State of California
AIR RESOURCES BOARD

RESEARCH PROPOSAL

Resolution 12-14

March 22, 2012

Agenda Item No.: 12-2-1

WHEREAS, the Air Resources Board (ARB) has been directed to carry out an effective research program in conjunction with its efforts to combat climate change, pursuant to Health and Safety Code sections 39700 through 39705;

WHEREAS, a research proposal, number 2736-273, entitled "Quantification of the Emission Reduction Benefits of Mitigation Strategies for Dairy Silage," has been submitted by the University of California, Davis; and

WHEREAS, the Research Screening Committee has reviewed and recommends for funding:

> Proposal Number 2736-273, entitled "Quantification of the Emission Reduction Benefits of Mitigation Strategies for Dairy Silage," submitted by the University of California, Davis, for a total amount not to exceed $400,000.

NOW, THEREFORE, BE IT RESOLVED that the Air Resources Board, pursuant to the authority granted by Health and Safety Code section 39703, hereby accepts the recommendation of the Research Screening Committee and approves the following:

> Proposal Number 2736-273, entitled "Quantification of the Emission Reduction Benefits of Mitigation Strategies for Dairy Silage," submitted by the University of California, Davis, for a total amount not to exceed $400,000.

BE IT FURTHER RESOLVED that the Executive Officer is hereby authorized to initiate administrative procedures and execute all necessary documents and contracts for the research effort proposed herein, and as described in Attachment A, in an amount not to exceed $400,000.

I hereby certify that the above is a true and correct copy of Resolution 12-14, as adopted by the Air Resources Board.

Mary Alice Morency, Clerk of the Board

ATTACHMENT A

"Quantification of the Emission Reduction Benefits of Mitigation Strategies for Dairy Silage"

Background

High ozone concentrations at ground level are one of the major air quality problems in California. Recent studies indicate that dairies in the San Joaquin Valley (SJV) are likely a significant source of volatile organic compounds (VOCs) and nitrogen oxides (NO_X), both of which are ozone precursors. Out of the approximately 1,700 dairy farms in California, more than 80 percent are located in the SJV, which has been classified as an extreme ozone nonattainment area. In order to attain the ozone standard in the SJV, it is necessary to reduce NO_X and VOC emissions. It is estimated that approximately 43 tons per day of VOCs, or 12 percent of total VOC emissions in the SJV, are from dairies. VOC emissions can arise from discrete sources at dairies, but current estimates suggest that silage is the largest contributing source. More data are needed, however, to understand the full extent of VOCs as well as other ozone-forming emissions, particularly NO_X.

The proposed research expands on past work by using multiple sampling techniques and including emissions measurements through the entire silage management cycle, from the creation of the silage pile to the feeding process. The project will also quantify reductions from less common practices, including those specified in the SJV Air Pollution Control District (SJV District) Rule 4570. The tasks were selected in consultation with the SJV District. The evaluation of the emissions impact from various mitigation strategies will improve quantification of the benefits of Rule 4570 as well as the overall emissions profile for dairies.

Objective

This project will measure VOC and NO_X emissions from silage processes and evaluate mitigation measures specified in Rule 4570 at three commercial dairy farms, perform controlled experiments and modeling to evaluate factors affecting silage emissions, and quantify the emission reduction benefits of the various silage management practices. Carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), ammonia (NH_3), and hydrogen sulfide (H_2S) will also be measured. The expected outcome of this research is an improved understanding of baseline air emissions from dairy silage and the effectiveness of mitigation strategies.

Methods

This project will evaluate VOC, NO_X and other gaseous emissions through all phases of silage management, from pile creation through the feeding process, using several different emissions measurement methods. The VOC measurements will be conducted, where possible, with multiple techniques, including open path Fourier Transform Infrared (FTIR) spectroscopy, flux chamber, and wind tunnel methods; offsite analysis of VOC species will also take place. Three greenhouse gases (GHGs): carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4), and two other important pollutants: ammonia (NH_3) and hydrogen sulfide (H_2S) will also be measured. In addition, other parameters to be monitored will include silage density, surface exposure area, chop

size, moisture content, lactic acid bacterial population, oxygen content, meteorology, etc.

The on-farm measurements will compare common silage management practices, such as conventional silage pile with standard chop-size, density, and use of front-end loader for silage removal, with less common practices, such as sealed "ag-bag" and the use of clean-cutting defacer for silage removal. For controlled experiments, emissions will be monitored from incubators containing different silage types and bacterial additives, and from total mixed ration (with or without added water) in the mixing wagon and feeding lanes. The emissions data collected from these and other studies will be used to refine and expand an existing VOC emission model for comprehensive assessment of emissions on the whole farm level.

Expected Results
This project will provide on-farm monitoring data for VOC, NO_X, and other important gases, and quantify emission reduction potentials of possible mitigation measures. The project will improve current baseline emission estimates from dairies and identify effective mitigation strategies for reducing dairy emissions from silage management.

Significance to the Board
The project will address the critical need for reducing emissions of ozone precursors in the San Joaquin Valley, and thereby help in attaining federal and local air quality standards for ozone in the region.

Contractor:
University of California, Davis

Contract Period:
36 months

Principal Investigator (PI):
Frank Mitloehner, Ph.D.

Contract Amount:
$400,000

Basis for Indirect Cost Rate:
The State and the UC system have agreed to a ten percent indirect cost rate.

Past Experience with this Principal Investigator:
Dr. Frank Mitloehner, the Principal Investigator, is the director of the Agricultural Air Quality Center at the University of California, Davis. Dr. Mitloehner is an internationally regarded expert on dairy and agricultural air quality issues. His team possesses a broad expertise in emissions testing, with access to some of the most advanced, field-proven equipment. The investigators have published extensively on agricultural air emissions, and demonstrated the capability to deliver high quality products in a timely manner. Their research experience in agricultural emissions and dairy silage

fermentation (including preliminary work on NO_X), as well as with the National Ambient Emissions Monitoring Study, further strengthen the project.

Prior Research Division Funding to University of California, Davis:

Year	2011	2010	2009
Funding	$1,394,560	$508,267	$1,588,387

BUDGET SUMMARY

Contractor: University of California at Davis

"Quantification of the Emission Reduction Benefits of Mitigation Strategies for Dairy Silage"

DIRECT COSTS AND BENEFITS			
1.	Labor and Employee Fringe Benefits	$ 214,177	
2.	Subcontractors	$ 78,000	
3.	Equipment	$ 12,000	
4.	Travel and Subsistence	$ 36,400	
5.	Electronic Data Processing	$ 1,500	
6.	Reproduction/Publication	$ 0	
7.	Mail and Phone	$ 1,000	
8.	Supplies	$ 14,468	
9.	Analyses	$ 12,000	
10.	Miscellaneous	$ 0	
	Total Direct Costs		$369,545
INDIRECT COSTS			
1.	Overhead	$ 30,455	
2.	General and Administrative Expenses	$ 0	
3.	Other Indirect Costs	$ 0	
4.	Fee or Profit	$ 0	
	Total Indirect Costs		$30,455
TOTAL PROJECT COSTS			**$400,000**

Attachment 1

SUBCONTRACTORS' BUDGET SUMMARY

Subcontractor: United States Department of Agriculture, Agricultural Research Services, University Park, PA

Description of subcontractor's responsibility: The subcontractor will assist with the evaluation and refinement of the silage VOC emission model. This will include collaboration in the development of procedures used to measure farm scale VOC emissions in California. The subcontractor will gather information and conduct simulations of California dairy farms and evaluate the model by comparing simulated emissions to measured values. If refinement of the model is needed, the subcontractor will evaluate model components and recommend code changes to improve model performance. When the model is functioning appropriately, simulation of farming systems will be conducted to evaluate the whole farm impacts of silage management options and mitigation strategies.

DIRECT COSTS AND BENEFITS				
1.	Labor and Employee Fringe Benefits	$	65,810	
2.	Subcontractors	$	0	
3.	Equipment	$	0	
4.	Travel and Subsistence	$	3,500	
5.	Electronic Data Processing	$	0	
6.	Reproduction/Publication	$	890	
7.	Mail and Phone	$	0	
8.	Supplies	$	0	
9.	Analyses	$	0	
10.	Miscellaneous	$	0	
	Total Direct Costs			$70,200
INDIRECT COSTS				
1.	Overhead	$	7,800	
2.	General and Administrative Expenses	$	0	
3.	Other Indirect Costs	$	0	
4.	Fee or Profit	$	0	
	Total Indirect Costs			$7,800
TOTAL PROJECT COSTS				**$78,000**