State of California
AIR RESOURCES BOARD

RESEARCH PROPOSAL

Resolution 10-11

February 25, 2010

Agenda Item No.: 10-2-1

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

WHEREAS, a research proposal, number 2696-266, entitled "On-Road Measurement of Emissions from Heavy Duty Diesel Trucks: Impacts of Fleet Turnover and ARB's Truck and Bus Rule," has been submitted by the University of California, Berkeley (UC Berkeley);

WHEREAS, the Research Division staff has reviewed and recommended this proposal for approval; and

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

> Proposal Number 2696-266 entitled "On-Road Measurement of Emissions from Heavy Duty Diesel Trucks: Impacts of Fleet Turnover and ARB's Truck and Bus Rule," submitted by UC Berkeley, for a total amount not to exceed $300,012.

NOW, THEREFORE, BE IT RESOLVED that ARB, pursuant to the authority granted by Health and Safety Code section 39703, hereby accepts the recommendation of RSC and approves the following:

> Proposal Number 2696-266 entitled "On-Road Measurement of Emissions from Heavy Duty Diesel Trucks: Impacts of Fleet Turnover and ARB's Truck and Bus Rule," submitted by UC Berkeley, for a total amount not to exceed $300,012.

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 $300,012.

I hereby certify that the above is a true and correct copy of Resolution 10-11, as adopted by the Air Resources Board.

Sandra Bannerman, Clerk of the Board

ATTACHMENT A

On-Road Measurement of Emissions from Heavy Duty Diesel Trucks: Impacts of Fleet Turnover and ARB's Truck and Bus Rule

Background

Despite improvements in emission control technologies, particulate matter (PM) remains remain a serious pollution problem. Large portions of the California population, including those in the South Coast Air Basin and San Joaquin Valley are exposed to levels that exceed California health-based PM2.5 standards. PM also impacts climate and visibility. Ultra-low sulfur fuel was introduced in California in 2006 to allow use of post-combustion treatment devices on diesel trucks for better control of PM emissions.

Heavy-duty diesel (HDD) vehicles are an important source of emissions of nitrogen oxides (NO_X) and PM; however, their emissions are expected to be reduced due to recent regulatory changes. National standards for diesel engine exhaust were applied to new vehicles beginning in 2007 with phase-in through 2010. Due to longer service lives for heavy-duty compared to light-duty vehicles California has required retrofit or replacement of older diesel engines and this requirement is expected to change emissions dramatically over the next four years.

Research measurement programs funded by Air Resources Board (ARB or Board) and performed by the proposed contractor from the mid-1990s through 2006 have characterized fleet average emissions from light-duty and heavy-duty vehicle fleets operating inside the Caldecott Tunnel. The 2006 results provide a baseline for comparison with results from the proposed research.

The proposed research will measure emissions from a large sample of individual HDD vehicles operating in 2011 and 2013 and will build upon results from measurements of emissions from individual trucks that were operating under similar conditions in 2006 to assess the extent of changes in distributions of emissions.

Objective

The primary objective of the proposed research is to characterize both NO_x and PM emissions from in-use HDD vehicles. Specifically, the proposed research will obtain distributions of emission rates for NO, NO_2, particle number (PN), black carbon (BC), and, in the ultrafine size range, particle number by diameter N(Dp) from individual exhaust plumes of a large sample of heavy duty trucks operating in 2011 and 2013. The plumes of at least 500 individual trucks will be sampled in each year. License plates will be recorded with video and the California plate information will be merged with DMV data to identify the vehicle model year and manufacturer.

Methods

To obtain distributions of emission rates for NO, NO_2, PN, BC, and, in the ultrafine size range, N(Dp) from individual exhaust plumes of a large sample of heavy duty trucks operating in 2011 and 2013, this research will draw air into instruments that will rapidly observe the changes in concentration associated with passage of individual truck

plumes. Observations will be used to provide fuel-based emission rates specific to the individual vehicle for each of the pollutants measured. The emission rates from individual vehicles will be reported per mass of fuel combusted; for example as grams of NO_X emitted per kg of fuel consumed, or as PN emitted per kg of fuel consumed.

Based on work the conducted in 2006 to characterize exhaust plumes of individual trucks, the current proposal calls for use of the Caldecott Tunnel infrastructure to provide the staging area for the instrumentation. However, the proposed research is not a tunnel study per se and the current proposal differs from 2006 in that the measurements will be made near the entrance, not inside the tunnel. Near the entrance, the time-averaged baseline concentrations will be much lower and very similar to ambient concentrations and thus there will be a stronger signal above background from the individual truck exhaust plumes to provide more precise measurements of the plume concentrations above ambient.

Expected Results
The research results are expected to significantly improve our understanding of the emissions from the HD vehicle fleet and how those emissions changed with implementation of newer control technologies. The analysis will include quantification of changes in emission rates and assessment of any interactive effects between exhaust pollutants. The analysis will provide emission rates per mass of fuel burned at the time of passage of individual truck plumes. Distributions of emissions will be provided from a large sample of individual heavy duty trucks (at least 500 each year) operating at the Caldecott Tunnel in 2011 and 2013. The measurements will provide the NO/NO_2 emissions splits and emission factor distributions for black carbon, PN, and, in the ultrafine range, particle size.

Significance to the Board
Understanding the distribution of emissions from individual HD vehicles representative of an in-use HDDV fleet and how that distribution changes over a multi-year period in response to regulations which introduce new control methods is relevant to policy decisions intended to reduce levels of ozone and particulate matter to protect public health.

Contractor:
University of California, Berkeley

Contract Period:
48 months

Principal Investigator (PI):
Professor Robert Harley

Contract Amount:
$300,012

Cofunding:

Although the proposed project is not directly co-funded, it will benefit from and build upon related measurements of fleet average HDDV emissions made by the same contractor at the same location in 2010 and those will be funded entirely by the U.S. EPA.

Basis for Indirect Cost Rate:
The University of California has agreed to a ten percent indirect cost rate.

Past Experience with this Principal Investigator:
Professor Robert Harley has conducted extensive research relevant to the proposed project at this location and extensive research for ARB with exceptionally high level of performance. His work from the early 1990s through 2006 has provided significant information on the speciation of vehicle exhaust emissions from in-use light-duty and heavy-duty vehicle fleets and has quantified the changes in mass emission rates in response to changes in fuel specifications and fleet turnover. His past theoretical and observational work has provided significant advances in understanding of emissions. His understanding of the implications of inventory improvement is underpinned by the fact that he has utilized his empirical results for validation and improvement of emission inventories and has also applied those emission inventories for regional modeling of atmospheric chemistry.

Prior Research Division Funding to UC Berkeley:

Year	2008	2007	2006
Funding	$1,169,448	$1,372,484	$1,607,398

BUDGET SUMMARY

Contractor: University of California, Berkeley

On-Road Measurement of Emissions from Heavy Duty Diesel Trucks:
Impacts of Fleet Turnover and ARB's Truck and Bus Rule

DIRECT COSTS AND BENEFITS			
1.	Labor and Employee Fringe Benefits	$ 166,279	
2.	Subcontractors	$ 100,009[1]	
3.	Equipment	$ 0	
4.	Travel and Subsistence	$ 4,000	
5.	Electronic Data Processing	$ 0	
6.	Reproduction/Publication	$ 75	
7.	Mail and Phone	$ 100	
8.	Supplies	$ 9,111	
9.	Analyses	$ 0	
10.	Miscellaneous	$ 1,500	
	Total Direct Costs		$281,074
INDIRECT COSTS			
1.	Overhead	$ 18,938	
2.	General and Administrative Expenses	$ 0	
3.	Other Indirect Costs	$ 0	
4.	Fee or Profit	$ 0	
	Total Indirect Costs		$18,938
TOTAL PROJECT COSTS			**$300,012**

[1] The subcontractor, a leading entity in the characterization of aerosols, will use advanced methods for aerosol measurements with high precision and fine time resolution

SUBCONTRACTORS' BUDGET SUMMARY

Subcontractor: Aerosol Dynamics, Inc.

Description of subcontractor's responsibility: The subcontractor will work in collaboration with Professor Harley. In particular, their work will focus on use of advanced methods for aerosol measurements with high precision and fine time resolution. Dr. Hering is the inventor of the water condensation particle counter used for real-time ultrafine PN measurements to be done as part of this research, and Aerosol Dynamics, Inc. has expert- level knowledge of aerosol measurements in general, and particle sizing and counting specifically.

DIRECT COSTS AND BENEFITS				
1.	Labor and Employee Fringe Benefits	$	57,558	
2.	Subcontractors	$	0	
3.	Equipment	$	0	
4.	Travel and Subsistence	$	100	
5.	Electronic Data Processing	$	0	
6.	Reproduction/Publication	$	0	
7.	Mail and Phone	$	0	
8.	Supplies	$	2,060	
9.	Analyses	$	0	
10.	Miscellaneous	$	0	
	Total Direct Costs			$59,718
INDIRECT COSTS				
1.	Overhead	$	40,291	
2.	General and Administrative Expenses	$	0	
3.	Other Indirect Costs	$	0	
4.	Fee or Profit	$	0	
	Total Indirect Costs			$40,291
TOTAL PROJECT COSTS				**$100,009**