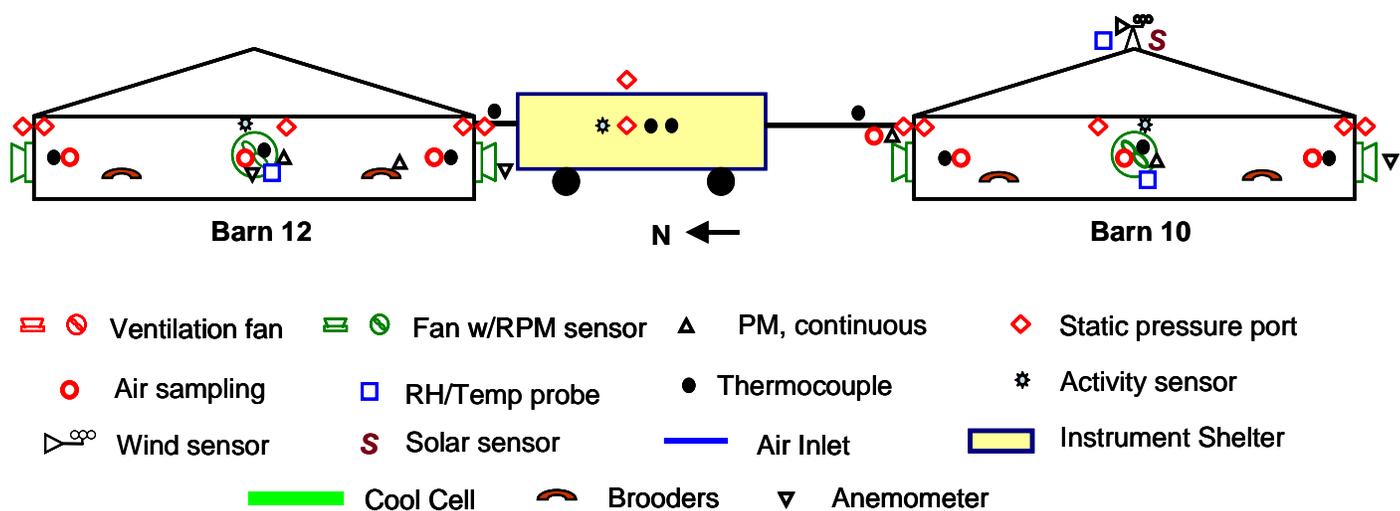


Figure 8. End (W) view of the barn schematics, showing part of the site monitoring plan for continuous air emission testing at barns 10 and 12.

Table 3. Analyte sampling locations at the CA1B site.

Analyte	Barn	Sampling Location*	#Locations**
Gases (NH ₃ , H ₂ S, NMHC, CO ₂)	10, 12	GSL-A: Directly in front of the inlet of fan 2, along a line connecting fans 5 and 10	2
	10, 12	GSL-B: 1 m E of fan 12 and 3 m from N wall	2
	10, 12	GSL-C: 1 m E of fan 7 and 3 m from S wall	2
	10, 12	INLET: In front of the 5 th ventilation inlet from the E end of barn 10 on N sidewall	1
PM (PM _{2.5} , PM ₁₀ , TSP)	10, 12	TEOM located 2 m in front of Fan 7	2
	10, 12	INLET: Beta-Gage in front of the 5 th ventilation inlet from the E end of barn 10 on N sidewall	1
VOC (canister, sorbent tubes, and/or impingers)	10, 12	1 m E of fan 7 and 3 m from S wall, at fan hub level (GSL-C)	2

*Gas sampling probes will be located at fan hub height, suspended from the ceiling.

**Total for entire site

GSL: Gas sampling location

PREF: Primary representative exhaust fan (fan #7).

GSS: Gas sampling system



Figure 9. California Broiler Site 1, barns 10 and 12, as viewed from their E end. The OFIS will be located in the space between the two barns, at the far end in this view.

Table 4. Exhaust air stream control sequence during gas sampling cycle. Solenoids 1 to 7 direct air streams to bypass manifold or sampling manifold (when “open”). Location 7 samples inlet air twice daily.

Solenoid #	Location	Sampling period						
		1	2	3	4	5	6	
1	B10: F7	open						
2	B10: F12			open				
3	B10: F2					open		
4	B12:F7		open					
5	B12:F12				open			
6	B12:F2						open	



Figure 10. The row of center posts to which thermocouples and activity sensors will be mounted.

Table 4. Characteristics of barns at the California broiler ranch site.

Parameter	Description
Livestock type	Broilers
Inventory per barn, nominal	21,000
# barns at site	16
Year of construction	1960s/2002
Barn type	Mechanically Ventilated
Orientation	E-W
Distance to site, km	163 (UCD)
Type of birds (genetics)	60% Cobb, 40% Ross
Average mass, kg	1.14 (2.5 lb)
Animal occupation, d	42
Type of floor	Rice hulls on dirt
Shower in/out?	No
Barn width, m	12.2 (40 ft)
Barn length, m	125 (410 ft)
Barn area, m ²	1,524 (16,400 ft ²)
Ridge height, m	4.2 (13.8 ft)
Sidewall height, m	2.3 (7.5 ft)
Barn spacing, m	12.2 (40 ft)
Basement depth, m	N/A
Manure collection	Housekeeper, Carry-All Soil Movers
Manure storage in barn, d	46 (brooder area), 155 (back)
Number of air inlets	60 sidewall/2 tunnel
Inlet type, m	Baffled eave inlet, 0.18 x 1.32 (0.6 ft x 4.3 ft)
Tunnel inlet type, m	Curtain, 18 x 1.92 (59 ft x 6.3 ft)
Inlet adjustment method	Vent machine
Inlet control basis	Static pressure
Controls vendor	Choretime (48), Aerotech (36)
Number of exhaust fans	12
# variable speed fans	0
Largest fan dia., m	1.22 (48 in)
Smallest fan dia., m	0.91 (36 in)
Fan spacing, m	0.2 (8 in)
Fan manufacturer	Choretime (48), Aerotech (36)
# ventilation stages‡	17
# temperature sensors†	6
Emergency ventilation	Generator
Artificial heating	LP Radiant brooders (14), 42,000 Btu/h Convection LP heaters (3), LB White, 180,000 Btu/h
Summer cooling	Tunnel/EP
Internet service type	Wireless DSL