STATE OF CALIFORNIA
AIR RESOURCES BOARD

MEETING OF THE

RESEARCH SCREENING COMMITTEE

December 11, 2015
9:00 a.m.

Air Resources Board
Research Division
Cal/EPA Building
1001 I Street
Sacramento, CA 95814
(916) 445-0753

State of California
AIR RESOURCES BOARD

Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Conference Room 510, 5th Floor
Sacramento, California 95814
(916) 445-0753

December 11, 2015
9:00 a.m.

AGENDA

State of California
AIR RESOURCES BOARD

Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Conference Room 510
Sacramento, California 95814
(916) 445-0753

July 8, 2015
9:00 a.m.

MINUTES

RSC Members in Attendance via teleconference

Harold Cota
Forman Williams
Suzanne Paulson
Philip Fine
Alan Vette
Rashid Shaikh
William Eisenstein

The Research Screening Committee (RSC or Committee) convened the meeting at 9:04 a.m. The minutes of the March 27, 2015 meeting were approved.

I. Request for Proposals (RFP)

1) "Evaluating Engine and Aftertreatment Performance and Deterioration for Heavy Duty Engines," $400,000, RFP No. 15RD006

   The Committee had one question on the RFP regarding the exact amount of funding. Staff clarified the total is $400,000.

   Motion: Move to accept the RFP.

   The Committee approved the RFP.

II. Proposed Contract Augmentation

1) "Advanced Plug-In Electric Vehicle Travel and Charging Behavior," University of California, Davis, $442,356, Contract No. 12-319

   One Committee member noted this augmentation was a good opportunity to leverage additional funds for an important research project, and wanted confirmation that the response rate to the survey had been good so far. Staff confirmed the response rate was approximately 4,000 households. Another Committee member noted that the number of households with each vehicle type that would be included in the study was listed as 46 households on page 8 of the proposal, whereas in other sections of the proposal 44 households were noted.

Motion: Move to accept the augmentation.

The Committee approved the augmentation.

III. New Research Projects

1) "Heavy-Duty On-Road Vehicle Inspection and Maintenance Program," Foundation for California Community Colleges, $499,560, Proposal No. 2789-283

   A Committee member suggested that the Air Resources Board (ARB or Board) encourage the publication of the literature review results. Staff responded that the contract requires the publication of a journal paper, and so the results will be published subsequent to project conclusion. The Committee member suggested that perhaps results could be published sooner, and staff said they would look into doing this.

   One Committee member asked about the proposed source for test vehicle selection, wondering if the maintenance practices of the proposed vehicle procurement-source are representative of the general vehicle population, the procurement-source vehicles perhaps being better maintained than typical in-use vehicles. Staff responded that the proposed procurement source is not the only means that will be pursued for identifying and procuring test vehicles, and that other methods of screening vehicles to identify high emitters will be undertaken, such as remote sensing.

   Concern was expressed by a Committee member about the proposed LIDAR instrument evaluation and possible conflict of interest, since the instrument would be operated by the manufacturer of the instrument. A robust QA/QC plan was recommended. Staff responded that ARB will work cooperatively with the United States Environmental Protection Agency (U.S. EPA) staff to conduct some instrument evaluations, both before the new project starts, as well as during the project itself. Staff stated the instrument supplier is a project subcontractor, and that the project principal investigators (PI) would be managing the data collection and analysis, including the LIDAR instrument, and so there will be an independent third-party assessment of the instrument performance. Staff added the project deliverables include all of the project data, so the instrument can be independently evaluated (by the contractor, the California Air Resources Board (ARB), and U.S. EPA staff).

   Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

   The Committee approved the proposal.

2) “Designing Vehicle Retirement and Replacement Incentives for Low-Income Households,” University of California, Los Angeles, $483,133, Proposal No. 2790-283

   Committee members asked for clarification on the sample sizes, target demographic, recruitment methods, and content for the focus groups, surveys, and self-sustaining market metrics. Committee members were satisfied with staffs’ response.

   Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

   The Committee approved the proposal.

3) “Identifying, Evaluating and Selecting Indicators, Indices and Data for Future Monitoring System of the Implementation of Sustainable Communities Strategies,” University of California, Los Angeles, $149,908, Proposal No. 2791-283

   One member recommended the research team include monitoring/development activity within priority development areas identified by Metropolitan Planning Organizations (MPO), and shared a concern that there may be “disharmonies” in datasets used by different MPOs. The member stated that responses to his comments were satisfactory.

   Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

   The Committee approved the proposal.

4) “Assessing the Travel Demand and Co-Benefit Impacts of Affordable TODs,” University of California, Berkeley, $300,000, Proposal No. 2792-283

   One Committee member expressed concern the budget and time constraints may not permit a study population of the maximum anticipated size of 400 participants, especially given the amount of time that researchers plan to allocate to individual participants. The member requested clarification on the actual anticipated study size and more detail in the budget and proposal to reflect how researchers will accommodate such a large study population if it will indeed approach 400 participants. The Committee expressed concern researchers may have overestimated the number of study participants that will have personal access to smart phones and suggested researchers develop an alternative plan for providing loaned devices if fewer than 50 percent of their participants own smart phones.

   Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

5) "Zero-Carbon Buildings in California: A Feasibility Study," University of California, Berkeley, $430,574, Proposal No. 2793-283

   Staff provided an explanation of the project and stressed the significance of the zero carbon buildings project to achieve long term climate goals.

   A Committee member asked staff to comment on the wedge analysis. Staff explained the wedge analysis was a simplified approach to estimate the greenhouse gas (GHG) emission reduction potential of various strategies to assist with making policy decisions.

   Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

   The Committee approved the proposal. Committee Member William Eisenstein recused himself and not present for this item.

6) "Characterize Physical and Chemical Properties of Manure in California Dairy Systems to Improve Greenhouse Gas (GHG) Emission Estimates," University of California, Davis, $151,423, Proposal No 2794-283

   The Committee expressed support of the project.

   Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

   The Committee approved the proposal.

7) "Characterize California-specific Cattle Feed Rations and Improve Modeling of Enteric Fermentation for California's Greenhouse Gas Inventory," University of California, Davis, $99,964, Proposal No. 2795-283

   The Committee expressed support of the project.

   Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

   The Committee approved the proposal.

8) "Policy and Scenario Analysis for Managing and Mitigating California's F-gas Emissions," University of California, Berkeley, $318,382, Proposal No. 2796-283

   A Committee member stated the project proposal is informative and thorough and includes sound research methods and a capable research team.

   A Committee member asked why the use of fluorinated gases is increasing.

Staff explained the use of GHG-intensive fluorinated gases, such as hydrofluorocarbons, is increasing because it is replacing ozone-depleting substances, such as chlorofluorocarbons, which are being phased out in response to Montreal Protocol mandates.

A Committee member asked whether a representative of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) would be likely to accept an invitation to provide input to the study. Staff stated that an invited ASHRAE representative would be likely to provide input due to the high degree of stakeholder interest in the topic.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

9) "Improved Understanding of the Magnitude of Trans-Pacific Long Range Transported Ozone Aloft at California's Coast," San José State University, $281,699, Proposal No. 2797-283

A Committee member expressed concern that there is no data analysis included, and the project is mainly a data collection effort. Staff explained that data analysis is not included due to both budget constraints and because ARB would like to lead the data analysis effort. Staff added that a data analysis plan will be developed within ARB before the field study.

A Committee member pointed out that items IV.9 and IV.10 are closely related. The ozonsonde measures vertical profile up to about 20-30 Km while the LIDAR can only measure up to about 2-3 Km. Staff explained the ozonesonde at the coast measures the long-range transported ozone aloft but the LIDAR in the valley mainly characterizes the vertical mixing of the ozone aloft down to the surface. The Committee member also asked if three months of ozonesonde measurements and six weeks of LIDAR measurements are long enough. Staff responded they believe the data collected will be very valuable for ARB to understand the temporal variations of ozone aloft and its impact on surface air quality, although there are always uncertain factors as with any field studies. The Committee member noted an error in the travel budget. Staff will work with the PI to correct it.

The Committee discussed specifics of the ozonsonde measurements with ARB staff, including the release and possible recovery of the sondes, and how the measurements may be impacted by meteorological factors, and the presence of oxidants other than ozone in the atmosphere. The Committee asked if there are any previous studies which evaluated the general performance of the ozonesonde measurements. Staff responded the ozonesonde is a well-established and widely used method for measuring ozone vertical profiles. It uses an electrochemical concentration cell for ozone measurements. The performance of the ozonesondes was evaluated in various studies. Staff will send a couple of references which investigated the accuracy and precision of electrochemical concentration cell ozonesondes to the Committee members after the meeting. Staff mentioned that ARB can do some testing as part of this project if needed. A Committee member commented that the method has been used for decades and the work proposed would be very valuable to the U.S. EPA.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

10) "LIDAR Profiling of Ozone in the San Joaquin Valley," National Oceanic and Atmospheric Administration (NOAA), $107,639, Proposal No. 2798-283

A Committee member stated this proposed study by NOAA is very valuable.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

IV. Draft Final Reports

1) "Environmental Fate of Low Vapor Pressure - Volatile Organic Compounds from Consumer Products: A Modeling Approach," University of California, Davis, $200,000, Contract No. 13-304

A Committee member asked which consumer product categories were included in the environmental fate modeling and which categories were not. Staff responded the environmental fate model was run for a list of major LVP-VOCs used in all consumer product categories (both indoor and outdoor). The environmental fate modeling for this project started with LVP-VOCs that have already made their way into the outdoor air, and estimated what portion will remain in the air gas phase to participate in ozone formation reactions. However, determination of the fraction of LVP-VOCs volatilized during the use of consumer products is beyond the scope of this project. In other words, how compounds reach the outdoor air through evaporation during outdoor use, or evaporation and subsequent ventilation when used indoor were not investigated in this study. Staff will ask the PI to make it clearer in the report. A Committee member said it is a sound study, and also pointed out that there are relatively large uncertainties in the modeling results.

Motion: Move to accept the report, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the report.

The meeting adjourned at 10:27 a.m.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: II.1
DATE: December 11, 2015
PROPOSAL NO.: 2799-284

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Heavy-Duty On-Road Vehicle Inspection and Maintenance Program
PRIMARY CONTRACTOR:	University of California, Riverside $320,899
SUBCONTRACTORS:	West Virginia University, $49,984 Mark Carlock (consultant) $67,500 Hager Environmental & Atmospheric Technologies, $54,117 Robert Harris (consultant) $7,500
PRINCIPAL INVESTIGATORS:	Thomas Durbin, Ph.D. Kent Johnson, Ph.D. Georgios Karavalakis, Ph.D. J. Wayne Miller, Ph.D. Mark Carlock, Ph.D. Nigel Clark, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$500,000
CONTRACT TERM:	24 Months

For further information, please contact Dr. John Collins at (916) 327-8097.

I. SUMMARY

Despite substantial reductions in oxides of nitrogen and diesel particulate matter emissions from heavy-duty vehicles (HDVs), these vehicles are still significant contributors to statewide and regional emissions of these pollutants. Because of their long service lives, it is important that HDVs remain in emissions compliance throughout their entire lifetimes, and a HDV inspection and maintenance (I/M) program is one means of trying to ensure this compliance. The objectives of this project are to: 1) identify and evaluate various approaches to HDV I/M and select one or more promising alternatives, 2) demonstrate and evaluate these alternatives in a prototype

HDV I/M program, and 3) conduct a cost analysis for this prototype program. Results from this project will be used to inform the design of an improved HDV I/M program for consideration by the ARB Board.

II. TECHNICAL SUMMARY

Objective

The objectives of this project are to evaluate possible HDV I/M alternatives, develop, demonstrate and evaluate a prototype I/M program for on-road HDVs, and perform a cost analysis of alternatives investigated during prototype HDV I/M program demonstration.

Background

Over the past twenty years, the ARB has reduced on-road HD engine emissions standards for oxides of nitrogen (NO_X) and diesel particulate matter (PM) by about 97 percent. Despite these significant improvements, HDVs over 8,500 pounds are still responsible for approximately a third of California's total NO_X emissions and over a quarter of the diesel PM. While new engines employ improved engine designs and exhaust aftertreatment to meet stringent emissions standards, California needs a more comprehensive HDV I/M program to ensure that in-use engines continue to meet emissions performance requirements throughout their useful lives which can include 20 or more years of operation and a nearly a million miles of travel.

Proposal Summary

The proposed principal investigators (PIs) for the project are Dr. Tom Durbin, Dr. Kent Johnson, Dr. Georgios Karavakalis, and Dr. J. Wayne Miller from CE-CERT, Dr. Mark Carlock a consultant, and Dr. Nigel Clark from West Virginia University (WVU).

In addition to the co-PIs, the project team would include Hager Environmental & Atmospheric Technologies (H.E.A.T.) who would provide their laser Emissions Detection And Reporting (EDAR) remote sensing device (RSD), Dr. Robert Harris, an economist, and two repair facilities equipped with a chassis dynamometers located in southern California. The repair facilities dynamometers would be outfitted with emissions analyzers provided by the project team, The project would consist of four tasks:

Task 1 - Literature review and HD I/M program development

Task 2 - Demonstration and evaluation of prototype HD I/M program

Task 3 - Cost analysis of the prototype program

Task 4 - Preparation of the final report and project administration

The CE-CERT proposal builds on previous research, providing a summary of this research and outlining the proposed technical approach for the project for Tasks 1 and 2. The proposed HD I/M project elements for study during Task 2 include: interrogation of the vehicle on-board diagnostic (OBD) system, chassis dynamometer emissions testing, and remote emissions sensing. Subsequent to the Task 2 demonstration and evaluation, the contractor would perform a cost analysis in Task 3 to determine the cost-effectiveness of the different possible HD I/M program elements studied, both in isolation, as well as part of a combined program (e.g., OBD only, remote sensing only, combined OBD and remote sensing, etc.). Interim reports are required at the completion of Tasks 1 and 3, and these reports, plus results from the Task 2 program demonstration and evaluation, would be combined into the final report in Task 4.

Chassis dynamometer emissions testing will be used as the 'gold standard'/'reference method' for determining tailpipe emissions, and determining repairs effectiveness in reducing emissions. Because of the high cost associated with emissions testing HDVs, CE-CERT proposes to utilize repair-grade chassis dynamometer for all as-received and after-repairs emissions testing. CE-CERT proposes to procure and test 50 HDVs during the demonstration and evaluation phase of the project. Selection of specific test vehicles, including high emitters, could include vehicles identified by HDV repair shops, high emitters identified by remote sensing, engine problems induced by the investigators, or other methods. Determination of specific methods to be utilized will be made as additional information is collected during the project execution.

III. STAFF COMMENTS

The proposal was reviewed and evaluated by ARB staff from the Research, Mobile Source Control, and the Industrial Strategies Divisions, and included both engineers/scientists and economists. The proposal before the Research Screening

Committee reflects input and guidance from ARB staff. The draft proposal was also shared with staff from the Bureau of Automotive Repair (BAR); the BAR conducts and administers the light-duty vehicle Smog Check program.

The contractor originally selected to conduct this research (the Foundation for California Community Colleges) withdrew from the contract because of personnel changes, and so ARB staff selected another contractor, CE-CERT. For the new project contract, Drs. Mark Carlock and Nigel Clark, co-principal investigators for the FCCC contract, will also be co-PIs, together with researchers from CE-CERT. So, in many ways, the new project is similar to the previous project, and the project will benefit from the combined expertise of Drs. Carlock and Clark, and the CE-CERT researchers.

The proposed project team is well qualified to conduct this project. CE-CERT researchers have a strong background in vehicle emissions testing and working with stakeholders such as trucking companies and vehicle repair facilities, Dr. Carlock possesses extensive experience with I/M program development and emissions modeling, Dr. Clark is a recognized expert in HDV emissions testing and HDV diagnosis and repairs, and Dr. Harris has extensive economics experience. The CE-CERT proposal demonstrated a good understanding of the subject of HD I/M program development. The proposed methods will include a variety of possible options that can be evaluated to determine the best method(s) for a new HD I/M program.

Last summer, a new HD I/M research report was released by the International Council on Clean Transportation, that addresses many of the subjects that were to be addressed in the literature review for the original project, and so the new project proposal from CE-CERT takes advantage of these recent research results.

The proposed use of a 'repair grade' chassis dynamometer to measure tailpipe emissions is considered by ARB staff to be a satisfactory alternative to much more expensive 'research grade' chassis dynamometer testing (about $660/test versus $10,000-$20,000/test). While research-grade chassis dynamometers are clearly superior in terms of simulating the entire domain of real-world vehicle operation, that is not the goal for this project. Instead, the goal is to correctly identify both complying and non-complying engines, and verify that the field test works (e.g., verify that RSD correctly passed or failed the engine when it is operated under some predefined engine operating condition[s]). For this purpose, a repair grade dynamometer is believed to be sufficient to adequately exercise the engine/vehicle to determine compliance under field-test conditions. Data can also be collected under lighter load conditions to help evaluate possible modifications to in-use compliance and/or certification procedures and methods.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $500,000, subject to any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.1
DATE: December 11, 2015
CONTRACT NO.: 12-320

STAFF EVALUATION OF A DRAFT FINAL REPORT:

TITLE:	Very Low PM Mass Measurements
CONTRACTOR:	University of California, Riverside
PRINCIPAL INVESTIGATORS:	Heejung Jung, Ph.D. Kent Johnson, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$100,000
CONTRACT TERM:	30 months

For further information, please contact Dr. John Collins at (916) 327-8097.

I. SUMMARY

The California Air Resources Board's (ARB) Advanced Clean Car (ACC) regulations adopted in 2012 include particulate matter (PM) emissions standards of 3 and 1 milligrams per mile (mg/mile). Concerns have been raised by auto companies about the repeatability of PM emissions filter measurements made at these low levels. The objective of this project was to investigate changes to the certification test procedures that could improve the repeatability of PM emissions measurements. Project results indicate that changes can be made to the test procedures to improve measurement repeatability, and this should aid in the implementation of the lower PM emissions standards.

II. TECHNICAL SUMMARY

Objective

The objective of this project was to investigate possible changes to the certification test procedures for light-duty vehicles (Code of Federal Regulations Parts 1065 and 1066) to improve measurement repeatability when making PM measurements at levels of 3 and 1 mg/mile. The project also included a survey of laboratory filter handling practices to learn how different vehicle testing laboratories compare with each other.

Background

In 2012, ARB adopted the Advanced Clean Car (ACC) regulations that include lowering the PM emissions standard from 10 to 3 mg/mile beginning in 2017, and from 3 mg/mile to 1 mg/mile beginning in 2025. Concern was expressed by the auto companies about the repeatability of PM filter measurements made at these low levels.

In order to investigate auto company concerns, the Coordinating Research Council (CRC) sponsored CRC project E-99 (Very Low PM Measurements), and solicited ARB co-funding. In the spirit of working with stakeholders, ARB provided $100,000 in co-funding, which accounted for about 20 percent of the total project budget.

The project was overseen by the CRC 'E-99 Panel' (a subcommittee of the CRC Real World Emissions Group [RWG]). The RWG oversees CRC research projects. Its members include auto and oil company representatives, the United States Environmental Protection Agency (U.S. EPA), ARB, and other stakeholders such as the Federal Highway Administration (FHWA). The Panel provided guidance and direction to the contractor, the University of California, Riverside (CE-CERT).

Project Summary

The project procured two light-duty gasoline vehicles (LDGVs) for testing: one to represent a 3 mg/mile vehicle, and a second to represent a 1 mg/mile vehicle. The 3 mg/mile vehicle was equipped with gasoline direct injection (GDI) technology, while the 1 mg/mile was equipped with port-fuel injection technology.

The vehicle emissions were tested over the Federal Test Procedure (FTP) and the US06 cycle, using test procedures specified in the Code of Federal Regulations (CFR) Parts 1065 and 1066. Screening tests were performed using a variety of different filter face velocities, dilution factors, and using different numbers of PM filters. The screening test results were analyzed and evaluated to develop recommendations for 'confirmatory' testing. The confirmatory testing results were used to develop suggestions for specific changes to the CFR.

For both vehicles the recommendations are to limit the filter face velocity to 150 cm/sec maximum, use a minimum dilution factor of 5, and use a single PM filter for the entire 3- or 4-phase test. For the 3 mg/mile PM standard vehicle, the recommendation is to use a 3-phase FTP (as is currently done), while for the 1 mg/mile vehicle the recommendation is to use a 4-phase FTP as a means of increasing the amount of PM collected, and reducing variability. These results indicate that PM measurements at 1 mg/mile are possible, although additional work is needed to determine if these results are applicable to larger vehicles and newer technology vehicles.

The filter survey included thirteen laboratories from auto and engine companies, government, and academic and research institutions. The survey gathered information about lab practices, quality control and quality assurance, reference filters, tunnel blanks, and robotic filter weighing. Results indicate that filter handling practices vary among different laboratories, and this affects the repeatability of PM measurements.

III. STAFF COMMENTS

The draft report was reviewed by ARB staff acting as a member of the CRC E-99 Panel, and by auto and oil company representatives on the Panel. ARB staff included members from various ARB divisions, including the rulemaking Emissions Compliance, Automotive Regulations and Science Divisions, and the Vehicle Emissions Testing Monitoring and Laboratory Division. The initial draft underwent extensive review, and was modified in response to two rounds of Panel comments. CRC approved the report.

The results indicate changes could be made to the certification test procedures to improve repeatability (although any changes would be a U.S. EPA decision), and that there is considerable variation among different test labs. The results from this project are consistent with ARB internal testing at very low PM levels, although ARB's results are generally less variable than results from this project. This could be due to better filter handling procedures, better lab practices, a lower volume of test vehicles, or other reasons.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.2
DATE: December 11, 2015
CONTRACT NO.: 11-316

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Development of a New Methodology to Characterize Truck Body Types along California Freeways
CONTRACTOR:	University of California, Irvine
PRINCIPAL INVESTIGATORS:	Stephen G. Ritchie, Ph.D. Yeow Chern A Tok, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$350,000
CONTRACT TERM:	48 months

For further information, please contact Dr. Nesamani Kalandiyur at (916) 324-0466.

I. SUMMARY

California has recently set new, aggressive targets for reducing pollution, including decreasing GHG emissions 40 percent below 1990 levels by 2030 and cutting petroleum use in cars and trucks by up to half from current levels by 2030 as an interim goal on the way to achieving reductions of 80 percent below 1990 levels by 2050. California also needs to meet federal ambient air quality standards for ozone and particulate matter (PM). Further, truck emissions are a major source of air pollution in California and have been linked to adverse health effects such as asthma and cardiovascular disease. To achieve air quality and climate change goals, it is critical to understand the travel characteristics of trucks in California. This study has developed and implemented a new methodology to collect high resolution truck activity data traveling on the California freeway system. The advantage of this methodology is that it uses the existing traffic detector infrastructure such as inductive loop detector (ILD) and weigh-in-motion (WIM) sites. This study has developed a method to provide detailed truck body classification for all vehicle types ranging from two axle pickup trucks to six or more axle semi-tractor trailers. The output from this study can be used to distinguish

the proportion of long haul and short haul trips in major corridors and vocation which informs vehicle duty cycle. This can improve the heavy-duty vehicle classifications in ARB's Emission Factor (EMFAC) motor vehicle emissions model and to predict the effectiveness of various emissions control programs. Further, the information from this study can also be used to calibrate and validate the statewide freight-forecasting model and can help inform freight models under development by metropolitan planning organizations (MPOs). The data from this study can be used as a key input to the California Vehicle Activity Database (Cal-VAD) to estimate the truck activities. Ultimately, the results from this study can help to develop strategies to reduce emissions from California's trucks for use in the State Implementation Plan, Scoping Plan, Short Lived Climate Pollutant Plan, and Sustainable Freight Action Plan.

II. TECHNICAL SUMMARY

Objective

The main objective of this study was to develop a truck body classification model using inductive loop signature data. The second objective was to develop hardware interface configurations and deploy a pilot program to collect ILD signature data using the advanced detector cards. The third objective was to evaluate the performance of the developed model by deploying advanced detector cards at 16 stations.

Background

In California, on-road trucks are significant sources of criteria and GHG emissions. Emissions estimation is complicated by the large number of trucks registered in other states that move goods into and out of California. Both state and federal agencies are investing billions of dollars to reduce goods movement emissions. However, the existing system for measuring truck activity does not provide enough detail to develop control strategies to mitigate emissions from trucks traveling in California. Therefore, there is an increasing need to have more accurate truck activity and body type information.

Currently, truck activity is collected using the ILD and WIM sites in operation across California. ILD stations (more than 13,000) are widely installed in the California freeway system to measure traffic volume and vehicle occupancy every 30 seconds. This provides estimates of truck counts but does not provide detailed truck classification. On the other hand, sparsely located WIM stations (about 106) collect gross vehicle weight, individual axle weights, vehicle speed, overall vehicle length, axle spacing, and vehicle classification, in real time from the traffic stream. A key element of the WIM system is that the data are generated continuously. The vehicle weight is measured by plates or piezo sensors embedded in the pavement. Speeds and vehicle lengths are measured using inductive loops that are placed before and after each weight sensor. However, both ILD and WIM do not provide information regarding body type of trucks and commodity flow. This information is critical for goods movement studies and freight forecasting models.

Project Summary

This project was divided into three phases. In phase one, a truck body classification model was developed to establish proof-of-concept. In phase two, the developed model was refined and recalibrated using additional data collected through a pilot program. In the last phase of this project, advanced detector cards were deployed to test the reliability and accuracy of the classification model. As part of this study, a large amount of truck data was collected and processed for model training and testing. In total, around 35,000 vehicle records were captured and processed from ILD and WIM site locations in California. In addition to inductive loop signature and WIM data, still images were also collected for each passing vehicle for validating the model. This study has created a comprehensive classification scheme that captures the diversity of trucks traveling in the California region.

Two versions of the model were developed for truck body classifications using inductive loop signatures: (i) inductive signature only and (ii) inductive signature and WIM. These models were based on a multiple classification approach with probabilistic model combination to predict a detailed truck body class for all vehicle types ranging from two axle pickup trucks to six or more axle semi-tractor trailers. The inductive signature only model can predict 47 body classes with correct classification rates ranging from 72 percent to 94 percent. This has significantly increased the level of details about trucks for emission estimation and freight modeling. The inductive signature and WIM model can predict up to 63 body classes with correct classification rates ranging from 75 to 96 percent. This model can even distinguish between enclosed van and refrigerated van. In general, refrigerated van is used to transport perishable goods and enclosed van is used to transport other commodities such as electronics. This level of detail helps to track perishable goods, especially those that are port-related.

As part of this project, advanced detector cards were deployed at 16 stations with the support of the California Department of Transportation (Caltrans). These stations were identified from the existing WIM and ILD sites located along interstate freeways and state route highways with significant truck volumes in the San Joaquin Valley region. The truck body classification from these 16 stations can be accessed via the Truck Activity Monitoring System (TAMS, http://freight.its.uci.edu/tams) web-based user interface.

III. STAFF COMMENTS

An earlier version of the draft report was reviewed and commented on by six ARB staff from the Air Quality Planning and Science Division and two staffers from Caltrans with different areas of expertise. Overall, the reviewers found that this report was well written and informative. Some clarifying questions and comments were sent to the investigators. A revised version of the draft report addressing all of the reviewers' comments was submitted to the Research Screening Committee for review and comments. There are some typos and minor editorial issues that should be corrected in the final version of the report.

This study has developed a new methodology to address the truck body type data gap in quantifying the criteria and GHG emissions from trucks and fill a critical research need in goods movement studies. ARB and Caltrans staff feel that it will benefit the state since it improves the emissions inventory and data for freight forecasting models. Further, this will help to develop strategies to reduce emissions from trucks to meet air quality and climate change goals. Moreover, it is a cost effective approach for truck activity data collection. As follow-up to this study, Caltrans is providing $1 million to deploy additional stations to collect the data across the state of California.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.3
DATE: December 11, 2015
CONTRACT NO.: 12-332

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	New Car Buyers' Valuation of Zero-Emission Vehicles
CONTRACTOR:	University of California, Davis
PRINCIPAL INVESTIGATORS:	Ken Kurani, Ph.D. Thomas Turrentine, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$358,806
CONTRACT TERM:	30 months

For further information, please contact Fereidun Feizollahi at (916) 323-1509.

I. SUMMARY

New car buyers' valuation of zero-emission vehicles (ZEVs) was assessed via on-line survey and in-person interviews with a subset of survey respondents. Questions about ZEV awareness, knowledge, experience, and consideration were asked prior to, and form the set of explanatory variables for, the valuation measure—the drivetrain type selected by each respondent as a plausible next new vehicle in a survey design game. The survey was administered in California and 12 other states, including those adopting California's ZEV rules under section 177 of the federal Clean Air Act. Even in California, awareness, knowledge, experience and consideration of ZEVs - battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs) - was low by almost every measure. Still, 38 percent of California respondents opted for one of these three ZEV drivetrains in the survey's design game, which reflects current sales availability and pricing of ZEVs as well as current federal and state government incentives. Respondent clusters are identified by motivations for or against designing a ZEV. The most commonly cited motivation for selecting a ZEV was fuel cost savings, while the most common reason for not selecting a ZEV was the limited number of

charging/fueling locations away from home. A major finding is that awareness of ZEV technologies and vehicle availability remains low.

II. TECHNICAL SUMMARY

Objective

The primary objective of this research is to collect information on the decision-making process and factors influencing the choices of new light-duty vehicles purchasers in California, with a particular focus on the barriers and motivations for purchase of near-zero and zero-emission vehicles. To do this, the study included three subsidiary tasks: 1) measure consumer awareness, knowledge, experience and valuation of ZEVs; 2) describe consumer decision making regarding ZEV purchase decisions; and 3) compare consumers in California with consumers in other states with similar ZEV requirements.

Background

To improve local air quality and reduce emissions causing climate change, California requires manufacturers of passenger cars and light trucks to sell ZEVs. ZEVs are any vehicle that releases zero emissions during on-road operation. Several other states have adopted this requirement, including: Oregon, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Rhode Island and Vermont. These states signed a memorandum of understanding creating, among other things, a ZEV Program Implementation Task Force. The Task Force published a ZEV Action Plan in May 2014 listing 11 priority actions, including deploying at least 3.3 million ZEVs—roughly 15 percent of new vehicle sales in the collective region of the signatory states—as well as adequate fueling infrastructure, both by the year 2025. While much of the focus is on vehicle supply, success is recognized to depend on the response of new car buyers. Funding for completion of this survey in states other than California was provided by the Northeast States for Coordinated Air Use Management (NESCAUM).

Project Summary

To accomplish study objectives an on-line survey and follow-up interviews with a sub-set of survey respondents were conducted. The survey was administered to samples of new car-buying households in California, Washington, Oregon, Delaware, Maryland, Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New

York, Rhode Island, and Vermont in December 2014. Follow-up interviews were conducted in California, Oregon, and Washington in January to March 2015. Survey data were analyzed both to describe the sample and to model ZEV valuation. ZEV valuation was assessed by the drivetrain type of a vehicle each respondent designs: internal combustion engine (ICEV), hybrid electric (HEV), PHEV, EV, or FCEV. The contractor evaluated the statistical significance of each explanatory variable's correlation with the respondents' drivetrain choices. A multivariate model estimated the probability a respondent designed a vehicle of each type. The meaning of the model is derived from the explanatory variables included and their effect on drivetrain type. Categories of potential explanatory variables included: 1) socio-economic and demographic measures, 2) vehicle purchase, ownership, and travel, 3) awareness and assessments of ZEVs, ZEV policy instruments, and technology, and 4) attitudes toward ZEV policy goals. In addition, respondents' self-reported motivations for and against selection of ZEV drivetrains were analyzed. Interview data were analyzed to identify themes in a three step process: 1) open coding during a first reading to identify possible themes and assign initial codes; 2) axial coding review and revision of initial themes based on multiple comparative readings; and, 3) selective coding to identify examples to illustrate themes.

California new car-buyers' valuations of ZEVs are largely unformed. Despite marketing ZEVs and deploying ZEV charging infrastructure as well as federal, state, and local incentives for ZEV purchase and use, most new car-buying households have yet to ask themselves the question, "How (much) do I value ZEVs?" The conclusion is reinforced by the interviews, in which it was clear most respondents were formulating their initial ZEV valuation in the process of completing their survey and interview. Overall, this means that how consumers will value ZEVs is still subject to new information and experience.

Within this overall context of generally low levels of awareness and experience, 38 percent of the California sample has a sufficiently positive valuation to design: a PHEV (21 percent); a BEV (11 percent); or an FCEV (6 percent). Households who have the infrastructure to charge or fuel at home are more likely to design a ZEV vehicle. Households with higher familiarity with all drivetrain types and greater experience driving HEVs, PHEVs, EVs, or FCEVs are more likely to have a higher ZEV valuation.

Households with more favorable assessments of the comparative safety and reliability of BEVs and PHEVs and households with more favorable assessments of the driving range per charge/fueling and charging and fueling times of ZEVs are more likely to design such vehicles. Households who are more concerned that air pollution represents both a regional threat and a personal risk are also more likely to design ZEVs. Households who have already considered purchasing a ZEV -- to the extent they have searched for information, visited a vehicle dealership, or may drive one already—have higher valuations of ZEVs.

The results of the research project will inform policy makers about the potential areas where policies, incentives, or outreach might be effective to remove significant barriers or enhance motivations for the adoption of ZEVs.

III. STAFF COMMENTS

Both the survey instrument and draft final report were reviewed by staff in ARB's Research, Mobile Source Control, Emissions Compliance, Automotive Regulations and Science Divisions. Staff provided several suggestions to the draft report's authors, including: more systematic comparison of California sample results to those of the other states/total sample; additional methodological descriptions of factor analysis, cluster analysis and multivariate modeling techniques applied to survey response data; a graphical representation of the movement of respondents through design game phases; and a tabular presentation of all the variables with statistically significant bivariate associations with the dependent variable, grouped by category and ranked by strength of association. In addition, staff asked the contractor to provide a new appendix listing every survey question together with frequency counts and values of the responses received. The contractor agreed to provide the complete frequency count appendix in the final version of this report; the current version includes a sample of the frequency count appendix for the committee's review. Staff communicated these comments to the research team, which updated the draft final report to address its suggestions.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.4
DATE: December 11, 2015
CONTRACT NO.: 11-326

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Analyzing the Economic Benefits and Costs of Smart Growth Strategies
CONTRACTOR:	University of California, Berkeley
SUBCONTRACTOR:	University of California, Los Angeles
PRINCIPAL INVESTIGATOR:	Daniel Chatman, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$330,000
CONTRACT TERM:	46 months

For further information, please contact Fereidun Feizollahi at (916) 323-1509.

I. SUMMARY

California's Senate Bill (SB) 375 (Sustainable Communities and Climate Protection Act of 2008) aims to reduce transportation-related GHG emissions through more efficient patterns of land development. To achieve the regional GHG reduction targets required by SB 375, local governments and landowners must implement smart growth plans developed by regional planning organizations. The success of SB 375 is therefore subject to the decisions of local land use authorities and developers. Advocates claim smart growth policies will reduce vehicle travel while benefitting residents, cities, and regions in the form of more attractive communities, more affordable housing, and healthier municipal finances.

In this study, the PI's analyzed the economic impacts of existing smart growth plans similar to those currently being considered and adopted throughout metropolitan California. Through five case studies of neighborhood-level plans already implemented in California, they examined the effects of smart growth interventions on residential development, commercial development, municipal budgets, and vehicle

travel. A combination of quantitative and qualitative methods to estimate the net benefits and costs from the regional, municipal, and household perspectives were used.

In most cases, the plans produced net benefits for the stakeholders considered. The benefits emerged from plans that resulted in denser development in relatively central locations with good access to transit. However, in some cases the plans produced costs, and impacts were not evenly distributed. The research suggests smart growth policies can produce benefits, but planners must be aware of potential costs.

II. TECHNICAL SUMMARY

Objective

The objective of this study is to better understand the economic benefits and costs of smart growth policies from the perspectives of regions, cities and households through systematic retrospective evaluation of specific smart growth projects. The research develops and applies an empirical, literature-based framework of benefit-cost analysis -- including both financial and non-financial metrics – to a series of smart growth case studies to help local governments better evaluate the potential economic impacts of smart growth policies, plans and projects.

Background

By creating places in which people can drive less, “smart growth” promises to reduce vehicle travel—and the associated GHG emissions. California has codified this concept in SB 375, which expects metropolitan planning organizations to plan for, and local governments to promote, smart growth development. To enable smart growth, local governments are rezoning for higher density development, reducing parking requirements, zoning underused industrial land for a mix of land uses, and requiring pedestrian-friendly design in transit station areas. The expectation is that more compact development, especially in already built-up places and near public transit, will allow people to drive less and travel more by public transit, bicycle, or on foot. The changes are expected to bring other benefits too, from more efficient use of existing infrastructure to higher property values, to more attractive communities. Yet it is not clear whether smart growth policies actually create these benefits—and at what cost.

Methods

To better understand the implementation and impacts of smart growth policies the contractors conducted case studies of five established neighborhood-scale smart growth plans and policies. They used a combination of qualitative interviews, review of documents, and analysis of existing data to estimate the impacts of smart growth policies.

To identify relevant case studies, experts familiar with smart growth and the implementation of SB 375 were interviewed. Five case studies were selected that were judged most relevant to cities implementing SB 375: San Jose Midtown, Los Angeles Vermont-Western, San Diego East Village, and San Diego Rio Vista, and Turlock Downtown. In each case, the city adopted a neighborhood-scale smart growth plan (or multiple plans) intended to create more compact, mixed-use development. The smart growth plans were adopted between the mid-1980s to 2001, emphasize infill development or redevelopment, and four include rail transit stations.

For each case study, the impacts of the smart growth plan and policies on development using interviews, site visits, public records, and analysis of several existing datasets we estimated. The key step in each case was to construct a likely scenario for what *would have* happened in the *absence* of the plans. This step necessarily involved uncertainty and hence our results should be seen as estimates rather than definite calculations. The project focused on impacts arising from residential development, commercial development, municipal finance, and vehicle travel. Impacts from the perspective of regions, municipal governments, and four types of households in the plan area: existing homeowners, prospective homebuyers, renters, and low-income households were estimated.

Results and Conclusions

For the most part, the smart growth plans and policies analyzed had positive net impacts from the regional, municipal and household perspectives. The table below shows net annual regional impacts. The plans generally resulted in greater housing production—whether it was due to relaxed zoning regulations or the catalyzing effects of public investment—in relatively central locations with good access to transit, instead of in more outlying, automobile-oriented areas. Higher densities generally led to more efficient municipal spending; increased housing supply meant more households could take advantage of transit access; and increased local amenities produced value for residents. Regions benefitted from relaxed zoning regulations that somewhat eased shortages of apartments and condominiums.

Annual net costs and benefits by case study from the regional perspective*

Region	Estimated benefits (costs) (2010 dollars)		Comparison statistics		
Case Study	**Low Impact Estimate**	**High Impact Estimate**	**Plan Area**	**2010 population**	**Year first plan adopted**
L.A. Vermont-Western	$2,480,043	$9,729,858	2.2 sq. mi.	54,479	2001
San Diego East Village	$38,724,674	$228,975,812	2.3 sq. mi.	12,414	1992
San Diego Rio Vista	$466,885	($5,914,384)	0.14 sq. mi.	3,737	1985
San Jose Midtown	$6,004,580	$9,009,144	0.33 sq. mi.	2,797	1992
Turlock Downtown	$1,849,653	$6,179,568	0.5 sq. mi.	1,073	1992

*Totals include potential income increases to plan-area landowners that may be presented separately in the final report.

However, in certain cases the plans resulted in costs for some stakeholders. For example, in Los Angeles, new housing was filled with singles and childless couples, and the neighborhood's population decreased despite some new housing production. Low-income households generally benefitted far less than did other households. Found benefits were generally smaller than planners initially expected, because some of the development envisioned in the plans never materialized, and much of the development would have occurred even without the smart growth plans and policies.

This research suggests smart growth interventions of the type envisioned by SB 375 can have economic benefits on net, at least for the stakeholders considered, and there can be synergies between reducing GHG emissions and improving housing affordability. At the same time, the research shows the importance of carefully considering how proposed plans and policies affect different stakeholders. Additionally, to achieve intended benefits, planners must identify existing plans and policies that work at cross-purposes with the smart growth interventions.

III. STAFF COMMENTS

The draft final report was reviewed and commented on by staff in ARB's Research, and Air Quality and Planning Science Divisions. Staff from both Divisions also commented on draft versions of interim deliverables, including the literature review, elite interview summaries, case selection and methodology summaries and the five individual case studies. Staff from both Divisions also reviewed multiple versions of the spreadsheet calculations that support each case study's estimation and netting of specific economic costs and benefits. The draft final report was also reviewed and commented on by staff from the California Strategic Growth Council, the California State Transportation Agency the Governor's Office of Planning and Research.

Reviewers of the draft report asked for variety of changes, including: greater uniformity of formatting in tabular presentation of results; more detailed presentation of individual impact measure estimation methods; a more detailed rationale for annualization of costs and benefits; revised treatment of potential incremental income available to plan-area landowners through development of additional housing units allowed under plan zoning changes; and, revised analysis of multi-family housing price impacts resulting from changes in plan-area multi-family housing supply. Comments on the draft case studies asked for clearer description of the treatment of alternative locations in development of counterfactual scenarios.

Staff communicated these comments to the research team, which updated the draft final report to address these suggestions. As requested, the research team corrected and supplemented the writing, tables and figures where noted throughout the report.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.5
DATE: December 11, 2015
CONTRACT NO.: 11-311

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Reducing In-Home Exposure to Air Pollution
CONTRACTOR:	Department of Energy/Lawrence Berkeley National Laboratory
PRINCIPAL INVESTIGATOR:	Brett C. Singer, Ph.D.
CONTRACT TYPE:	Standard Agreement
TOTAL AMOUNT:	$1,300,863
CONTRACT TERM:	48 months

For further information, please contact Ms. Peggy Jenkins at (916) 323-1504.

I. SUMMARY

Mitigation measures are needed to reduce entry of outdoor pollution into homes in areas that exceed ambient air quality standards and those in close proximity to vehicle emissions. Investigators tested eight combinations of pollutant removal technologies and mechanical ventilation systems to assess their effectiveness in reducing indoor pollutant levels in homes and the associated energy use. They measured outdoor and indoor air pollutant levels for each system in a modern test house. The primary focus of the pollutant measurements was on PM2.5, ultrafine particles (UFP), and black carbon (BC). Results showed substantial benefits of high efficiency filtration, but with varying energy costs. Use of a high efficiency filter [Minimum Efficiency Reporting Value (MERV) 16] on a supply ventilation system was most effective in reducing indoor concentrations of outdoor particles (97-98 percent reduction) with low energy usage. High efficiency filtration on the central forced air system achieved similar results, but with a greater energy penalty; however, energy use would be lower with a newer technology system. This study provides information that can be used to improve California's building codes and reduce indoor exposures to air pollutants.

II. TECHNICAL SUMMARY

Objective

The objective of this study was to assess the effectiveness and the energy use of combinations of mechanical ventilation and high efficiency filtration systems for reducing indoor exposures to outdoor- and indoor-generated pollutants. This study focused primarily on reducing indoor levels of outdoor-origin UFP, PM2.5, and BC, with a secondary focus was on outdoor-origin volatile organic compounds (VOCs) and ozone and indoor-generated particles.

Background

Some areas of California do not meet state and national ambient air quality standards for PM2.5 and ozone, although outdoor air quality has significantly improved over the last few decades. Additionally, pollutant concentrations – especially UFP – can be many times higher very near the roadway compared to distant locations. Infiltration of outdoor air pollutants into homes increases indoor air pollution levels and occupants' exposures. Indoor-generated pollutants from cooking and other sources can pose additional health risks. The California Title 24 Energy Code requires mechanical ventilation in new homes to increase indoor-outdoor air exchange and thus reduce indoor concentrations of indoor-generated air pollutants on residents' health. However, filtration of outdoor air brought into homes is not required in the ventilation standards. Strategies to mitigate indoor exposures to outdoor pollutants are needed especially for people who live in high pollution areas and high traffic areas.

Project Summary

The investigators installed seven enhanced pollutant removal systems (i.e., combined mechanical ventilation and high efficiency filtration systems) and a reference system to examine the reduction of indoor exposures to outdoor- and indoor-generated air pollutants and associated energy efficiency in an unoccupied test house located in Sacramento, CA. The reference system consisted of a continuous bathroom exhaust fan and a low efficiency MERV4 filter in the central air heating and cooling system; filtration of incoming outdoor particles is via removal by deposition on the building shell as the air moves through cracks and crevices. The features of the seven enhanced systems varied by ventilation design [supply systems, central systems, a Heat Recovery

Ventilator (HRV), and a mini-split system], filtration location, and filter efficiency (i.e., MERV8 to MERV16). The test house is sited in an area of high PM2.5 and ozone concentrations and also is approximately 800 feet from a freeway with busy traffic (Interstate 80). This enabled the investigators to better assess the outdoor air pollution impact on indoor air quality.

Ultrafine particles, PM2.5, BC, ozone, and nitrogen oxides (NO_x) concentrations and air exchange rate (AER) were measured both indoors and outdoors for each system over multi-day periods across two seasons (i.e., summer and fall/winter). The investigators simultaneously operated two identical sets of continuous air pollutant analyzers for outdoor and indoor measurements during each experimental period. The size distribution of particle number concentrations measured ranged from 6 nm to 2.5 µm, which includes UFP (6–100 nm). PM2.5 mass concentrations were estimated using size-resolved particle number concentrations. Other environmental data such as temperature, relative humidity, and wind speed and direction also were monitored. VOC removal was measured during the summer season when filtration technologies intended for VOC removal were used; these included an activated charcoal filter, a Purafil filter, and an LBNL-developed catalyst sorbent filter.

Energy use was calculated by incorporating measurements and rated power consumption of each air flow component with system run-time estimates obtained through modeling for several different California climate zones. Three sets of data were used to estimate the additional annual energy consumption needed for each system: (1) energy use to operate the enhanced pollutant removal systems for longer hours, (2) increased fan power for the high efficiency filters, and (3) additional energy consumption for several systems with air cleaning devices [e.g., electrostatic precipitator (ESP) and high efficiency particle in air (HEPA) and activated carbon bypass].

Cooking emissions from stir-frying green beans were used to generate indoor PM for tests of four systems' abilities to remove indoor-generated particles. Detailed assessments of indoor particle removal mechanisms were also conducted. Additionally, airflow resistance of the high efficiency filters was measured.

All the enhanced pollutant removal systems reduced indoor particle concentrations, with varying degrees of pollutant reduction performance and energy use. Pollutant removal effectiveness ranged from 63-98 percent for PM2.5, 82-99 percent for UFP, and 38-96 percent BC. Several systems were especially effective at particle removal. High performance filtration (i.e., MERV16) on a supply ventilation system most effectively decreased the indoor levels of outdoor-origin PM, with reductions of 97–98 percent for PM2.5 and 97–99 percent for UFP, with low additional energy use. However, because filtration was located on the supply system, it was not effective in removing particles of indoor origin. MERV16 filtration on the traditional, single motor central forced air system combined with a fan controller also performed very well and also removed indoor particles, but consumed more energy. The investigators note that this energy penalty can be reduced by more than 50 percent by using newer central system technologies such as an efficient low- or multi-speed motor, and/or use of specially programmed operation of the systems to run only just before and during times when the home is occupied. When operated daily for several hours, an enhanced system with MERV13 in the supply system and an ESP reduced indoor particle levels by 81 percent for PM2.5 and 90 percent for UFP. A system with a mini-split fan and MERV13 on continuous low speed airflow decreased indoor particle levels by 95-96 percent for PM2.5 and 96 percent for UFP. In addition, a system, which was operated with a HEPA filter and activated carbon bypass intermittently rather than continuously as intended by the manufacturer, showed the reduction of indoor particles by 78-79 percent for PM2.5 and 83 percent for UFP. This system, however, was estimated to consume much higher energy compared to other systems. Lastly, indoor-generated particles from cooking were effectively removed not only by some central system/high efficiency filtration combinations, but also by portable air cleaners, the latter with only a small incremental energy use.

Measured airflow reductions for high efficiency filters were low: 2.7 percent for a MERV 16 filter, and 4.9 percent for a MERV 13 filter. The three tested VOC removal technologies reduced levels somewhat compared to the reference system, but overall results were not impressive. The report includes many detailed results on removal of indoor particles, particle deposition, and other parameters.

III. STAFF COMMENTS

This draft final report was reviewed by ARB staff from the Research Division and a group of four external advisors. This report reflects the tremendous efforts by Dr. Singer and his team members at Lawrence Berkeley National Laboratory for system design, field sampling, and data processing and analysis. The results of this study will be useful for improved ventilation and filtration measures in the residential building code in California.

Staff has the following comments on the draft final report:

1. The purpose of the NO_X monitoring, the core results, and the reason the data were not used as planned in data analysis all need to be included in the main report.
2. The low reductions in airflow of the high efficiency filters reported in Table 2-4 need to be included in/moved to the Results Section, as they are measurement data obtained in this study. They also should be discussed briefly in the Discussion and Summary and Conclusions Sections, because airflow resistance has been one of the primary arguments against use of high efficiency filters.
3. Figures 3.24 and 3.37 are not easily understood, and require additional explanation and clarification in the text. The x-axis title in figure 3.24 also needs correction.
4. Tables 3-4 and 3-5 provide the key results of percent particle reduction from the study. They would be improved by revising the captions to begin "Percent reduction in…" and adding a sentence or two of additional explanation in the text.
5. The Discussion Section should include brief discussion of some of the particle penetration and removal measurements obtained in this study.
6. Page 118, the statement regarding "If a filter becomes a code requirement…" needs to be corrected; Title 24 already requires filtration in central systems in homes, and it must have an efficiency rating of MERV 6 or higher.
7. Page 122, the statement regarding recommending supply ventilation over exhaust ventilation "for the express purpose of controlling formaldehyde concentrations…" should be reconsidered or clarified. Supply ventilation is not common in California, and one important purpose of this study was to assess

supply ventilation for its ability to remove incoming particles from the air. An assessment of the utility of any system should take into account the impact of the system on all aspects of indoor air quality; here, impacts on incoming particles as well as formaldehyde removal and other pollutants should be considered.

8. Some statements in the Discussion, Summary and Conclusions, and Recommendations Sections do not appear to be directly based on the results of this study or on any cited literature. A tighter focus would be beneficial for those using the results of this study for future code revisions.
9. Some additional limitations of the study should be included in Section 4.3, such as that tests were only conducted for one week in each of two seasons; the weather was sometimes inconsistent and unusual for the season and conditions thus were quite variable for the tests of the different systems (so some differences seen are not necessarily due to differences among the systems); and that PM2.5 mass is estimated from continuous devices which includes substantial uncertainty and results may not reflect actual PM2.5 levels.
10. There are a number of typographical errors to be corrected; staff will provide a mark-up copy to the contractor.

Staff will provide comments from the external advisors and any additional staff comments at or before the meeting.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.6
DATE: December 11, 2015
CONTRACT NO.: 11-306

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Atmospheric Measurement and Inverse Modeling to Improve Greenhouse Gas Emission Estimates
CONTRACTOR:	Department of Energy/Lawrence Berkeley National
PRINCIPAL INVESTIGATOR:	Marc L. Fischer, Ph.D.
CONTRACT TYPE:	Standard Agreement
TOTAL AMOUNT:	$680,000
CONTRACT TERM:	48 months

For further information, please contact Dr. Abhilash Vijayan at (916) 324-0621.

I. SUMMARY

The California Global Warming Solutions Act of 2006 (Assembly Bill 32 (AB32)) requires ARB to reduce statewide greenhouse gas (GHG) emissions to 1990 levels by 2020. This effort relies on accurate accounting of emissions for effective mitigation planning and verification of future emission reductions. Atmospheric GHG measurements from networks of towers, when combined with inverse model estimation techniques, have the potential to accurately quantify current GHG emissions. This project reports on tower measurements and inverse model analyses of emissions for major GHGs which include fossil fuel CO_2 ($ffCO_2$); methane (CH_4); and nitrous oxide (N_2O); using multi-site and multi-year atmospheric observations. An inverse modeling framework was used to estimate emissions by comparing GHG mixing ratios with an atmospheric transport model (Weather Research and Forecasting and Stochastic Time-Inverted Lagrangian Transport, WRF-STILT) predictions based on high-resolution prior emission models that were evaluated using meteorological predicted and measured carbon monoxide (CO) mixing ratios. Utilizing this technique, the analysis yields state annual anthropogenic CH_4 emissions that are slightly higher

(1.2 - 1.8 times) than the anthropogenic emission in ARB's current inventory (1.64 Tg CH_4/yr in 2013), and state annual anthropogenic N_2O emissions of 75 – 97 Gg N_2O/yr, that are 1.5 - 2.5 times larger than the current ARB inventory (44 Gg N_2O/yr in 2013). Assuming the model bias in CO is applicable to CH_4 and N_2O, the estimated emissions drop to 1.0 - 1.6 times the ARB inventory for CH_4, and 1.3 - 2.3 times the ARB inventory for N_2O, if corrected for the 10 percent median emissions. The results also suggest that the livestock sector was likely the major contributor to the state total CH_4 emissions, while a large portion of the increase in global atmospheric N_2O can be attributed to the use of fertilizers with agricultural activities likely being a significant source of anthropogenic N_2O emissions in California.

While the ffCO_2 emission, which accounts for the majority of the total GHG emission in California, is similar to the state inventory in central and southern California, this study shows that the state inventory underestimates both CH_4 and N_2O emissions, in particular in the Central Valley region. This study's results suggest that while continued effort to reduce ffCO_2 emissions should be the first priority in achieving California's GHG emission goals, mitigation of CH_4 and N_2O emissions from the Central Valley would provide additional benefits.

II. TECHNICAL SUMMARY

Objective

The objective of this project was to validate and improve California's GHG emissions inventory using ambient GHG measurements from ARB's tower-based GHG network along with intensive inverse modelling efforts. Specifically, Lawrence Berkeley National Laboratory (LBNL) was tasked with the following objectives: 1) continue and extend GHG measurements at an existing LBNL measurement site in Walnut Grove, CA; 2) implement GHG measurements at a new site that samples air representative of the Riverside and San Bernardino regions; and 3) apply an inverse modeling framework to estimate GHG emissions from the major emission regions of California.

Background

AB 32 directs ARB to adopt regulations to require the reporting and validation of statewide GHG emissions, to reduce the statewide GHG emissions to 1990 levels by 2020. Recent studies indicate that there are still differences between bottom-up inventory and top-down ambient air measurement based emissions estimates. The observed uncertainties are especially evident for inventory estimates of methane and nitrous oxide, both potent GHGs. Methane is also a powerful short lived climate pollutant (SLCP). This study was designed to build on an inverse modelling framework developed for California, continue and expand parts of the GHG network, and take advantage of an expanded GHG monitoring network throughout California. Atmospheric GHG measurements from towers, when combined with inverse modeling techniques have the potential to quantify GHG emissions and reduce uncertainties.

Project Summary

This project reports on the estimation of statewide GHG emissions derived from tower measurements and inverse model analyses. The major GHGs studied in this project include fossil fuel CO_2, methane, and nitrous oxide using multi-site and multi-year atmospheric observations.

This project successfully continued GHG measurements at an existing LBNL measurement station at Walnut Grove near Sacramento, and implemented GHG measurements at a new site in Southern California (San Bernardino) that samples air representative of the Riverside and San Bernardino regions.

An inverse modeling framework was used to estimate emissions by comparing GHG mixing ratios from towers with atmospheric transport model predictions based on high-resolution spatial emission inventories. The investigators assessed the uncertainty in the transport model predictions using a combination of meteorological and carbon monoxide measurements. In general, the seasonal mean biases in boundary layer wind speed, direction, and boundary layer height were found to be small compared to random errors. The atmospheric model simulations were found sufficient to estimate emissions of CO and likely other GHGs across California to within 10-13 percent on annual timescales. Using observations for 2009 – 2012 this study found that $ffCO_2$

emissions are within ~10 percent of the prior estimate. Using CH_4 measurements from 13 sites across California during June 2013 – May 2014, this study found that state annual anthropogenic CH_4 emissions are 1.2 - 1.8 times the anthropogenic emission in ARB's current inventory (2.42 ± 0.49 Tg CH_4/yr 2.17 – 2.65 compared to 1.64 Tg CH_4/yr in 2013). The estimated CH_4 emissions drop to 1.0 - 1.6 times ARB's inventory if the 10 percent median emissions were corrected, assuming the bias in CO is applicable to CH_4. The study also observed that CH_4 emissions from the Central Valley and the major urban regions (San Francisco Bay Area and Southern California Air Basin combined) accounted for 58 percent and 26 percent of the total posterior emissions, respectively. This study combined with other studies (e.g., analysis from volatile organic compound (VOC) measurements) suggests the livestock sector was likely the major contributor to the state total CH_4 emissions.

For N_2O emissions during the same period, this project estimated state annual anthropogenic N_2O emissions to be 1.5 – 2.5 times larger than the current ARB inventory (87 $\pm$ 22 Gg N_2O/yr compared to 44 Gg N_2O/yr in 2013). The estimated N_2O emissions drop to 1.3 - 2.3 times the ARB inventory if corrected for the 10 percent median emissions assuming the bias in CO is applicable to N_2O. This study's results reinforce the understanding that a large portion of the increase in global atmospheric N_2O can be attributed to the use of fertilizers, and agricultural activities are likely a significant source of anthropogenic N_2O emissions in California. The results also indicate that seasonal variations in California's N_2O emissions are relatively small compared to that of the mid-western region of the US.

The study summarized that while the $ffCO_2$ emission, which accounts for the majority of the total GHG emission in California, are similar to the state inventory in central and southern California, the state inventory underestimates both CH_4 and N_2O emissions, in particular in the Central Valley region. This study's results suggest that while continued effort to reduce $ffCO_2$ emissions should be the first priority in achieving California's GHG emission goals, mitigation of CH_4 and N_2O emissions from the Central Valley would provide additional benefits.

III. STAFF COMMENTS

The draft final report was reviewed by staff from the Air Quality Planning and Science Division (AQPSD) and the Industrial Strategies Division (ISD). This project provides a comprehensive assessment of statewide GHG emissions from a top-down analysis perspective with the application of a robust inverse modeling framework. The model results can be used to critically evaluate, diagnose and consequently improve emissions inventories. The project investigators have developed a highly sophisticated modelling framework and comprehensive analysis. Both the model inputs (“priors”, or spatialized emissions inventories) and model outputs (“posterior” emissions) were developed and achieved in close collaboration and discussion with ARB research and program staff. This project also added an important tower site to monitor GHG in San Bernardino, closing a gap in the statewide ARB GHG monitoring network. At the end of the project, this tower site was transitioned to ARB’s Monitoring and Laboratory Division and now is a permanent part of the ARB GHG monitoring network. Furthermore, the project provided an important continuous long-term record of AB 32 relevant GHGs for Central California at the Walnut Grove tower in combination with flask sampling for the previously mentioned GHG species, radiocarbon $^{14}CO_2$, and VOC tracer measurements at the same location.

Overall, ARB staff considers the draft final report to be of high quality. Staff worked closely with the investigators to address specific comments on presentation of data analyses, conclusions, and research recommendations that would improve program understanding, and provide a robust evaluation of the contribution of various sectors to statewide GHG emissions. As such, ARB staff believes the report is of high quality and provides the agency with valuable information on regional methane, nitrous oxide, and fossil fuel carbon dioxide emissions.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.7
DATE: December 11, 2015
CONTRACT NO.: 11-315

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Source Speciation of Central Valley GHG Emissions Using In-Situ Measurements of Volatile Organic Compounds
CONTRACTOR:	The Regents of the University of California, Berkeley (UCB)
SUBCONTRACTOR:	Lawrence Berkeley National Laboratory (LBNL)
PRINCIPAL INVESTIGATORS:	Allen Goldstein, Ph.D. (UCB) Marc Fischer, Ph.D. (LBNL)
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$360,000
CONTRACT TERM:	48 months

For further information, please contact Dr. Eileen McCauley at (916) 323-1534.

I. SUMMARY

To guide development of greenhouse gases (GHGs) reduction strategies, California has developed state-wide GHGs emission inventories (EI). ARB has supported research to improve our GHGs EI, developing regional and source specific information for some GHGs. For example, the Board has supported methane and N_2O research programs including measurements at towers and inverse modeling. In this project, the principal investigators (PIs) used proton transfer mass spectrometry (PTR-MS) to continuously measure a suite of volatile organic carbon species (VOCs), at five elevations on a tall tower in Walnut Grove from summer 2012 through early fall 2013. The VOC data and continuous CO_2, CH_4, and CO measurements were analyzed by the PIs to develop source apportionments for CH_4 and N_2O. Their results confirm that dairies and livestock are the largest regional sources contributing to CH_4 emissions, accounting for 55 - 90 percent of total emissions over different seasons. N_2O agriculture emissions accounted for about 80 – 90 percent of the observed enhancements during fertilizer use

in the spring and summer but declined to about 20 percent of the observed enhancements in late fall season when crops are harvested. In contrast, N_2O emission from the dairy and livestock source were relatively constant across seasons, accounting for > 80 percent of the total enhancements in fall and winter. and fractionally less when agricultural emissions were larger. The role of motor vehicle and hydrocarbon extraction emissions was not significant in the regional inventory and which differs from the state-wide GHGs EI. Study findings highlight the importance of long-term measurements to validate the inventory of non-CO_2 GHG sources.

II. TECHNICAL SUMMARY

Objective

This project funded one year of VOC tracer measurements to constrain estimates of GHG emissions from multiple sources that are currently difficult or impossible to distinguish based on then-existing measurements and modeling. Specific objectives included:

1) Continuous high accuracy concentration measurements for a suite of VOCs over one full year at five elevations from 10 to 525 meters above ground level at the Walnut Grove tall tower site coordinated with the ongoing continuous CO_2, CH_4, CO, 222-Rn and N_2O measurements.
2) Analysis of concentration time series of VOC tracers and GHG's to attempt to distinguish individual source category contributions to the regional GHG emissions.
3) Combining the measured data in an already existing inverse modeling analysis framework (developed for previously collected data at the Walnut Grove tower) to ascribe regional emission estimates to specific source sectors.

Background

Climate Change Solutions Act of 2006 (Assembly Bill 32 (AB32)) obliged the Board to comprehensively manage California anthropogenic emissions of greenhouse gases (GHGs: CO_2, CH_4, N_2O). There are global baseline concentrations for these GHGs and most GHGs are emitted from multiple anthropogenic sources. Some sources emit additional chemicals which can serve as tracers for those specific source categories.

This project established the first continuous measurements of VOCs as GHG source tracer concentrations in the Central Valley of California.

The Board has funded and maintained the Walnut Grove Tower (WGT) measurement program, as well as other ambient monitoring programs aimed at constraining GHG emissions, for more than a decade. The WGT allows collection of gaseous data at five elevations above ground level (525 m, 394 m, 262 m, 131 m, and 10 m) with hourly resolution. The PI has performed VOC tracer analysis in Bakersfield during CALNEX 2010 and with some aircraft flights during the California Airborne Biogenic VOC Emission Research in Natural Ecosystem Transects (CABERNET) campaign.

Project Summary

This goal of this project was to obtain temporally resolved source-apportioned distribution of CH_4 and N_2O enhancements from the Walnut Grove Tower (WTG), which is located 30 miles south of Sacramento. The PI conducted a pilot project in summer of 2011 and demonstrated that PTR-MS could be successfully deployed for continuous automated VOC measurements switching between multiple inlet heights at the Walnut Grove tower. Following the pilot study, the PTR-MS was further optimized. Continuous measurements of CO_2, CH_4, N_2O, CO, and ~20 VOC masses (m/z) were collected at WTG from summer 2012 through early fall 2013. All measurements were processed to final data to yield 60 min average time resolution concentrations for each measurement height.

The PIs applied PMF to the combined GHG-VOC data suite and knowledge of VOC source markers was used to identify the likely and relative GHG source contributions to each PMF source factor. The PIs further used seasonality to apply PMF on individual time periods to evaluate the temporal dependence of the contributing GHG sources. Based on a well-mixed requirement limiting the vertical gradient in mixing ratios, a subset of the measured GHG and VOC data was selected for the inverse modeling. By comparing mixing ratios for samples from different levels of the tower, the PI defined the well-mixed criteria for each season. For source speciated analysis, the PI adjusted the a priori emissions for each source sector with a set of linear scaling factors. These factors represented the source sector weights such that differences between the predicted and measured GHG signals.

III. STAFF COMMENTS

Air Quality Planning and Science, Industrial Strategies, Monitoring and Laboratory, and Research Division staff reviewed this report. Staff provided detailed comments and the PIs agreed with ARB's points and agreed to address all of them. The revised report was sent to the RSC but staff did not have an opportunity for detailed review before it was mailed. Any additional concerns or comments from staff on the revised draft final report will be shared at the meeting.

This project was the first use of speciated VOCs as tracers for sources of GHGs. It demonstrated the use of a source apportionment methodology, commonly used for criteria pollutants, can also provide valuable insights to improve GHGs inventories.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.8
DATE: December 11, 2015
CONTRACT NO.: 11-313

STAFF EVALUATION OF DRAFT FINAL REPORT

TITLE:	Evaluating Mitigation Options of Nitrous Oxide Emissions in California Cropping Systems
CONTRACTOR:	University of California, Davis
PRINCIPAL INVESTIGATOR:	Martin Burger, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$400,000
CONTRACT TERM:	36 months

For further information, please contact Dr. Dongmin Luo at (916) 324-8496.

I. SUMMARY

Agricultural soils are a major source of the GHG nitrous oxide (N_2O) in California, contributing 53 percent of the State's total N_2O emissions. Production of N_2O in soil is mainly a microbial process involving transformation of various nitrogen (N) species, which can be affected by many soil variables governing soil microbial activities. It is possible, therefore, to minimize N_2O emissions from soil through proper management practices that would shun soil conditions known or suspected to stimulate N_2O emissions. This project examined effects of different N fertilizer types and placements, use of nitrification inhibitors (NIs), subsurface drip irrigation (SDI), and organic management on N_2O emissions from crops of tomato, corn, and lettuce. Overall, the use of NIs, SDI instead of furrow irrigation (FI), and incorporation of N fertilizer into two instead of one band most consistently reduced N_2O emissions in tomato or corn. SDI effects in lettuce were inconclusive. Organic management in tomato showed slightly higher direct N_2O emissions than conventional management, due to the FI associated with organic systems. N_2O emissions in different fertilizer sources were in order of ammonium N > mixed ammonium and nitrate N > nitrate N, indicating that nitrification contributed more N_2O than denitrification in the systems tested. The results of this study

provided experimental evidence for mitigating N_2O emissions from California cropping systems. More analyses, however, would be required to assess the economic and other environmental impacts as well as the total carbon footprint of the management options before ARB can make any policy recommendations.

II. TECHNICAL SUMMARY

Objective

The primary purpose of this project is to identify and demonstrate alternative management practices that can reduce N_2O emissions from leading California field crops (tomato, corn, and lettuce). Specific objectives are to: 1) measure N_2O fluxes and compare emission differences between the conventional and alternative management practices; 2) characterize key variables controlling N_2O emissions; and 3) measure crop yields to evaluate N use efficiency.

Background

N_2O is a potent GHG that contributes to global warming. Agriculture soils are the major source of N_2O on both the global scale and in California, accounting for 53 percent of anthropogenic N_2O emissions in California. Because N_2O is produced in soil through microbiological processes involving transformation of N species, its emission is closely related to soil N content and influenced by other soil factors that affect microbial activities such as soil water content, organic carbon availability, oxygen supply, etc. Previous studies conducted in California and elsewhere have showed that N_2O emissions from soil can vary substantially in response to agricultural management practices, especially N fertilization, irrigation, and use of nitrification inhibitors.

This project is a follow-up study of a previous contract that characterized baseline N_2O emissions from major California cropping systems under conventional management practices. The project evaluated several management practices, chosen based on existing studies that demonstrated potential for reducing N_2O emissions from agricultural soils: use of nitrification inhibitors, subsurface drip irrigation, lowered fertilizer concentrations in soil, and manipulation of N fertilizer sources. Field experiments were carried out in three leading California field crops of tomato, corn, and lettuce. In addition, organic management of tomato was studied that relies entirely on N-containing organic wastes (compost manure and guano) as N fertilizer sources. The results were intended to identify best management practices that can mitigate N_2O emissions from agricultural soils. Data from the project will also be used in a current modeling effort to refine and validate a geochemical process-based model for simulating N_2O emissions from California cropland.

Project Summary

The project measured N_2O emissions in tomato, corn, and lettuce cropping systems managed under standard or alternative management practices to identify management options that can be used to mitigate N_2O emissions from agricultural soils. Environmental variables that can potentially affect N_2O emissions such as nitrate (NO_3^-) and ammonium (NH_4^+) concentrations in the soil, soil water content, soil organic carbon content, soil pH, and soil and air temperatures, were also measured. In addition, crop yields were determined in order to evaluate N use efficiency.

Use of a NI, dicyandiamide (DCD), was tested in tomato and corn. Between 11-29 percent reductions of N_2O emissions were observed in the SDI fields of tomato. Reductions were 60 and 63 percent in corn for two seasons, but insignificant for one season due to the premature application of the NI. Despite lowered N_2O emissions, the use of DCD had no impacts on crop yield or N use efficiency in either crop. It appeared that NI is more effective in systems where there was a higher N_2O emission potential such as FI fields of corn than the SDI fields of tomato.

Effects of SDI were tested in corn against FI. SDI reduced N_2O emissions by 60-95 percent, and the maximum reduction was observed in two band application of UAN (a combination of ammonium- and nitrate-N) with SDI. The irrigation effects were inconsistent in lettuce where a combination of surface drip irrigation and sprinkler irrigation was compared to sprinkler irrigation alone.

Tests on the fertilizer N forms and placement were conducted in corn. Of the three N fertilizers, aqua ammonia (i.e., ammonium-N) emitted the most N_2O, followed by UAN and calcium nitrate (nitrate-N alone). However, these results should not be used as recommendations for nitrate fertilizers as they consume more energy to manufacture and possess a higher leaching potential in some soils causing groundwater contamination. In all cases, two-band application of N fertilizers in the row consistently reduced N_2O emissions than one-band application, indicating that decreasing N concentrations in soil can likely be applied as mitigation strategies for N_2O.

Finally, organic management of tomato showed slightly higher N_2O emissions, but similar total carbon footprint compared to conventional practices according to a preliminary Life Cycle Assessment (LCA). More information and a bigger sample size would be needed to draw conclusions about the carbon footprint of any farming systems.

III. STAFF COMMENTS

Two versions of the report were widely distributed for comments, both internally at ARB and externally with a large group of stakeholders, and the revised report was well received. The project was considered to be executed thoroughly and thoughtfully, and the results represent an important addition to the body of knowledge about the effects of management practices on N_2O emissions from agricultural crops. The Principal Investigator added more information in response to the review comments, such as Table 10, the summary table for experiments and purposes, and Section 5, Recommendations and Economics. There were, however, controversial comments on the LCA analysis for conventional and organic tomato systems. Some stakeholders suggested the LCA analysis be removed while others suggested more elaboration on the study. We recommended keeping the discussion of LCA in place, but with no further analysis as LCA was not part of our objectives for this study, and an accurate assessment would require additional data covering N fertilizer manufacture processes, transportation, water pump efficiency, etc.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.9
DATE: December 11, 2015
CONTRACT NO.: 11-305

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Modeling the Formation and Evolution of Secondary Organic Aerosol during CalNex 2010
CONTRACTOR:	University of Colorado, Boulder
PRINCIPAL INVESTIGATOR:	Jose-Luis Jimenez, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$350,000
CONTRACT TERM:	48 months

For further information, please contact Dr. Eileen McCauley at (916) 323-1534.

I. SUMMARY

Secondary organic aerosols (SOA) formed from oxidation of gaseous precursors can constitute a large fraction of the submicron particulate mass and are responsible for significant health and climate effects. Despite their importance, a substantial gap remains between model predictions and field measurements of SOA concentrations. The objective of this project is to improve modeling of the concentration, composition and evolution of SOA in California by using measurements from the CalNex 2010 field campaign to optimize and constrain recent SOA models. Results from this study show that volatile organic compounds (VOCs) alone are insufficient to account for the observed SOA and that primary semi-volatile and intermediate volatility organic compounds (P-S/IVOCs) are needed in models explain ambient concentrations. Several different parameterizations of P-S/IVOCs were investigated; these showed large differences in SOA production, which underscores the need to better constrain these species. The dominant contributors to SOA formation in the South Coast are emissions from gasoline and diesel vehicles and cooking. At long photochemical ages (~3 days), all recent parameterizations of SOA formation over predict urban SOA. Heterogeneous oxidation and fragmentation of SOA are likely to play major roles at the highest

photochemical ages. Results from this project provide important model parameterization comparisons and constraints on SOA formation and aging rates for regulatory models such as CMAQ; these advances will help improve ARB's modeling basis for SIP development.

II. TECHNICAL SUMMARY

Objective

The objective of the project is to improve models for sources, composition and evolution of organic aerosols in California. This was done by both evaluating a variety of state-of-the-science SOA models against field measurements taken during the CalNex 2010 field campaign (Aerosol Mass Spectrometer (AMS) and supporting field measurements) and adjusting the parameters in these models to improve their performance.

Background

The ability of regulators to develop effective control strategies for PM rests on their effectiveness to accurately predict effects of alternative emission control scenarios on ambient air quality. Current models exhibit poor performance for organic aerosols, which are composed of a tremendous number of chemical species with different volatilities. Many of these species are formed through secondary oxidation of co-emitted organic vapors. More specifically, current SOA models are poor at predicting the sources, evolution and concentrations of ambient SOA. Traditional 3-D photochemical models that use estimates of SOA formation from oxidation of VOC precursors typically underestimate observed ambient OA concentrations, often by a factor of two or more. To treat this deficiency, recent SOA models incorporate a refined description of volatility of organic compounds – the volatility basis set (VBS) – and oxidation processes that produce SOA. Although these additions to air quality models generally improve agreement with ambient measurements, large uncertainties remain in how such an approach should be implemented in 3-D regional photochemistry aerosol models. For example, primary semi- and intermediate-volatility organic compounds (P-S/IVOC) are only indirectly constrained by air quality models and are currently not included in emission inventories. The rates of photochemical aging and overall reaction mechanisms for the P-S/IVOC are also poorly understood and constrained. Modeling improvements in these areas will likely require expansion of the VBS methodology to a 2-D VBS description, in which the oxygen to carbon (O:C) ratio is included along with volatility classes.

Significant steps in updating and improving OA models for California were taken by the Jimenez Group during the CalNex LA 2010 field campaign, where they deployed a High Resolution (HR)-AMS system and complementary instrumentation (Thermal Denuder and Potential Aerosol Mass (PAM) instruments) to the Pasadena site to better characterize ambient aerosols. In addition to these instruments, approximately 70 additional instruments were deployed by other groups at the site, making this one of the largest studies of aerosols and their precursors ever carried out in California. Measurements included: OA mass, O:C ratio, and OA composition (apportionment of OA into hydrocarbon-like organic aerosols – HOA – and one or more components of oxygenated organic aerosols – OOA), volatility characterization from Thermal Denuders, potential yields of SOA from OA precursors (from the Potential Aerosol Mass instrument), and concentrations of several SOA precursors. These data form the constraints from which OA modeling improvements are based.

Project Summary

This project modeled SOA formation and evolution in Pasadena during CalNex 2010 with three different methods: 1) a box model; 2) a 3-D dimensional model - WRF-CMAQ; and 3) a simple two-parameter model. Comparisons of modeled with measured concentrations indicate that SOA formed from P-S/IVOCs, or a similar source, must be included in the models to accurately predict SOA concentrations in Pasadena. SOA from VOC oxidation alone is insufficient to explain observed concentrations.

Three parameterizations for SOA formation from P-S/IVOCs were investigated in a box model: P-S/IVOC oxidation from Robinson et al. (2007), Grieshop et al. (2009), and Pye and Seinfeld (2010. Oxidation of VOCs was kept the same in all models - a parameterization of Tsimpidi et al. (2010). Model/measured comparisons showed that the Grieshop parameterization best predicts SOA concentration at the urban site, and also more accurately predicts SOA oxygen content, although this conclusion is dependent on model parameters that are not well-constrained. The relative importance of VOCs and P-S/IVOCs as contributors to urban SOA over different time and length scales remains unclear. Depending on the parameterization used in the box model, the amount of urban SOA from VOCs can range between 15 – 53 percent of the total predicted SOA for the Pasadena ground site. All the parameterizations used in the box model over predict urban SOA at photochemical ages larger than one day when compared to field observations; this has implications for their use in regional and global models.

SOA source apportionment was also carried out using the box model results. Among explicitly modeled VOCs, methylbenzenes contribute the most SOA mass. In contrast, measured PAHs including naphthalene, 1 methylnaphthalene, and 2-methylnaphthalene are relatively minor precursors and contribute 0.7 percent of the SOA mass. The overwhelming majority of urban SOA is attributable to diesel vehicles, gasoline vehicles, and cooking-related emissions; their contributions are estimated to be 16 – 27 percent, 35 – 61 percent, and 19 – 35 percent, respectively (based on model results; where the factor of 2 difference in the contribution accounts for variation from the box models). A significant amount SOA consists of a background that appears to be formed outside the Los Angeles Basin and transported in. The fraction of fossil and non-fossil urban SOA from the different models is generally consistent with the measurements. Importantly, a large source of urban non-fossil SOA most likely due to cooking is identified, whereas biogenic SOA formed from urban-scale emissions makes a small contribution.

The final portion of the modeling work adapted a two parameter model of Hodzic and Jimenez (2011) – called SIMPLE - to predict SOA concentrations in Pasadena. This model successfully predicts SOA concentration and oxygen content with accuracy similar to the more complex parameterizations. Furthermore, the optimal parameters for the SIMPLE model are very similar in both Mexico City and Pasadena, which indicates that this computationally inexpensive model may be useful for predicting pollution SOA in global and climate models. Of note is that pollution SOA is estimated to account for 17 percent of global SOA, and ~1/3 of urban SOA may be nonfossil from cooking and other sources.

Other analyses completed were measurements of SOA formation and OA aging that were made using a photochemical oxidation flow reactor (coupled to an HR-AMS, a scanning-mobility particle sizer (SMPS), and an ozone (O_3) monitor) during the CalNex field campaign. This is the first application of an oxidation flow reactor to ambient urban air. Results from this work provide constraints on the evolution of urban SOA for the growth phase and for the decay phase at long ages, which are difficult or impossible to observe with ambient measurements.

III. STAFF COMMENTS

The draft final report was shared with staff from ARB's Air Quality Planning and Science Division (AQPSD), and the Research Division (RD). RD staff is very satisfied with the quality of work performed and with the presentation of results in the Report. Any comments received from AQPSD will be shared with the committee.

This work made substantial contributions to the understanding of SOA formation in urban areas and at the same time raised important questions about the importance of different sources for SOA precursors. In this respect, the relative importance of diesel, gasoline, cooking and biogenic sources to SOA formation is still unresolved. Recent work on the effect of wall losses on chamber studies of SOA formation has also raised concerns that VOC yield rates may be incorrect in current models. Further studies of emissions from vehicles and cooking using the latest improved instrumentation are recommended by the PI to address these issues. In parallel with such work, further study of ambient aerosols and VOCs is recommended - advanced OA characterization should be added to some air quality monitoring sites (e.g. Aerodyne Aerosol Chemical Speciation Monitors). Above all, further and increased collaboration between researchers in this area (modeling and measurement) should be encouraged (e.g., writing a state-of-the–science review paper by key groups). In this regard, ARB staff is working on holding a joint meeting of PIs involved in SOA work in order to both develop broader cooperation between groups and help target the most useful types of chemical information to modelers.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: III.10
DATE: December 11, 2015
CONTRACT NO.: 10-314

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Probing the Intrinsic Ability of Particles to Generate Reactive Oxygen Species and the Effect of Physiologically Relevant Solutes
CONTRACTOR:	University of California, Los Angeles
PRINCIPAL INVESTIGATOR:	Suzanne E. Paulson, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$301,039
CONTRACT TERM:	36 months

For further information, please contact Dr. Dongmin Luo at (916) 324-8496.

I. SUMMARY

Determining the 'causative agents' in particulate matter (PM) that are responsible for damaging health is the subject of increasing research activity but many questions remain. A scientific consensus has emerged that oxidative stress mediated by reactive oxygen species (ROS) is a major mechanism by which PM contributes to illnesses and mortality. Freshly collected ambient particles are able to generate significant amounts of ROS. This work was aimed at understanding the components in PM responsible for ROS formation under physiological conditions and the role of two important ROS: hydrogen peroxide (H_2O_2) and hydroxyl radical ($^{\bullet}OH$). Measurements of aerosols in the field were complemented by laboratory studies of ROS generation by metals and organics in PM. The detailed analysis of organics and metals from field samples identified the attribution of those components and sources most responsible for ROS activity to their sources, particularly copper from motor-vehicle braking and humic-like substances from biomass-burning. The results are expected to enable the development of PM controls that target the sources that are most responsible for the toxicity of PM.

II. TECHNICAL SUMMARY

Objective

The objectives were to quantify the generation of $^{\bullet}OH$ and H_2O_2 by particle components in simulated lung fluid (SLF), to conduct field studies in Claremont and Fresno to measure quinones and elements, and determine $^{\bullet}OH$ and H_2O_2 generation by PM under physiological conditions.

Background

Determining the 'causative agent' in particles responsible for damaging health is the subject of significant research activity, but questions remain. Scientists believe that oxidative stress mediated by ROS is a major mechanism by which PM pollution contributes to a range of illnesses. When ambient PM samples are extracted into laboratory solutions, significant amounts of H_2O_2 and $^{\bullet}OH$ radical are generated catalytically. The most likely catalysts responsible for ROS generation are transition metals, quinones, and possibly other unknown organics. Studies have focused on limited segments of the phenomenon, measuring H_2O_2 generation and its relationship to transition metals or quinones, or measuring $^{\bullet}OH$ and its relationship to transition metals. In addition, physiologically relevant concentrations of antioxidants present in lung lining fluid influence the ability of redox-active species to generate ROS. Therefore, laboratory studies used simulated lung fluid (SLF) in cell-free assays to measure ROS formation from transition metals and quinones.

Project Summary

This study attempted to understand particulate formation of ROS, by monitoring H_2O_2 and $^{\bullet}OH$ radical generation as well as transition metals and organics, including quinones, in ambient aerosol samples and laboratory-generated test aerosols. Most of these analyses were performed in the presence of physiologically relevant levels of four endogenous pulmonary reductants: ascorbate, glutathione, uric acid, and citrate. Measurements of aerosols in the field were complemented by laboratory studies of $^{\bullet}OH$ and H_2O_2 generation by mixed redox-active PM components (e.g., transition metals and quinones). Some samples were extracted in the presence of dithiothreitol (DTT), an electron donor that has been correlated with markers for biological ROS production.

Laboratory Studies

Synthetic mixtures containing quinones and metals to produce peroxides and $^{\bullet}OH$ were measured to test the hypothesized mechanisms, at concentrations reflecting those measured in field sample extracts. To probe the mechanisms responsible for the production of H_2O_2 and $^{\bullet}OH$ from PM, measurements were conducted on laboratory-generated PM.

Field Studies

A summer field campaign was conducted in Claremont (a South Coast inland site), with high photochemical smog. A winter field campaign was conducted in Fresno, with significant biomass burning. Field samples were extracted into cell-free SLF, a buffered solution containing three antioxidants (ascorbate, glutathione, uric acid), and citric acid to mimic proteins that may chelate transition metals *in vivo*. The samples were subjected to three assays that characterized ROS production/consumption (DTT, $^{\bullet}OH$, and H_2O_2). Additional assays were conducted for components commonly identified in PM: ten soluble transition metals (also speciated iron [Fe]), four quinones, and several PAHs.

Results

Copper (Cu), phenanthraquinone, and naphthoquinones (1,2-NQN and 1,4-NQN) form H_2O_2 in SLF, but only Cu and 1,2-NQN are likely important at ambient concentrations. Iron (Fe) suppressed H_2O_2 formation in SLF, but had a smaller effect in ambient PM extracts, possibly because organic ligands in the PM reduced Fe reactivity. Overall, Cu produced most of the H_2O_2 generated from typical ambient PM. However, measured rates of H_2O_2 formation in ambient PM extracts were lower than rates calculated from soluble Cu; this underestimate was likely due to either H_2O_2 destruction by Fe, or a reduction in Cu reactivity due to organic ligands from the PM. ROS activity was found to be much higher in Fresno samples compared to Claremont, likely due to the wintertime prevalence of humic-like substances (HULIS) from biomass burning. From PM2.5, Cu generally dominated H_2O_2 generation, while Cu and Fe dominated $^{\bullet}OH$ generation. Strong correlations were observed between ROS production and transition metals, especially Cu and Fe, with weaker correlations with quinones.

III. STAFF COMMENTS

The draft final report was reviewed by ARB's Research Division and by the Office of Environmental Health Hazard Assessment. Comments were sent to the PI, and a revised draft final report was expected to address these comments. Here is a summary of staff comments:

1. Several types of SLF have been used for research; the report should explain why this study used a particular formulation. For example, chelating agents and surfactants are used in other SLF formulations that could have an effect on ROS chemistry.
2. PM_4 was sometimes obtained instead of $PM_{2.5}$, meaning a considerable contribution from coarse aerosols. What is the significance of comparisons with $PM_{2.5}$ data sets?
3. This study focused on soluble transition metal ROS chemistry; the final report should discuss the possible role of insoluble Cu and Fe particles (such as nanoparticles that could be ingested by macrophages that produce ROS in response).

Just before the mail-out of this evaluation to the Research Screening Committee, staff received a revised draft final report. Staff is in discussion with the PI regarding the revisions, and may present additional comments at the December 11 meeting.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.