STATE OF CALIFORNIA

AIR RESOURCES BOARD

MEETING OF THE

RESEARCH SCREENING COMMITTEE

May 17, 2013
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

May 17, 2013

9:00 a.m.

AGENDA

I. Approval of Minutes of Previous Meeting: iii-ix

March 8, 2013 meeting

II. Discussion of Draft Final Reports:

1) "Study of In-Use Emissions from Diesel Off-Road Equipment," University of California, Riverside, $300,000, Contract No. 08-315 1

2) "Integrated Physical and Chemical Measurements of Heavy-Duty Diesel Emissions at WVU Full Scale Wind Tunnel," University of California, Davis, $419,914, Contract No. 08-322 7

3) "Improved Characterization of Primary and Secondary Carbonaceous Particles," University of California, San Diego, $255,000, Contract No. 09-328 12

III. Discussion of New Research Projects:

1) "Examining Factors that Influence ZEV Sales in California," University of California, Los Angeles, $295,377, Proposal No. 2758-276 17

2) "The Future of Drop-In Fuels: Life-Cycle Cost and Environmental Impacts of Bio-Based Hydrocarbon Fuel Pathways," University of California, Berkeley, $400,000, Proposal No. 2759-276 22

3) "The Feasibility of Renewable Natural Gas as a Large-Scale, Low-Carbon Substitute," University of California, Davis, $330,934, Proposal No. 2760-276 26

4) "Collection of Activity Data from On-Road Heavy-Duty Diesel Vehicles," University of California, Riverside, $371,724, Proposal No. 2761-276 30

5) "Air Quality Impacts of Low Vapor Pressure-Volatile Organic Compounds," University of California, Riverside, $405,338, Proposal No. 2757-276 35

6) "Environmental Fate of Low Vapor Pressure – Volatile Organic Compounds from Consumer Products: A Modeling Approach," University of California, Davis, $200,000, Proposal No. 2762-276 40

7) "Co-Exposure to Particulate Matter and Ozone: Pulmonary C-Fiber and Platelet Activation in Decreased Heart Rate Variability," University of California, Davis, $600,782, Proposal No. 2763-276 45

8) "Cardiovascular Effects of Multi-Pollutant Exposure: Mechanisms and Interactions," University of California, Irvine, $583,621, Proposal No. 2764-276 51

9) "Developing a New Methodology for Analyzing Potential Displacement," University of California, Berkeley, $695,792, Proposal No. 2765-276 56

10) "Effectiveness of Sound Wall-Vegetation Combination Barriers As Near-Roadway Pollutant Mitigation Strategies," University of California, Los Angeles, $516,139, Proposal No. 2766-276 62

IV. Discussion of Responses to a Request for Proposals:

1) "Evaluating Technologies and Methods to Lower Nitrogen Oxide Emissions from Heavy-Duty Vehicles," RFP No. 12-310, Proposal No. 2767-276

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

March 8, 2013
9:00 a.m.

MINUTES

RSC Members in Attendance via teleconference

Harold Cota
Steven Japar
Irva Hertz-Picciotto
Rachel Morello-Frosh
Tracy Thatcher
Alan Vette
Forman Williams

The Research Screening Committee (RSC or Committee) convened the meeting at 9:07 a.m. The minutes of the October 26, 2012 meeting were approved.

I. Draft Final Reports

1) "Cardiopulmonary Health Effects: Toxicity of Semi-Volatile and Non-Volatile Components of Ultrafine Particulate Matter," University of California, Irvine, $501,484, Contract No. 07-307

   A few minor editorial changes were requested. Additionally, clarification was requested regarding sample sizes of the different experimental treatment groups.

   Motion: Move to accept subject to the inclusion of comments from staff and Committee.

   The Committee approved the report.

2) "Personal, Indoor, and Outdoor Particulate Air Pollution and Heart Rate Variability in Elderly Subjects with Coronary Artery Disease," University of California, Irvine, $235,000, Contract No. 08-307

   Some minor revisions were requested. These included correcting typographical errors.

The Committee also asked for clarification regarding some of the statistical analyses that were performed for this study. They requested that information be added to two of the figures in the report, in order to clarify the statistical significance of the findings. Additionally, the Committee asked that further discussion of some of the analyses' limitations be included in the report.

The Committee also requested that the authors include more caveats in their discussions of particular results that involved relatively few subjects.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the report.

3) "Characterization of the Atmospheric Chemistry in the Southern San Joaquin Valley," University of California, Berkeley, $1,095,000, Contract No. 08-316

Staff noted that some statements in the report needed to be more nuanced and that the contextual setting or representativeness of the study results needed to be clearly articulated. The Committee noted the large amount of information and important data in this report. There was some discussion about the relative contributions of gasoline and diesel sources to secondary organic aerosol and divergent conclusions between different researchers. It was noted in general that more information on assumptions and caveats were needed in the report but in particular regarding the diesel secondary organic aerosols (SOA) analysis. Committee members also offered various thoughts about the utility and appropriateness of using a journalistic paper-style approach for presenting results in a report. Specific Committee comments noted that the first two bulleted analytical results in the Executive Summary seemed to differ and need to be stated more clearly. Also, Section 6 (Conclusions and Recommendations) included only recommendations and so needed a paragraph or two regarding conclusions.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the report.

4) "Characterization of Ambient Aerosol Sources and Processes During CalNex 2010 with Aerosol Mass Spectrometry," University of Colorado at Boulder, $285,000, Contract no. 08-319

Staff received several minor comments from a National Oceanic & Atmospheric Administration representative. For the most part, these requested further contextual information, such as the consistency of aerosol mass spectrometer measurements with Standard Reference Measurements and comparison of CalNex particulate matter concentrations with those from the South Coast Air Basin monitoring network. These comments will be addressed in a revised final report.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the report.

5) "Hourly In-Situ Quantitation of Organic Aerosol Marker Compounds During CalNex 2010," University of California, Berkeley, $249,999, Contract No. 09-316

The Committee noted the report inferred that control of precursors contributing to the formation of secondary organic aerosols was needed but was not very specific about the volatile organic compounds emission controls needed (e.g., both local and regional controls are said to be needed but specific sources were addressed in a subjective manner, if at all). It seemed that the regulatory implications are not different from what's already being done. The report could mention more about the new diesel regulations in the State and how the SOA might be impacted.

The Committee was concerned that only particle-phase organics were included in the positive matrix factorization (PMF) analysis (p. 38) and whether this assumption might introduce any bias in the results. Also, the range of numbers presented for the SOA2 and SOA3 PMF solutions needs to be clarified (i.e., specific percentages were presented for other factors but ranges were presented for these two solutions – what are the uncertainties?). The discussion in the last paragraph of Section 4.7 should be clarified or expanded. The Committee also noted that the figures should be interspersed with the text and that the figures (including captions) should be sufficiently comprehensive to stand alone.

The Committee had reservations about the journalistic paper-style and some members would like to see a report section on Methods to learn more about what was actually done. The report needs to stand on its own – although the material (content) appears complete, the report will be in the public domain and so must adequately convey the study and results to that audience.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the report.

6) "A Field Experiment to Assess the Impact of Information Provision on Household Electricity Consumption," University of California, Los Angeles, $173,934, Contract No. 08-325

Staff provided comments from additional reviewers. The reviewers found the report to be well organized, straightforward and easy to read. They provided some general comments and some editorial suggestions. One reviewer also found that the report provides further evidence that a one-size-fits-all message can be counter-productive since low users tend to "revert to the norm" of higher usage when, utilities communicate with them about their "low" status.

A Committee member suggested that the graphs and figures should be integrated into report instead of at the end. In addition, they suggested that table captions go on top and figure captions go below the figure. The Committee found that the figure captions are too brief and should be expanded so that they can stand alone. An appendix should also be added to show the online educational survey.

A Committee member expressed concern that there wasn't a good sense of the average time period before and after the treatment and that this should be clarified in the final report. The discussion should also talk about how sustainable the observed decrease in energy use is. The results imply that strategies should target high users but there should be more information on that in the discussion.

A Committee member suggested that the discussion should include a more detailed discussion of the sensitivity to the gift cards amount. Do the results allow the researchers to conclude that we don't need to use Amazon cards since many people didn't accept the offer? The report should also discuss whether future research should also address income, linguistics and household size.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the report.

7) "Identifying Determinants of Very Low Energy Consumption Rates Observed in Some California Households," University of California, Davis, $104,911, Contract No. 09-326

A Committee member expressed concern about the fact that the conclusion is more of a question than a conclusion and major points need to be cleaned up. The message that the low-users contain a diverse demographic is not emphasized enough and occluded by the fact that they are on average lower income. There is also confusion on why the surveyed subset of low users is different from the average low user.

A Committee member thought it was a worthwhile study but that the structure of the report was confusing. It was suggested that the order of the hypotheses be rearranged in a more logical order. It was also suggested that the researchers include a tips section because there was so much variation in what the low-users did and it's too spread out throughout the report.

A Committee member suggested that the graphs and figures should be integrated into report instead of at the end. In addition, they suggested that table captions go on top and figure captions go below the figure.

Motion: Move to accept subject to the inclusion of comments from staff and Committee. Rachel Morello-Frosch abstained from voting.

The Committee approved the report.

8) "Black Carbon and the Regional Climate of California," University of California, San Diego, $820,483, Contract No. 08-323

The Committee had the following comments:

In the abstract and several other instances throughout the document, the authors refer to black carbon emissions reductions in California in the context of global warming/cooling. Because this work focuses on California, it seems more appropriate to use either atmospheric warming/cooling effects or regional warming/cooling.

The Committee noted that student t-test may not be an appropriate statistical test for these data. Student t-test assumes normal distribution. Other non-parametric tests of differences could be considered here depending on the distribution of the data. Staff explained that it is true that non-parametric tests are more powerful than the student t-test because they made no assumption of normality or homogeneity of variance. However, the analyses were performed using only five years of simulation. The usefulness of the statistical tests is primarily limited by the sample size rather than by the statistical methods used. Hence the report did not include other statistical tests that complicate the interpretations of the results.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the report.

II. Response to a Request for Proposal

1) "Technical Analysis of Vehicle Load-Reduction Potential for Advanced Clean Cars," $250,000, RFP No. 12-311

A Committee member asked how scores were assigned for each proposal. Staff responded that Mobile Source Control Division and Research Division staff assigned the scores; the proposals had also been informally reviewed by United States Environmental Protection Agency staff, though they did not participate in the scoring process.

A Committee member asked whether ARB staff would have access to the proprietary data proposed to be analyzed. Staff responded that the data would be available for inspection during the contract period to verify the results of the analysis, but any subsequent use of the data following the expiration of the contract would require additional access rights.

Committee members agreed with staff's scoring of the proposals given the expertise required to complete the scope of work and the proposed hours to be spent by project personnel.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the proposal. Steven Japar was not present for the vote.

III. Other Business

1) Update on a research proposal titled, “Investigating Controls and Measurement Methods of Semi-Volatile Organic Compound Emissions from Light-Duty Vehicles”

   Staff informed the Committee that the contractor for the proposal approved at the October 26, 2012 RSC meeting, changed from Colorado State University, Fort Collins to University of California, Berkeley. The title was modified to “Investigating Semi-Volatile Organic Compound Emissions from Light-Duty Vehicles.” The investigators, total budget, and scope of work did not change. The reason for the change was that Professor Robinson left Colorado State University to return to Carnegie Mellon University.

2) Update on RFP 12-310 titled, “Evaluating Technologies and Methods to Lower Nitrogen Oxide Emissions from Heavy-Duty Vehicles”

   It is now a 1.6 million dollar project. We’re doing two technologies, stoichiometric natural gas with three way catalyst and diesel with selective catalytic reduction (SCR).

3) Resolution for Dan Costa

The meeting adjourned at 11:15 a.m.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: II.1
DATE: May 17, 2013
CONTRACT NO.: 08-315
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Study of In-Use Emissions from Diesel Off-Road Equipment
CONTRACTOR:	University of California, Riverside
PRINCIPAL INVESTIGATORS:	Kent Johnson, Ph.D. Tom Durbin, Ph.D.
CONTRACT TYPE:	Interagency Agreement
BUDGET:	$300,000
CONTRACT TERM:	60 months

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

I. SUMMARY

Off-road diesel engines are a significant contributors to the California nitrogen oxides (NO_X) and particulate matter (PM) emissions inventories, but are not very well-characterized emissions sources because only the engine is certified, and until recently in-use emissions testing was problematic. Using their recently Environmental Protection Agency (EPA) approved portable emissions measurement system (PEMS), researchers from the University of California, Riverside, collected in-use emissions and engine parameter data from a fleet of 27 units of in-use construction equipment using the PEMS located on-board the emissions source being tested in the field. NO_X and PM emissions generally appear to be below the applicable emissions standards, although comparisons are complicated by the differences in engine operation between the steady-state certification test cycle, and actual in-use, transient engine operation. These new data are expected to be included in future updates of ARB's off-road emissions inventories. The improved emissions inventories for off-road sources will assist ARB policymakers and stakeholders in assessing the emissions contributions from these important sources.

II. TECHNICAL SUMMARY

Objective

The objective of this project was the collection of engine parameter and pollutant emissions data from a fleet of in-use off-road construction equipment that will be used for future updates to ARB's off-road emissions inventories. This more general objective is different than the original, and more specific, project objective of trying to determine in-use off-road diesel engine deterioration rates. This original objective was modified because the difficulties with recruitment (discussed below) would have rendered impossible any attempt at a deterioration study.

Background

As the on-road motor vehicle fleet complies with increasingly stringent emissions standards, the emissions contribution from the off-road sector increases in importance. However, unlike on-road motor vehicles, off-road source present unique emissions measurement and modeling challenges compared to on-road motor vehicle fleet.

First, only the off-road engine is required to be certified, and no in-use compliance requirements or procedures currently exist for off-road engines. This has historically made in-use testing of off-road sources problematic. And second, while the on-road vehicles fleet is comparatively homogeneous, off-road emissions sources are quite diverse. The off-road emissions fleet is primarily diesel- and gasoline-fueled, and includes such diverse sources as aircraft, locomotives, ocean going vessels, airport ground support equipment, construction and mining equipment, agricultural equipment, small off-road engines (lawn mowers, string trimmers, etc.), recreation vessels (e.g., personal water craft), and snowmobiles. And, in addition to all of these different equipment types, the off-road population is further subdivided into eight horsepower (hp) category bins, and five emissions certification Tiers, resulting in hundreds of equipment type/hp category/certification Tier combinations.

Over the past several years PEMS have been developed and refined to the point where PEMS are now practical to use for routine pollutant data collection purposes in the field. The size and diversity of the off-road population means that only a small subset of the

in-use off-road population can be emissions tested in any single test project. So, with the above in mind, this project focused on recruiting and in-the-field emissions testing a small fleet of in-use off-road construction equipment using a PEMS located on-board the equipment being emissions tested.

Project Summary

In broad terms, the project consisted of the following tasks:

- Equipment recruitment,
- Emissions testing, and,
- Data processing, analyses, and reporting of results

Equipment recruitment: The equipment tested ultimately ended up being recruited largely from participants in ARB's Air Quality Improvement Program (AQIP) off-road hybrid pilot project. Early participants were drawn from CE-CERT contacts, but these were public agency fleets or rental companies tested over 'choreographed' (contrived) equipment operations, and so AQIP contacts were used to recruit some private fleets.

Emissions Testing: The recruited units were tested using on-board PEMS, and for some units, emissions testing was conducted over choreographed operations, while for the last 17 units, testing was of equipment in actual revenue service.

Data processing, analyses and reporting: CE-CERT performed extensive data processing (initial post-processing, time-alignment of real-time power and emissions data, taking a three-second moving average to smooth out the peaks in the data, and separating out idle emissions). Per direction from ARB client division (PTSD), the CE-CERT data analyses focused on instantaneous (second-by-second) 'power-based emission rates' that are in units of mass/time (g/hour), instead of the current 'brake-specific' methodology that utilizes composite test-cycle average emissions rates in units of grams per brake horsepower-hour. Results are presented in two sections: 1) general summary of results using three metrics; and 2) power-based results using gram/hour emissions factors.

Results: The results should be qualified by noting that the certification test cycle is an 8-mode steady-state engine dynamometer test cycle, while the emissions testing was conducted in the field, over transient engine operation. In addition, the 'load factors' (an indication of the amount engine power or 'work' being done by the engine over some time interval) tended to be different between the certification test cycle and the in-use testing, and this will also influence results. Results are expressed in units of g/hour.

General summary

NO_X emissions - NO_X emissions were generally below the applicable certification standards, and did not show a trend with respect to model year and certification standards. NO_X emissions ranged between about 120 and nearly 800 g/hour.

PM emissions - PM emissions were also usually below the applicable standards, although six units had high PM emissions. PM emissions had a wide range - between near zero for the DPF-equipped engines, to about 63 g/hour for the highest emitter.

Carbon dioxide (CO_2) emissions - As might be expected for competitive reasons, fuel consumption, and hence CO_2 emissions, on a g/bhp-hr basis, were similar among most of the test fleet at about 520 - 650 g/bhp-hr.

THC emissions - THC emissions were generally low, although two backhoes did have high THC emissions. THC emissions ranged between about 3 - 46 g/hour, with 20 units at or below 15 g/hour.

CO emissions - CO emissions ranged between about 0 (post-DPF) and 518 g/hour, and were generally well below NO_X emissions, although there were three cases where CO rivaled or exceeded NO_X emissions.

Power-based analyses

As the emission inventories for off-road sectors improve it has become clear that more information is needed to better understand how these equipment operate and how emissions vary with operation and as newer and more efficient emission control devices are utilized. This analysis focused on emissions data as a function of instantaneous

power to help inform how emissions vary under different operating conditions. The regression results for the power-based analyses are presented in section 5. This is only a cursory look at how emissions vary with power but a good first step to understanding this relationship.

III. STAFF COMMENTS

The final report was reviewed by ARB's Research Division (RD) and Planning & Technical Support Division (PTSD) staff, and reflects considerable input from PTSD staff. The version of the report before the Committee has undergone extensive revisions, reflecting ARB staff comments and direction.

The project had two major problem areas: 1) PEMS procurement; and 2) equipment recruitment. Each is discussed below.

PEMS procurement: The original plan was to borrow an ARB-owned PEMS from another division for the emissions testing portion of the project, but other higher priority projects and difficulties in recruiting participants resulted in only abortive attempts to use ARB's PEMS. Ultimately, CE-CERT (with some financial assistance from this project's amended contract) was able to work with AVL to get EPA approval of the AVL gaseous and PM PEMS, and demonstrate CFR Part 1065 compliance. This part 1065-compliant integrated PEMS was used to test last 17 units, while first ten were tested with a similar gaseous PEMS (a SEMTECH PEMS) and the AVL PM PEMS, that were installed on a more 'piecemeal' fashion.

Participant recruitment: ARB's client division staff (PTSD) expressed a strong preference for specific in-use equipment types in actual revenue service, and owned by private fleets, and trying to meet all of these target parameters this proved to be problematic. Target equipment types (specific equipment type, desired fleet-representative engine manufacturer, model year, certification Tier, and horsepower category) were difficult-to-impossible to locate. ARB's RD staff became actively involved in equipment recruitment using ARB's confidential off-road DOORS database, but turned up few leads of anyone willing to participate period, much less fitting the target

test fleet parameters such equipment type, model year, Tier, etc. On a separate, but related front, RD and CE-CERT staff were working with ARB's Mobile Source Control Division staff on a programmatically completely independent, but technically similar, project involving hybrid off-road equipment. AQIP participants were paid incentives to partially subsidize the purchase new hybrid bulldozers and excavators, and as part of the project/program, had to agree to emissions testing so that ARB could determine the fuel consumption and emissions impacts of hybrid equipment compared to conventional equipment. AQIP participants were compensated for the loan of their equipment for emissions testing, and with MSCD approval, AQIP participants were solicited about participation in ARB's off-road emissions inventory improvement project (the RD project provided no compensation). To increase the number of potential participants, instead of targeting a large fraction of the test fleet on only one or two equipment and hp categories, the equipment list was expanded to include a variety of equipment types, targeting equipment with some prevalence in the in-use fleet.

This project was a challenge to manage, and was successfully completed only because of the confluence of the two ARB projects, and flexibility on the part of the MSCD and AQIP project participants, and the client division. The two off-road projects highlight the importance of financial incentives in securing good equipment owner participation in such an emissions testing project.

IV. STAFF RECOMMENDATIONS

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.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: II.2
DATE: May 17, 2013
CONTRACT NO.: 08-322
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Integrated Physical and Chemical Measurements of Heavy-Duty Diesel Emissions at WVU Full Scale Wind Tunnel
CONTRACTOR:	University of California, Davis
PRINCIPAL INVESTIGATOR:	Anthony S. Wexler, Ph.D.
CONTRACT TYPE:	Interagency Agreement
BUDGET:	$419,914
CONTRACT TERM:	54 months

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

I. SUMMARY

Understanding the health impact of mobile source diesel particles is challenging due to the complex physical and chemical evolution of the particles in the engine combustion, exhaust aftertreatment devices, and atmospheric plume-processing, especially near roadways. The linkage between the particle emissions measured in the laboratory and near roadways is lacking. The research objective of the project was to characterize the physical and chemical evolution of diesel particulate matter emissions measured in a full-scale wind tunnel imitating real-world, near-road environmental conditions. Particulate matter, gaseous pollutant concentrations, and meteorological parameters were measured by multiple real-time instruments on cross-section sampling planes at various distances downwind of the exhaust at test speeds of 5, 20, and 35 mph. At the low test speed, the exhaust plume had high residence time, low turbulent mixing, and narrow dimension. At the high test speeds, the exhaust plume initially stretched longitudinally, but later expanded vertically due to the high turbulent mixing. Particles measured from the pre-2007 truck showed consistent changes in particle size

distribution at test speeds of 20 and 35 mph as follows. Nucleation mode particles initially grew in size, and their concentration increased, and then shrunk in size, and their concentration decreased in the wind tunnel. The post-2007 vehicle emitted unusually high accumulation mode particle concentrations due to a crack in the diesel particulate filter (DPF) and a DPF regeneration event. Particles measured from the post-2010 trucks were significantly lower than the other two trucks, and in fact were comparable to the background particle concentrations. This study presents various particle evolution patterns from the three trucks, and further extensive data analysis work should follow to investigate several unexplained unique particle behaviors in the tunnel that may be related to the crack in the DPF, uncertainties in the aerosol instruments, and others.

II. TECHNICAL SUMMARY

Objectives

The research objectives are to characterize the physical and chemical evolution of diesel particulate matter emissions in a full-scale wind tunnel, imitating the real-world near-road environmental conditions. Specific objectives of this research project include:

- Construct a full-scale wind tunnel and sampling platform for heavy-duty diesel emission tests;
- Measure diesel emissions in the wind tunnel;
- Quantify ultrafine particle formation and growth patterns;
- Understand how the plume aging process affects the chemical and physical properties of diesel particles.

Background

Over 35 million people are estimated to live near large roadways and other major transportation facilities in the United States, and countless others living, working or going to school in close proximity to traffic emissions throughout the nation. Human exposure to traffic-generated air pollutants near roadways is a California and nationwide concern due to the particle related health impacts such as premature death, respiratory diseases and others. Understanding the health impact of mobile source diesel particles is challenging due to the complex physical and chemical evolution of the particles in the

engine combustion, exhaust aftertreatment devices, and atmospheric plume-processing, especially near roadways. The particle emissions have been extensively investigated in the controlled laboratory environment, (e.g., Continuous Volume Sampling (CVS) system) where their physical and chemical properties have been characterized. However, linkage between particle emissions measured in the laboratory and near roadways is not well understood, especially for ultrafine particles (less than 100 nanometers). Further, the introduction of DPF and selective catalytic reduction (SCR) aftertreatment technologies has complicated the physical and chemical behavior of ultrafine particles because the DPF and SCR remove nearly all solid soot particles. Because most of diesel solid soot particles are made of black carbon, a strong light-absorbing compound, the introduction of DPF and SCR will significantly change the particle optical properties, hence the climatic impact. It is necessary to characterize the physical and chemical evolution of the diesel particles in a test set-up imitating the real-world near-road ambient conditions.

Project Summary

This project originally planned to characterize the physical and chemical evolution of the exhaust plumes in the National Full-Scale Aerodynamics Complex (NFAC) in NASA Ames Research Center. However, management of the NFAC was transferred to the Department of Defense (DOD), and due to changing priorities DOD was not able to confirm test dates. After continuing delays and an uncertain test schedule, the investigators and ARB decided to construct a full-scale wind tunnel at West Virginia University (WVU). The wind tunnel constructed at WVU is an open-circuit configuration, the test section of the wind tunnel is 16 feet high, 16 feet wide, and 100 feet long, and houses the cab of a heavy-duty truck. Three heavy-duty diesel trucks, a pre-2007 truck without aftertreatment, a post-2007 truck with DPF, and a post-2010 truck with DPF and SCR, were tested at 5 mph for idling, 20 mph for flat road cruising, and 35 mph for steady state cruising. In the full-scale wind tunnel, instantaneous emissions of particulate matter, gaseous pollutants, and meteorological parameters were measured by multiple real-time instruments on 130 sampling points divided into 10 cross-section sampling planes at various distances downwind of the exhaust stack.

Wind velocities and CO_2 concentrations in the tunnel were modeled with computer simulators and compared to measurements for testing the capability of simulating plume dispersion and aerosol dynamics in the wind tunnel. The simulated results varied significantly from the measured results within 0.5 meter of the truck exhaust, but generally agreed with the measurement further down the tunnel.

Particles measured from the pre-2007 truck showed consistent physical and chemical evolution at each test speed. Nucleation mode particles (less than 50 nanometers) from the exhaust exit grew in size, and their concentration increased. At further distance from the exhaust exit, nucleation particles shrunk in size, and their concentration decreased. This pattern of particle size and concentration changes is comparable to the pattern of particles observed near roadways. At the idle speed, particle concentrations measured in the tunnel do not change at the same rate as CO_2 due to slower particle dilution than gas dilution, and show unexpectedly high accumulation mode particles (greater than 50 nanometers and less than 1 micrometer). However, at the speeds of 20 and 35 mph, the nucleation mode particles showed a general grow-shrink particle evaluation pattern as expected; nucleation mode particles grew in size within 1 meter of the truck exhaust and shrunk in size at further distance from the truck exhaust.

Particles measured from the post-2007 truck showed much higher accumulation mode particle concentrations than expected from a DPF equipped vehicle. The high accumulation mode particles were not expected at the given short residence time in the wind tunnel. It was later found that the high accumulation mode particle concentrations were due to a crack in the DPF that allowed accumulation mode particles to pass through, and also due to DPF regeneration events that occurred during the tests at 20 and 35 mph. Due to the cracked DPF and DPF regeneration event, the pattern of nucleation mode particle evolution was unusual; particles initially grew, shrank, and regrew, which violates a general grow-shrink particle evaluation pattern.

Particle concentrations measured from the post-2010 truck were significantly lower than from the other two trucks, and in fact were almost comparable to the background level particle concentrations. Not only particle emissions, but also NO_X emissions due to the

SCR operation were extremely low, especially at 35 mph, compared to the other two trucks.

This study presents various particle evolution patterns from the three trucks, and further extensive data analysis work should follow to investigate several unexplained unique particle behaviors in the tunnel that may be related to the crack in the DPF, uncertainties in the aerosol instruments, and others. The investigators identified a number of uncertainties and unexplainable measurement results such as unexpected growth of accumulation mode particles and unexpected three mode particle size distributions (nucleation, nucleation + accumulation, and accumulation modes) instead of classical two mode particle size distributions (nucleation and accumulation modes), and suggest further data analysis and investigation of tunnel measurements.

III. STAFF COMMENTS

Staff reviewed this report and provided comments to the investigators, and the investigators were responsive in addressing the comments. Staff believes that this project has made initial progress to quantify ultrafine particle formation and growth patterns and to understand how the plume growth process affects the chemical and physical properties of diesel particles. With further extensive data analysis and investigation, the results are expected to be published in peer reviewed journals. Staff notes that the dataset generated from this study combined with extensive additional data analysis work has great potential to provide valuable information on the evolution of particles which cannot be easily observed in laboratory dilution tunnel testing.

IV. STAFF RECOMMENDATIONS

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

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: II.3
DATE: May 17, 2013
CONTRACT NO.: 09-328
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Improved Characterization of Primary and Secondary Carbonaceous Particles
CONTRACTOR:	University of California, San Diego
PRINCIPAL INVESTIGATOR:	Professor Lynn M. Russell
CONTRACT TYPE:	Interagency Agreement
BUDGET:	$255,000
CONTRACT TERM:	40 months

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

I. SUMMARY

Many urban and rural areas are out of compliance with California and federal ambient air quality standards for fine particulate matter (PM2.5). While advances have been made in measuring and modeling the inorganic ionic species that are found in particulate matter, much less is known about the organic fraction. Yet organic matter can be a major constituent of aerosols. Better understanding and characterization of organic aerosols through improved measurements are needed in order to identify their emission sources and impacts on health, visibility, and climate. This research included measurements of organic mass (OM) concentration by Aerosol Mass Spectroscopy (AMS) and Fourier Transform Infrared spectroscopy (FTIR), as well as X-ray Fluorescence (XRF) for elemental tracers. The results indicate that vehicle emissions are the main source of the OM portion of particulate matter. OM accounted for 56 percent of submicron particle mass (PM1) in summer at Bakersfield, California, with secondary organic aerosols (SOA) components contributing 80 percent to 90 percent of OM from May 15 to June 29, 2010. SOA formed from alkane and aromatic compounds, the two major classes of vehicle-emitted hydrocarbons, accounted for 65 percent of OM (72 percent SOA) in the summertime San Joaquin Valley (SJV). This research project

supports ARB's strategy of reducing vehicular emissions which are the main source of OM.

II. TECHNICAL SUMMARY

Objective

The objective of this study was to quantify the mass fraction of organic functional groups to emissions from combustion and biological processes using trace metal and organic molecular signatures. The organic aerosol sampling was carried out at a designated sampling location southwest of Bakersfield in the southern SJV, in coordination with CalNex 2010 measurements.

Background

Regulatory efforts to comply with PM2.5 standards require improvements in our knowledge of the factors controlling the concentration, size, and chemical composition of fine particulate matter. OM can be divided broadly into two components: organic carbon (OC), and all other non-organic mass, and it generally refers to the mass of the entire carbonaceous material, including hydrogen and oxygen. OM can be emitted directly from combustion sources or it can be formed from gas species in the atmosphere, referred to as SOA. Quantitative, time-resolved knowledge of the composition of atmospheric particulate organic matter is critical for identifying its sources, to understanding its formation and transformation processes, and to evaluating its roles in air quality and in global climate change. In several peer-reviewed publications, organic source apportionment of OC and OM has been carried out using organic molecular markers to identify sources. These recent findings illustrate the need to improve the chemical characterization of SOA in California so that its sources can be identified.

In addition, aerosol particles play an important role in the radiative balance of the atmosphere, with their organic fraction representing one of the largest uncertainties in our ability to quantify climate cooling and feedback effects. Because of the overlapping importance of organic aerosols for both climate and air quality, this project was carried out at Bakersfield in the context of the CalNex campaign, a short-term atmospheric sampling program through which the combined issues of climate change and air quality

were studied to develop new integrated policies. During the CalNex campaign, many types of atmospheric measurements were used to study constituents contributing to both climate change and poor air quality. Ground-based measurements were located in a measurement supersite in the southern SJV at Bakersfield.

The Bakersfield supersite allowed for comparison of complementary collocated measurements and was able to extend the comparisons to measurements available from the other platforms. The SJV contains many regions in which the average hourly ozone and PM2.5 levels are above the California state standards. With its combination of meteorology, geography, and local and transported sources, the Bakersfield site in the southern SJV was an ideal location for the CalNex supersite, where the causes and effects of pollution could both be studied. Ground-based measurements focused specifically on the intensive study of particulate mass and ozone.

Project Summary

To study the sources and formation of SOA in the SJV, the UCSD investigators conducted field measurements at Bakersfield during May 15 – June 29, 2010. The objectives of the work were achieved by fulfilling the following specific research tasks: 1) collection and measurement of ambient fine particles during the intensive field campaign; 2) factor analysis for source apportionment; 3) identification of particle clusters using cluster analysis; and 4) potential formation mechanisms of the SOA components. Chemical composition of PM1 and PM2.5 were measured using a set of complementary, ensemble, and single particle analysis techniques, including FTIR, AMS, and scanning transmission X-ray microscopy with near edge absorption fine structure (STXM-NEXAFS).

The most commonly used factor analysis tool in atmospheric sciences is positive matrix factorization (PMF). In this study, PMF was used to extract major components that contributed to the organic mass. Cluster analysis applied to the ensemble infrared spectra, the single-particle mass, and NEXAFS spectra, separated particles into several groups, each of which has characteristics of distinct sources or atmospheric processes. Based on the composition and diurnal cycle of the SOA components and their

relationships with potential atmospheric oxidants, formation mechanisms of the SOA components were estimated.

On average, OM in PM1 and PM2.5 was 2.42 and 3.23 µg m^{-3}, respectively. PMF analysis was applied to the FTIR and AMS measurements, resulting in very high agreement between the two sets of independently-derived factors, both of which suggested that SOA components accounted for 80 to 90 percent of fine particle OM. A majority of the OM was composed of oxidized components, of which the vehicular emission oxidation products accounted for 65 percent of the OM in summer 2010 at Bakersfield, California. In particular, the alkane and aromatic SOA components, which are the oxidation products of the two major vehicular exhaust constituents, were consistently identified from the FTIR and the AMS measurements. Compared to the vehicular emission SOA, the biogenic SOA was relatively small, accounting for 10 percent of the OM. However, this factor was high during the night when its mass fraction reached up to 50 percent and contained the largest mass fraction of organo-nitrate groups (8 percent). The downslope winds from the mountains to the east and south of the sampling site likely brought biogenic VOCs, typically terpenes emitted from the coniferous trees from the forests, providing nighttime precursors.

This study also identified aerosols likely emitted from local petroleum operations and cooking activities, which were mainly in particles smaller than 200 nm. Though these sources were negligible in the inventory of primary emissions for the Bakersfield site, they accounted for 13 percent and 7 percent of the PM1 organic mass, respectively. The results indicate that vehicular emission is the main source of OM. In addition, the different VOC sources, oxidants, and formation mechanisms identified in this work demonstrate the complexity of emissions and atmospheric processes at Bakersfield. Not only did anthropogenic and biogenic SOA components differ in composition, they also differed in size. Namely, oxidized alkane and aromatic SOA components was largely distributed in 200- to 500-nm-sized particles, suggesting that they were formed from condensation of gas-phase oxidation products, while biogenic SOA was in 400- to 700-nm-sized particles at night, likely due to condensation of biogenic SOA on large primary particles.

III. STAFF COMMENTS

Staff from ARB's Planning and Technical Support, Monitoring and Laboratory, and Research Divisions as well as staff from the National Oceanic and Atmospheric Administration reviewed an earlier version of the report and the current version has incorporated staff comments to improve its clarity. The final report accurately describes the completed work and its implications, and identifies future research needs. The reviewers' comments generally recognized the quality of the research effort and the practical importance of the results. The project successfully completed the stated objectives and the report does an excellent job of documenting the findings. The investigators also prepared a "Response to Comments" file that addresses comments made by the review team. In addition to preparing this final report, the investigators have published their results in three peer-reviewed journals. The response document and the published papers were sent to the RSC members along with the draft final report.

Overall, this project advanced monitoring and analytical methods to improve our understanding of emissions and atmospheric processes impacting aerosol concentrations in the Bakersfield area. This project also provided useful new data for air quality attainment strategies in the SJV, where the highest annual PM2.5 concentrations in the United States occur. The analysis of these data will inform the development of the next State Implementation Plan for the SJV and increase our understanding of the pathways leading to secondary organic aerosols. Because of the uncertain radiative roles of organic aerosols, these results are also important in climate change research. These measurements and observations are a valuable resource to the entire CalNex team as the various investigators continue analyzing the data and comparing the SJV measurements with those from the other CalNex supersite in Pasadena.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: III.1
DATE: May 17, 2013
PROPOSAL NO.: 2758-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Examining Factors that Influence ZEV Sales in California
PRIME CONTRACTOR:	University of California, Los Angeles $224,144
SUBCONTRACTOR:	University of California, San Diego $71,233
PRINCIPAL INVESTIGATORS:	J.R. DeShazo, Ph.D. Brett Williams, Ph.D.
TOTAL AMOUNT:	$295,377
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	24 Months

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

I. SUMMARY

Consumer response to near- or pure zero-emission vehicle (ZEV) offerings and incentives in the future as the market continues to evolve and expand will be important to understand for achieving long-term climate and air quality goals. The objective of this research is to understand the emerging ZEV market in California by merging monthly ZEV registration data with census tract-level data and using econometric methods to correlate spatial and temporal factors with vehicle sales. This research would complement existing efforts by providing a more holistic perspective of the entire consumer base and also allow for more explicit evaluation of trends in the market relative to policy and market factors. The results of this study will be used to describe the current ZEV market and to refine future estimates of ZEV market potential in California for expected compliance with the Advanced Clean Cars program.

II. TECHNICAL SUMMARY

Objective

The primary objective of this research proposal is to test various hypotheses related to spatial or temporal factors associated with current ZEV sales trends. The second objective of this proposal is to develop a method and model to project ZEV sales under different policy or market scenarios based on the findings of the hypotheses.

Background

Renewed interest in ZEV technology has led to growing volumes of plug-in hybrid electric vehicles (PHEV) and full battery electric vehicles (BEV) recently being sold in California. To date, hydrogen fuel cell vehicles, the other widely expected ZEV technology will not be included since it has not been fully commercialized. While still relatively small in market share compared to the full offerings of new vehicles sold each year, these ZEV sales numbering in the tens of thousands provide an initial opportunity for empirical research on this evolving market. Past research prior to showroom availability of these vehicles required reliance on publically funded preference surveys for hypothetical vehicle purchases or studies based on limited deployments of prototype or conversion vehicles. Understanding how the current market develops - as a result of current incentive policies as well as for other reasons - can provide insights into how this market may change in response to new ZEV offerings or new or continued supporting policies. Such findings will be useful for determining future compliance pathways with ARB's Advanced Clean Cars program.

Proposal Summary

This research proposal would merge monthly ZEV registration data for December 2010 to December 2013 with census tract level data in order to correlate the spatial and temporal factors that influence ZEV sales across California. The researchers will employ fixed-effects and random-effect panel-data models to test how three categories of variables affect ZEV sales in different census tracts statewide. The first group of variables relate to public policies designed to support the ZEV market. These include incentive programs, such as the Clean Vehicle Rebate Program, federal tax credits, HOV lane access, and the installation of low-cost public charging infrastructure. The second group relates to various prices and vehicle attributes, which are often beyond

the reach of public policy but nonetheless influential in consumer decision making. Such variables include the diversity of vehicle body styles available as ZEVs, the diversity of manufacturers producing ZEVs, battery sizes of different electric vehicles, vehicle prices, and the prices of gasoline and electricity. Last group of variables cover geographic or socioeconomic factors, which may be expected to change very slowly, if at all. This last group includes variables like income levels, employment rates, and household structure, as well as more novel variables such as the proximity of other ZEV owners and environment characteristics. Although causation may be difficult to establish between certain factors within a census tract and the presence of a ZEV sale, the researchers will employ quasi-experimental methods to exploit sudden or discrete events occurring during the study period, e.g. changes in rebate levels or fuel prices, or the introduction of new models, to increase confidence in a causal relationship.

Based on the explanatory power of each of these variables to account for variations in ZEV sales, the researchers would then develop a model to project future sales under different scenarios. Scenarios may differ based on assumptions about changes in public policies, vehicle characteristics and offerings, prices, socio-economics, and land use patterns. The model results would inform how future changes in these factors may affect ZEV sales growth rates and market shares, and in turn, possible compliance strategies and impacts of various ZEV programs and policies.

III. STAFF COMMENTS

An initial draft of this proposal was reviewed by ARB staff in the Research and Mobile Source Control Divisions, as well as staff at the California Energy Commission, California Department of Transportation, and the United States Environmental Protection Agency (U.S. EPA). Their comments have been addressed in the proposal being considered by the Committee. Generally these comments were supportive of the proposal and focused on requests for elaboration on possible variables to be included in the analysis, the data processing methods, and the validity and limitations of project outcomes. Additional ARB comments on a second draft included requests that the submitted proposal clarify the format of project deliverables and expand the discussion on the data analysis and model development process and work plan. No substantive

comments were received from other agencies on the second draft; any subsequent comments will be presented to the committee at their meeting.

ARB has recently sponsored multiple projects related to current and potential buyers of ZEVs, which rely on direct communication with consumers and their voluntary participation. This proposal would complement these existing efforts by evaluating the ZEV market from a more holistic perspective through the analysis of complete monthly vehicle registration records and providing a measure of the representativeness of surveys and interview respondents to the overall ZEV buying population. While ZEV sales to date have been somewhat limited in both volumes and vehicle types, understanding the early market can still provide useful insights, especially in evaluating effectiveness of incentive policies. Although early adopters may not be fully indicative of future more mainstream consumers, it is still important to capture how the market is currently developing and to create a baseline for comparison of future changes. Unique to this proposal relative to existing research is its explicit focus on spatial factors, which will inform whether ZEVs are more concentrated in specific areas or more diffusely spread across the state. Additionally, this proposal will develop and demonstrate a data analysis method that if proven useful can be fairly easily repeated in the future on an expanded data set. Such a method would be especially useful following the introduction of fuel cell vehicles, to allow for a systematic analysis of their market development compared to those of plug-in electric vehicles.

The research team led by Dr. J.R. DeShazo and Dr. Brett Williams from UCLA's Luskin Center for Innovation will provide ARB with a new perspective on ZEV market development. The two lead investigators complement each other well, are knowledgeable about the issues, and have demonstrated past success supporting government agencies at various levels. Dr. DeShazo has a strong background in econometrics related to consumer research, public finance, and renewable energy policy while Dr. Williams has worked for twenty years with automakers and government agencies to support commercialization of alternative fuel vehicles. They currently serve as the prime research contractor for the U.S. Department of Energy and California Energy Commission's Plug-in Electric Vehicle Readiness Plan for the Southern California Association of Governments region and recently completed the Southern

California Plug-in Electric Vehicle Readiness Atlas; both projects required similar data acquisition, processing, and aggregation as will be utilized for this proposal.

IV. STAFF RECOMMENDATION

Staff recommend the Research Screening Committee approve this proposal for a total amount not to exceed $295,377, 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 NEW RESEARCH PROJECT
ITEM NO.: III.2
DATE: May 17, 2013
PROPOSAL NO.: 2759-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	The Future of Drop-In Fuels: Life-Cycle Cost and Environmental Impacts of Bio-Based Hydrocarbon Fuel Pathways
PRIME CONTRACTOR:	University of California, Berkeley
PRINCIPAL INVESTIGATOR:	Arpad Horvath, Ph.D.
TOTAL AMOUNT:	$400,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Drop-in fuels are cleaner alternatives to fossil-derived gasoline and diesel fuels that would require the least modification to the existing infrastructure and vehicle fleet. Similar to other biofuels, drop-in fuels have the potential to reduce greenhouse gas emissions and are superior to petroleum-based fuels in terms of their impacts on air quality when combusted. In order to be commercially viable, the fuels need to be available in sufficient quantities and at competitive prices. Drop-in fuels are currently in a research and development phase, with pilot- and demonstration-scale plants under construction, but further research on the feasibility and cost-effectiveness of producing these fuels is needed.

For this project, researchers will analyze the technology, feasibility, costs, and environmental impacts of drop-in fuels at both demonstration and commercial scales. The researchers will consider a variety of different production pathways, including conversion of alcohols or sugars to hydrocarbons, algal oils, upgrading syngas, and conversion of biomass to bio-oil. They will perform a geospatial analysis to estimate where fuel production facilities could be located in order to maximize production and

minimize environmental impacts. And they will develop strategies to monitor and track supplies, costs, and progress of these technologies. The results of this project will help assess the potential for production and use of drop-in fuels for achieving California's climate goals.

II. TECHNICAL SUMMARY

Objective

This project will investigate the technology, feasibility, costs, barriers, and environmental impacts associated with producing drop-in fuels on a commercial scale for use in California.

Background

In order to achieve California's climate and air quality goals, emissions from transportation will need to decline significantly in the coming decades. ARB's Low Carbon Fuel Standard (LCFS) calls for a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020. The LCFS incentivizes the production and sale of low carbon-intensity transportation fuels by establishing a set of performance standards in the form of declining carbon-intensity levels that fuel producers and importers must meet each year for their fuel pools beginning in 2011.

Certain industry studies have contended that the fuels necessary to comply with the LCFS standards in the 2015 timeframe will not be available when they are needed, but these studies are both pessimistic with respect to availability, and also focus on the assertion that the LCFS will have large cost impacts on consumers. Studies have indicated that biofuels will be needed to achieve long-term energy and climate goals in the transportation sector, especially for aviation, shipping, heavy-duty and off-road vehicles that cannot be easily electrified. ARB also has a research project underway to model the air quality impacts of projected biomass and biogas utilization in the SJV and South Coast Air Basins. Although drop-in fuels are essential to meeting California's climate change goals, the technology and infrastructure needed to commercially produce these fuels through economically viable pathways still requires significant research.

Proposal Summary

ARB's LCFS is a cornerstone of California's effort to meet AB 32 goals, and requires the development of lower carbon fuels and the adoption of more efficient, advanced technology vehicles. The original design of the LCFS provides time for the development of these technologies, but in order to achieve commercial production, the technologies need to be encouraged now. Although there are several types of renewable fuels, drop-in fuels would require the least modification to the existing infrastructure and vehicle fleet. If a low carbon intensity drop-in fuel were developed, it would aid in compliance without adding costs associated with fleet turnover and additional infrastructure, but the fuel needs to be available in sufficient quantities and at competitive prices. A recent ARB staff report examined several technology transformation scenarios needed to meet California's 2050 goals for the reduction of both greenhouse gas and criteria pollutant emissions, and the scenarios in this report include an assumption that all liquid fuels would be derived from renewable feedstocks by 2050, preferably in the form of drop-in fuels. Since drop-in fuels are in a research and development phase, with pilot- and demonstration-scale plants under construction, further research on the technology and infrastructure is needed.

The researchers will gather existing information and analyze the technology and feasibility, and the life cycle costs and environmental impacts, at both demonstration and commercial scales. The researchers will perform a geospatial analysis to estimate where facilities could potentially be located in order to maximize production while minimizing environmental impacts. Research needs and barriers to the success of these technologies will be identified, as well as strategies to overcome these barriers. Strategies to monitor and track progress of these technologies as well as supplies and costs will also be developed. The project results will provide data that will influence LCFS policy in California or other jurisdictions worldwide that are developing their own LCFS-like programs. If this research leads to the development of lower carbon fuels, it will be to the benefit of regulated parties under the LCFS and to California consumers. In the longer term, the data will inform many other initiatives of ARB that might support the need for drop-in fuels.

III. STAFF COMMENTS

The review team for this project included staff from ARB's Stationary Source and the Research Divisions, California Department of Transportation, California Energy Commission and U.S. EPA. Upon reviewing the four proposals submitted for this project, the proposal from UC Berkeley ranked highest. The review team was especially impressed by the thorough environmental impact assessment. No other proposal included water use and public health impacts in their environmental assessment and those are key aspects that ARB staff and others had prioritized.

The research team from UC Berkeley has a wealth of experience with life cycle analysis (LCA), biofuels, infrastructure, and the other scientific areas relevant to this project. Professors Horvath and McKone have approximately 50 collective years of relevant experience. They have published over 220 articles and reports in the areas of air and water quality, human and ecological impact assessment, product and service LCA, transportation and industrial energy analysis, and product life-cycle optimization. Both professors derive valuable experience from their involvement with the U.S. EPA's Science Advisory Board and from experience with several past ARB projects. Dr. Corinne Scown was first a graduate student under Professor Horvath and then a postdoc and principal researcher on their Energy Bioscience Institute project on the global life-cycle assessment of biofuels.

The UC Berkeley researchers were asked to revise their proposal to include more information on the methods they plan to use for their economic analysis. The review team also asked that the researchers include a technical advisory board to inform the researchers on barriers to commercialization and monitoring strategies. The final draft proposal that the UC Berkeley research team submitted addressed all of the concerns expressed by the review team.

IV. STAFF RECOMMENDATION

Staff recommend the Research Screening Committee approve this proposal for a total amount not to exceed $400,000, subject to inclusion of any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: III.3
DATE: May 17, 2013
PROPOSAL NO.: 2760-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	The Feasibility of Renewable Natural Gas as a Large-Scale, Low-Carbon Substitute
PRIME CONTRACTOR:	University of California, Davis
PRINCIPAL INVESTIGATOR:	Amy Jaffe
TOTAL AMOUNT:	$330,934
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	24 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Renewable natural gas is a promising near-term, low carbon-intensity transportation fuel for both light-duty and heavy-duty vehicle applications. The Low Carbon Fuel Standard regulation already incorporates a number of pathways for renewable natural gas production such as landfill gas, dairy digesters, and high solids anaerobic digesters. Widespread, large-scale production of renewable natural gas would help achieve California's greenhouse gas emission reduction objectives, but more research is needed to facilitate the market penetration of this fuel. This project will examine renewable natural gas production and distribution, particularly for transportation fuel use in California. The researchers will develop a map of current and potential production sites, and will examine the feasibility, costs, and environmental impacts of large-scale production and use. They will evaluate optimization of facility locations in order to maximize production and minimize environmental impacts. The researchers will also identify potential barriers to expanded production, and strategies to overcome them. The results of this research will provide insights into the economic and environmental feasibility of large-scale production and use of renewable natural gas as a low-carbon transportation fuel in California.

II. TECHNICAL SUMMARY

Objective

This project will determine the technological and commercial feasibility of producing large quantities of renewable natural gas fuels for use in California.

Background

In order to achieve California's climate and air quality goals, emissions from transportation will need to decline significantly in the coming decades. ARB's Low Carbon Fuel Standard (LCFS) calls for a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020. The LCFS incentivizes the production and sale of low carbon-intensity transportation fuels by establishing a set of performance standards in the form of declining carbon-intensity levels that fuel producers and importers must meet each year for their fuel pools beginning in 2011.

Certain industry studies have contended that the fuels necessary to comply with the LCFS standards in the 2015 timeframe will not be available when they are needed, but these studies are both pessimistic with respect to availability, and also focus on the assertion that the LCFS will have large cost impacts on consumers. There are already examples of low carbon intensity fuels coming into the market, for example, the landfill gas-to-liquefied natural gas (LNG) facility at the Altamont landfill produces enough LNG to power a portion of Waste Management's fleet. Maximizing the market penetration of renewable natural gas requires research to identify the technical, commercial, financial, marketplace, and regulatory barriers that are specific to renewable natural gas production.

Proposal Summary

This project will examine renewable natural gas production and distribution, particularly for transportation fuel use in California. Researchers will develop a map of current and potential sources for renewable natural gas production, both in California and elsewhere in the United States, identifying, analyzing, and comparing the technology and production methods involved, feasibility, costs, environmental impacts,

advantages/disadvantages, volumetric capacities, and distribution methods to bring the fuel into California for vehicular use. The analysis will consider optimizing facility locations in order to maximize production of renewable natural gas while minimizing potential environmental impacts, and will provide a preliminary estimate of the life cycle greenhouse emissions as well as localized emissions of criteria and toxic air pollutants, and other potential environmental and public health impacts that are of significant concern. Researchers will also identify barriers to the successful expansion of renewable natural gas production, and, where applicable, strategies to overcome these barriers and should identify additional areas of research. Results will provide essential data that will inform future refinements to the State's LCFS program and other climate change and air quality initiatives.

III. STAFF COMMENTS

The review team for this project included staff from ARB's Research and Stationary Source Divisions (SSD), California Public Utilities Commission, California Department of Transportation, California Energy Commission and U.S. EPA. Upon reviewing the three proposals submitted for this project, the proposal from UC Davis was clearly the strongest and had the most qualified team of researchers. Staff at the U.S. EPA were particularly supportive of this research since, although the EPA has done some previous work to facilities nation-wide, their product lacks the sophistication and fine-scale analysis that the results from this project will provide.

The Institute of Transportation Studies at UC Davis has assembled an impressive group of experts for this project. Mrs. Amy Jaffe will serve as the principal investigator and will oversee this project. Mrs. Jaffe is a widely published, leading expert on global energy policy and energy and sustainability. Dr. Rosa Dominguez will serve as the project manager and is an expert in fuels research, particularly in life cycle analysis and carbon accounting. Task Leaders include Dr. Joan Ogden, who has considerable experience in alternative fuel modeling, Dr. Mark Delucchi and Dr. Richard Plevin will serve as the two life cycle experts. Dr. Nathan Parker has significant experience in geospatial analysis and has already provided valuable work for the Biomass Collaborative. In this project,

Dr. Parker will investigate strategies to optimize the production of renewable natural gas in California

The UC Davis researchers were asked to revise their proposal to include more information on the feasibility and cost of renewable natural gas as a transportation fuel as well as more information on their previous work and how this new work will build on their past research efforts. The UC Davis researchers also met with staff in the Stationary Source Division to determine which lifecycle analyses and outputs would be most useful and compatible with the work they are doing for the Low Carbon Fuel Standard. The final draft proposal that the UC Davis research team submitted addressed all of the concerns expressed by the review team.

IV. STAFF RECOMMENDATION

Staff recommend the Research Screening Committee approve this proposal for a total amount not to exceed $330,934, subject to inclusion of any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO: III.4
DATE: Mary 17, 2013
PROPOSAL: 2761-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Collection of Activity Data from On-Road Heavy-Duty Diesel Vehicles
CONTRACTOR:	University of California, Riverside
PRINCIPAL INVESTIGATORS:	Kanok Boriboonsomsin, Ph.D. (PI) Kent Johnson, Ph.D. (Co-PI)
TOTAL AMOUNT:	$371,724
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	24 Months

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

I. SUMMARY

This proposal addresses the importance of collecting activity data from heavy-duty diesel trucks equipped with SCR aftertreatment systems. SCR reduces NO_X in the exhaust stream, but requires adequate temperatures, typically at least 200°C, for the reduction to take place. However, there will be times when this temperature requirement is not met, such as initial engine start and during low loads experienced when the engine is idling, or when the vehicle is moving slowly on flat terrain. It is thus critical to characterize heavy-duty diesel truck activity profiles including operation duty cycles, number of engine starts, and engine soak time distributions, by their vocation type. Because there are 68 different SCR-equipped engines sold in California, and 27 different medium heavy-duty and heavy heavy-duty truck categories in EMFAC2011, a strategic data collection plan is important for the limited funding resources. This proposal first identifies major truck vocation types that are most likely to contribute the most to the state's NO_X emission inventories, then instruments 80 trucks with GPS data loggers and 20 trucks with Electronic Control Units (ECU) + Global Positioning System (GPS) data loggers, and collects instantaneous truck activity data for at least one month

and up to six months on each vehicle. The collected data will be used to develop truck activity profiles by their vocation type. The activity profiles will provide critical information for updating emission inventories, quantifying the frequency of good SCR function from trucks meeting the 2010 NO_X certification standard, and comparing the vocational duty cycles to the certification duty cycles.

II. TECHNICAL SUMMARY

Objectives

The objective of this research is to characterize the heavy-duty truck activity profiles including duty cycles, starts and soak duration for different types of vocational uses such as line haul, drayage, delivery, and others. The results will be used to improve the heavy-duty NO_X emission inventory model, currently EMFAC2011, to estimate the frequency of good SCR function, and to compare NO_X emissions over the certification cycle to the duty cycles developed by vocation type.

Background

Considerable reduction in NO_X emissions is needed for the State of California to meet ambient air quality standards for ozone and particulate matter. To achieve some of the reduction, the NO_X emission standard for heavy-duty on-road engines requires a 90 percent reduction in 2010 from the previous standard. To meet the new standard, diesel engine manufacturers are in most cases using SCR in advanced engine exhaust aftertreatment systems. SCR reduces NO_X in the exhaust stream, but requires adequate temperatures for the reduction to take place. Typically, the SCR needs to be at least 200°C before significant NO_X reduction is achieved. However, there will be times when this temperature is not met, such as initial engine starts and during low loads, experienced when the engine is idling or when the vehicle is moving slowly on flat terrain. The frequency of low temperature and low duty operations varies for a truck depending on its vocational use. In line-haul application, a truck operates mostly with high load to maintain high-speed cruise, while the truck runs with frequent stops in a local goods delivery application. As truck activity changes, SCR functionality of the truck for NO_X reduction changes. Therefore, it is critical to characterize heavy-duty diesel truck activity profiles including duty cycles, number of engine starts, and engine soak

time durations, by vocation type. The heavy-duty diesel truck activity profiles are fundamental for updating emission inventories and quantifying real-world NO_X emissions from trucks meeting the 2010 NO_X certification standard.

Proposal Summary

There are 68 different SCR-equipped engines sold in California, and 27 different medium heavy-duty and heavy heavy-duty truck categories in EMFAC2011, some of which have multiple vocation types. Thus, the approach to their activity data collection in this research needs to be strategic where a combination of GPS and ECU data collection methods will be used for targeted truck categories and vocation types. The project will be carried out through a series of tasks.

1) Screening Analysis. The screening analysis will determine truck vocation types that contribute the most to the State's NO_X emission inventories. This analysis starts with current truck categories in EMFAC2011 and to the extent that is applicable, MOVES2010b. In addition, recent literature on NO_X emissions from different categories of trucks will be reviewed and, if relevant, used to augment the selection of truck categories to be included for the next tasks of truck recruitment. Because this project pursues instrumenting 100 trucks with GPS and ECU+GPS data loggers, the truck sampling strategy will depend on the number of selected truck categories and vocation types from this screening analysis.

2) Truck Recruitment. The recruiting effort will be focused on the truck categories and vocation types identified in the Screening Analysis. Given the necessity for a short project timeline and the long lead time for truck recruitment, parallel recruiting efforts will be made. These include hiring consultants to assist with recruitment, recruiting fleets from the UCR contacts, and recruiting fleets from ARB contacts. Truck recruitment is an uncertain task because it can be difficult to obtain the participation and cooperation of fleet operators. After recruitment and before proceeding with the measurement phase of the project, the contractor will consult with ARB to ensure that the recruited fleets are adequate to meet the objectives of the project. If not, ARB may terminated or re-direct the project. UCR investigators

anticipate UCR to instrument the trucks in Southern California fleets and to work with ARB to instrument the trucks in Northern California fleets.

3) Truck Data Collection. Trucks recruited by the Truck Recruitment task will be instrumented with GPS or ECU+GPS data loggers, and their instantaneous activity data will be collected. The data collection will be continuous for at least one month and up to six months. During the data collection period, the collected data will be stored on board as well as transferred wirelessly to UCR's data server.

4) Trucks Data Analysis. For each truck category and vocation type, UCR investigators will analyze the ECU and GPS data to determine the number of starts per day, soak time distribution per day, and other trip statistics (e.g., average distance, average duration, average speed, etc.). Using the second-by-second vehicle speed from the GPS data, the investigators will develop a representative chassis-dynamometer duty cycle for each truck category and vocation type and compare it to the certification cycle.

5) Meetings and Reports. There will be a kickoff meeting at the beginning of the project. In addition, there will be two status update meetings between UCR and ARB to discuss the truck recruitment status and any changes in the project plan before starting the Task 3, Truck Data Collection. Progress reports will be provided quarterly. A draft Final Report will be provided six months prior to the end of the project, and comments on the draft will be incorporated into a Final report. The investigators will present a Chair's Air Pollution Seminar on the completed project and will author one or more peer reviewed papers describing the results achieved.

III. STAFF COMMENTS

The proposal was developed collaboratively between UCR investigators and ARB staff, and has been reviewed by staff in the Research, the Mobile Source Operation, the Mobile Source Control, and the Planning and Technical Support Divisions.

Collecting data on heavy-duty truck activity and SCR inlet temperatures will greatly help providing a better understanding of the relationship between vehicle operation and SCR performance on a fleet basis. This will allow modelers to quantify the impact of NO_X performance issues due to low SCR temperatures on the California NO_X emission inventories. The heavy-duty diesel truck activity profiles are fundamental components for updating emission inventories, quantifying real-world NO_X emissions from trucks meeting the 2010 NO_X certification standard, and comparing duty cycles by vocation type to the certification duty cycles. Staff believes that this project will provide critical information to accurately quantify the NO_X emissions and SCR functionality from heavy-duty diesel trucks operating in California.

The research concept was approved by the Board during its March Board meeting as part of the fiscal year 2013-2014 research plan. The team of investigators is very strong, having a great deal of experience in the collection and analysis of truck activity data. ARB has collaborated very successfully with this team at UCR on a number of related projects in the past. Results from this study will be published in peer-reviewed journals and through conference presentations.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $371,724, subject to inclusion of appropriate additions and revisions in response to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: III.5
DATE: May 17, 2013
PROPOSAL NO.: 2757-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Air Quality Impacts of Low Vapor Pressure-Volatile Organic Compounds
PRIME CONTRACTOR:	University of California, Riverside
PRINCIPAL INVESTIGATOR:	David R. Cocker III, Ph.D.
TOTAL AMOUNT:	$405,338
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

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

I. SUMMARY

Low vapor pressure-volatile organic compounds (LVP-VOCs) are ingredients used in some consumer product formulations to meet VOC limits because the ARB Consumer Products Regulations provide an exemption for LVP-VOCs. This exemption was intended to exclude compounds that do not readily participate in ozone formation. However, some recent laboratory testing indicates that certain LVP-VOCs may have previously unrecognized air quality impacts. In light of these findings, research to better understand the atmospheric emissions of LVP-VOCs from consumer products and their impacts on ozone and SOA formation is needed. This research project will investigate the ambient evaporation rates of LVP-VOCs--both as pure compounds and in formulated consumer products sold in California, and conduct environmental chamber studies on selected LVP-VOCs and products that contain them to explore ozone and secondary organic aerosol formation from these compounds. The results will improve estimates of the emission rates of LVP-VOCs and their impacts on air quality, and can be used to improve air quality models. The results will also be used as part of ARB's assessment as to whether the exemption for LVP-VOCs in the Consumer Products Regulations should be modified.

II. TECHNICAL SUMMARY

Objective

The objective of this project is to investigate the emissions of low vapor pressure-volatile organic compounds from consumer products and their impacts on air quality. It is designed to evaluate the evaporation flux, and therefore atmospheric availability, of specific LVP-VOCs both as pure compounds and in formulated consumer products sold in California. The project also aims to evaluate the ozone and secondary particle formation of these compounds once they enter the atmosphere using a state-of-the-science environmental chamber.

Background

LVP-VOCs are ingredients used in some consumer product formulations and are exempt by ARB from compliance with VOC limits for consumer products based on their low vapor pressure/ high boiling point. The LVP-VOC exemption was initially developed to exclude compounds that do not readily participate in ozone formation and typically represented a small fraction of the overall composition of a formulated product. However, some recent laboratory testing indicates that certain LVP-VOCs may be present in the gas phase under ambient conditions, and some LVP-VOCs have high Maximum Incremental Reactivity (MIR) values relative to ethane, the traditional bright line between photochemically-reactive and non-reactive VOC compounds. Therefore, emissions of LVP-VOCs could contribute to the formation of ozone. However, the rates of volatilization of LVP-VOCs in different formulations of consumer products are not well characterized. Research efforts, including emission tests and chamber studies are needed to further understand the role of LVP-VOCs on ozone and SOA formation and to improve modeling for State Implementation Plans. This project is intended to address the knowledge gaps in our understanding of LVP-VOC emissions and their participation in atmospheric processes that lead to ozone and SOA formation.

Proposal Summary

The research team at the College of Engineering Center of Environmental Research and Technology (CE-CERT) at UCR will conduct the laboratory and environmental chamber experiments to develop key parameters for the evaluation of the ozone and

SOA formation potential of consumer products containing LVP-VOCs. The work will consist of two major tasks:

Task 1: Investigate LVP-VOCs volatilization rates

This task includes evaluation of ambient evaporation rates of LVP-VOCs both as pure compounds and in formulated consumer products sold in California. The volatility measured as the atmospheric flux of the species will be experimentally determined using three separate analytical approaches. These results are necessary to assess the availability of LVP-VOCs for ozone and PM formation.

Task 2: Environmental Chamber Studies of Ozone and SOA Impacts of LVP-VOCs

A state-of-the-science environmental chamber located at the CE-CERT of UCR will be used to investigate ozone and SOA formation from LVP-VOCs. This task will include: 1) new method development for injection of LVP-VOCs and consumer products into the environmental chamber while minimizing thermal degradation of the compounds studied; 2) development of a chamber model to account for partitioning of LVP-VOCs to surfaces within the chamber (walls or particles); and 3) development of chemical mechanisms necessary to more accurately estimate ozone and PM formation from LVP-VOCs. Task 2 will provide the critical inputs necessary to evaluate the atmospheric impacts of LVP-VOCs and provide the baseline data necessary to improve ozone and PM2.5 modeling and evaluate whether changes to the LVP-VOC exemption should be considered.

The primary deliverables for this project include an interim report (including the experimental data collected) for Task 1, and a final report, which will describe all the work carried out as part of this program. The data obtained in the experiments carried out for this project will be made available to the ARB staff.

III. STAFF COMMENTS

Three major tasks are listed in the Statement of Work (SOW) for the Air Quality Impacts of LVP-VOCs as part of the ARB Proposal Solicitation for FY13-14: 1) Investigate the ambient rates of volatilization of LVP-VOCs used in various consumer products sold in California; 2) Conduct laboratory chamber studies on selected LVP-VOCs and products formulated with LVP-VOCs to investigate the atmospheric ozone and particulate matter

impacts of LVP-VOCs; and 3) Investigate the environmental fate of LVP-VOCs in selected consumer products. Three draft proposals were received in response to this solicitation. Staff from ARB's PTSD and RD, and South Coast Air Quality Management District (SCAQMD) reviewed the proposals. The review team agreed that Dr. David Cocker's (UCR) proposal was the strongest for Task 1 (volatility measurements) and Task 2 (environmental chamber measurements), and Dr. Deborah H. Bennett (UCD)'s proposal was the strongest for Task 3 (environmental fate modeling for LVP-VOCs). Also, the review team is in agreement that the state-of-the-art CE-CERT environmental chamber operated by Dr. Cocker is uniquely suited to the LVP-VOC ozone and SOA formation potential measurements. The review team therefore recommended funding two contracts for the Air Quality Impacts of LVP-VOCs research area. This UCR project will cover Task 1 (Investigate volatilization rates of LVP-VOCs) and Task 2 (Laboratory chamber experiments on the impact of LVP-VOCs on ozone and PM formation) of the SOW. Dr. Bennett will be the Principal Investigator (PI) for the project focusing on environmental fate modeling of LVP-VOCs.

Based on the comments on the draft proposal, staff discussed with the PI revisions to refine the proposal to focus on the volatility measurements and chamber experiments. Staff from RD, PTSD and SCAQMD also commented specifically on the proposed experimental procedures including number of compounds to be tested, number of variable parameters, duration of volatility measurements, and potential issues with the chamber experiments for LVP-VOCs. In addition, staff asked for an interim report for the volatility measurements at the end of the first year of the project because the data collected from this task will be used by the other contract for environmental fate modeling. The PI revised the proposal and the updated draft final proposal was also distributed to staff at ARB and SCAQMD for additional comments. Some minor editorial comments were received and forwarded to the PI to finalize the proposal. The PIs of both LVP-VOC projects also reviewed each other's final proposal. The revised proposal provides detailed information on methodologies and technical approaches/tools for measuring the volatilities and ozone/SOA formation potentials of LVP-VOCs. Some potential issues associated with the chamber experiments of LVP-VOCs are discussed and solutions are proposed. Staff is confident that the proposed research work will

provide critically important data and information to assess the air quality impacts of LVP-VOCs.

The investigators working on this project will be Dr. David R. Cocker III, Dr. William P. L. Carter, and Dr. Gookyoung Heo. The researchers have extensive experience in measurement of the emissions of VOCs using different methods, environmental chamber studies, and development of chemical mechanism for ozone and PM modeling.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $405,338, 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 NEW RESEARCH PROJECT
ITEM NO.: III.6
DATE: May 17, 2013
PROPOSAL NO.: 2762-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Environmental Fate of Low Vapor Pressure - Volatile Organic Compounds from Consumer Products: A Modeling Approach
PRIME CONTRACTOR:	University of California, Davis, $178,046
SUBCONTRACTOR:	University of California, Berkeley, $21,954
PRINCIPAL INVESTIGATOR:	Deborah H. Bennett, Ph.D.
TOTAL AMOUNT:	$200,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	24 Months

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

I. SUMMARY

The top three reactivity-based total organic gas emission sources in California's South Coast Air Basin are light-duty passenger cars, off-road equipment, and consumer products, indicating that VOC emissions from consumer products could be a significant contributor to ozone formation. Currently low vapor pressure –LVP-VOCs used in consumer products are exempted from VOC limits in ARB's Consumer Product Regulations. Depending on the emission rate, portion remaining in the gas phase, and reactivity, LVP-VOCs could be another contributor to ozone formation. However, to evaluate the impacts of LVP-VOCs on air quality, more research is needed to better understand the emission and environmental fate of LVP-VOCs, including what portion of LVP-VOCs disposed down-the-drain will be emitted to air and what portion of LVP-VOCs emitted will be in the gas phase to form ozone. This research project will develop multimedia environmental modeling tools to determine the fraction of emitted LVP-VOCs in the gas phase that is available for ozone formation reactions. The results from this project can provide important information and modeling tools for ARB to determine

whether the exemption for LVP-VOCs in the Consumer Products Regulations should continue as is or be modified.

II. TECHNICAL SUMMARY

Objective

The overall objective of this project is to develop multimedia environmental modeling tools to determine: a) what portion of LVP-VOCs disposed of down-the-drain will be emitted to air; and b) what portion of LVP-VOCs emitted either through consumer product use or from a wastewater treatment facility will be available in the gas phase to form ozone.

Background

LVP-VOCs are currently exempt from compliance with VOC limits for Consumer Products Regulations based on their low vapor pressure/ high boiling point. However, recent research indicates that certain LVP-VOCs may evaporate over an extended time period, despite their high boiling points or low vapor pressures, and become atmospherically available for ozone and PM formation. Moreover, some LVP-VOCs have higher MIR values than ethane, a chemical often chosen as the bright line between photochemically-reactive and non-reactive compounds. Therefore, the emissions of LVP-VOCs could have a significant impact on the formation of ozone. However, there is limited information available about how the use of consumer products containing VLP-VOCs results in releases and transport, and what the ultimate environmental fate of LVP-VOCs is. In addition, for LVP-VOCs that are disposed down the drain and enter wastewater treatment facilities, the fate and transport of the compounds in ambient environments needs to be modeled to estimate the resulting percent of the product used that may have an impact on air quality. Better understanding of the emission and multi-media pathways of these LVP-VOCs and their atmospheric availability is needed to assess their impacts on ozone and SOA formation. This project is designed to develop multimedia environmental modeling tools to estimate the fraction of emitted LVP-VOCs in the gas phase that is available for ozone formation reactions.

Proposal Summary

The proposed work by researchers at University of California, Davis (UCD) and University of California, Berkeley (UCB) includes development of multimedia environmental fate models to determine the fraction of emitted LVP-VOCs from consumer product use and a wastewater treatment facility that is available for potential formation of ozone. First, a wastewater emission model will be developed to predict emission rates of LVP-VOCs that may occur at wastewater treatment facilities or in the discharge zone of the facilities. Then, an appropriate multimedia model will be developed to evaluate what portion of the compounds emitted from consumer product use (as determined from chamber experiments) will participate in ozone formation. The CalTOX multimedia environmental model will be integrated with the wastewater emission model and other necessary model components into a multimedia mass-balance model to predict the fate and transport of emitted LVP-VOCs among various compartments. The model will be run on a number (~25) of LVP-VOCs to predict the fraction of LVP-VOCs that leads to formation of ozone. Based on the modeling results, a simple estimation tool of the fraction of LVP-VOCs available to form ozone in the air will be developed.

All modeling exercises will be done at UCD. Models and data generated will be backed up nightly to a secure, encrypted repository. A final report summarizing the model development and all of the results of the data analysis will be submitted to ARB. The full model developed during the study will also be provided to ARB.

It is anticipated that this project will provide the ARB with both a full model and a simple estimation tool to determine the impact of the emissions of LVP-VOCs on total ozone formation, thus improving ARB's understanding of the role of consumer products in California's air quality.

III. STAFF COMMENTS

Three major tasks are listed in the Statement of Work (SOW) for the Air Quality Impacts of LVP-VOCs as part of the ARB Proposal Solicitation for FY13-14: 1) Investigate the ambient rates of volatilization of LVP-VOCs used in various consumer products sold in California; 2) Conduct laboratory chamber studies on selected LVP-VOCs and products

formulated with LVP-VOCs to investigate the atmospheric ozone and particulate matter impacts of LVP-VOCs; and 3) Investigate the environmental fate of LVP-VOCs in selected consumer products. Three draft proposals were received in response to this solicitation. Staff from ARB's Planning & Technical Support, and Research Divisions, and South Coast Air Quality Management District (SCAQMD) reviewed the proposals. The review team agreed that Dr. Deborah H. Bennett's (UCD) proposal is the strongest for Task 3 (environmental fate modeling for LVP-VOCs) and Dr. David Cocker's (UCR) proposal is the strongest for Tasks 1 (volatility measurements) and 2 (environmental chamber measurements). The review team therefore recommended funding one research contract with Dr. Deborah Bennett on the environmental fate modeling of LVP-VOCs, and another contract on the volatility measurements and chamber experiments (also presented to the Committee at this meeting).

Based on the reviewers' comments on the draft proposal, staff asked Dr. Bennett to revise the proposal by removing other tasks of the original draft proposal, and focus the research on the development and application of multimedia environmental fate models for LVP-VOCs. The PI revised the proposal and the updated draft final proposal was also distributed to staff at ARB and SCAQMD for additional comments. Some minor editorial comments were received and forwarded to the PI to finalize the proposal. The PIs of both LVP-VOC projects also reviewed each other's final proposal. The revised final proposal includes a detailed description of the development of the wastewater emission model and the integrated multimedia fate and transport model. The project will also evaluate the necessity of including extra components in the outdoor multimedia model CalTOX such as a two-box regional airshed model and a dynamic condition in atmosphere. The researchers will run the model for a list of compounds developed in conjunction with ARB, and then use two statistical approaches to analyze the input (i.e., chemical properties) and output (i.e., the fraction of gas-phase LVP-VOCs) of the model above and develop a simple estimation tool of the fraction of LVP-VOCs available to form ozone in the air. The results from this project can provide important data and modeling tools for ARB to evaluate the air quality impacts of LVP-VOCs, and decide if the LVP-VOC exemptions in the Consumer Products Regulations should be revised.

The research team from UCD and UCB has strong multimedia environmental fate model development experiences. The PI has also contracted with ARB previously to validate down-the-drain emission factors for several Consumer products and has successfully managed several large research projects for ARB.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $200,000, 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 NEW RESEARCH PROJECT
ITEM NO.: III.7
DATE: May 17, 2013
PROPOSAL NO.: 2763-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Co-Exposure to Particulate Matter and Ozone: Pulmonary C-Fiber and Platelet Activation in Decreased Heart Rate Variability
PRIME CONTRACTOR:	University of California, Davis
PRINCIPAL INVESTIGATOR:	Fern Tablin, VMD, Ph.D.
TOTAL AMOUNT:	$600,782
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

For further information, please contact Dr. Alvaro Alvarado at (916) 445-4843.

I. SUMMARY

People are routinely exposed to ambient air that contains a complex mixture of air pollutants. PM2.5 and ozone (O_3) appear to be responsible for the majority of serious health effects related to air pollution exposure, although little is known about whether or not they have interactive or synergistic effects on health endpoints. Exposure to PM2.5 has been significantly associated with adverse cardiovascular effects in a number of studies, and recently published results have suggested that ozone exposure, well-known to induce respiratory effects, may also have cardiovascular effects. Although the biological pathways through which inhaled air pollution impacts cardiovascular function are unclear, research has suggested that pulmonary, vascular and neuronal mechanisms each contribute to increased cardiovascular morbidity and mortality related to air pollution exposure. Normal and spontaneously hypertensive (SH) rats with implanted telemetry units that record the electrocardiogram and breathing pattern will be exposed for six hours to filtered air, and PM2.5 and O_3, alone and in combination. At the end of exposure, animals will be euthanized and the following endpoints evaluated: platelet activation, persistence of platelet-monocyte aggregates, levels of serotonin and

thromboxane A2 (TXA2) in blood from the left ventricle, endothelial activation in the terminal pulmonary arterioles and the coronary vasculature, diameter and wall thickness of the pulmonary arteries, heart and lung histopathology, presence of platelet aggregates in blood vessel walls, heart rate variability, assessment for cardiac arrhythmias, and immunocytochemical assessment of nerve fibers (C-fibers) activation in heart and lung tissues. The resulting data will help to elucidate the specific roles of platelets, the vascular endothelium, pulmonary C-fibers, and pulmonary vascular vasoconstriction in altering cardiovascular function. The results of this study will advance our understanding of the biological mechanisms mediating the cardiovascular and pulmonary effects of multi-pollutant exposures, and how different mechanistic pathways converge to induce adverse health effects. This knowledge will contribute to development of health protective ambient air quality standards, and may also contribute to development of new efficient emissions reduction approaches that target more than one air pollutant simultaneously.

II. TECHNICAL SUMMARY

Objectives

The objective of this study is to examine a hypothesized mechanistic pathway for the cardiovascular effects of ozone and PM2.5, and to examine whether the effects of co-exposure to these pollutants are additive or synergistic in laboratory animals.

Background

Although the NAAQS are developed for single air pollutants, humans are exposed simultaneously to a complex mixture of ambient air pollutants. Because of the single pollutant focus of the NAAQS, little is known as to whether or not there are interactions or synergisms among various ambient pollutants.

Epidemiologic studies are the basis for the PM2.5 NAAQS, and they have consistently shown, contrary to expectations, that PM-related health effects on the cardiovascular system are larger and more clinically significant than those on the respiratory system. There are substantial gaps and uncertainties in our understanding of the biological mechanisms through which inhaled PM2.5 influences heart function. In contrast to the PM2.5 NAAQS, the ozone NAAQS is primarily based on human exposure studies that

have investigated the relationship between well-defined ozone exposures and changes in clinical endpoints, primarily of the respiratory system. Several mechanistic pathways are known through which ozone exposure causes respiratory health effects. Recent research suggests that ozone exposure may also have cardiovascular effects, which have not been appreciated to date; however, little is known about potential biological mechanisms for these cardiovascular effects. More importantly, from a public health perspective, very little is known about whether or not there are interactions or synergisms between mechanisms with concomitant exposure to O_3 and PM2.5.

Previous research results indicate that exposure to fine and ultrafine PM increases inflammatory cytokines and activates platelets in the systemic circulation, although the source of the cytokines and mechanistic pathway through which platelets are activated are unclear. Activated platelets can release biomarkers that directly affect heart muscle function. Recent data also suggest that inhaled PM2.5 may directly activate C-fibers in the airway walls that are known to cause airway constriction and hyperresponsiveness. Ozone exposure is known to activate the same airway nerve fibers, producing bronchoconstriction and airway hyperresponsiveness. Furthermore, it is also known from non-air pollution studies that activation of C-fibers can influence the function of the heart muscle. The possible convergence on the heart muscle of both the mechanistic pathways originating with activated platelets in the central circulation, and activation of C-fibers in the airways by inhaled air pollutants (PM2.5, ozone, or a mixture of pollutants) is a new line of investigation that has not been previously pursued. In addition, the information cited above hints at possible interactive effects related to concurrent exposure to PM2.5 and ozone.

This project is important to the ARB, as well as to the U.S. EPA because the results of this study will strengthen the biological support for epidemiological associations between PM2.5 exposure and adverse health effects. The results will reduce uncertainty in epidemiological studies on O_3 by addressing concerns about potential confounding of O_3 effects by concomitant PM2.5 exposure. This, in turn, will contribute to ensuring that future revisions to the PM and ozone NAAQS are adequately health protective. Furthermore, although the NAAQS are based on single pollutants, people are typically exposed to mixtures of air pollution. U.S. EPA has recently adopted a

multipollutant perspective, particularly with reference to NAAQS implementation and development of emissions reduction regulations. The results of this study could help guide development of more efficient future emission control strategies and methodologies that reduce emissions of more than one pollutant simultaneously, while also contributing to development of health protective NAAQS.

Proposal Summary

This study will examine a hypothesized mechanistic pathway for PM2.5- and ozone-induced cardiovascular dysfunction in an animal model. Specifically, the study will explore how pulmonary, vascular, and neuronal actions converge to cause cardiovascular dysfunction in normal and spontaneously hypertensive rats. The proposed experiments will address the hypothesis that co-exposure to PM2.5 and O_3 leads to synergistic activation of pulmonary C-fibers and platelets. This activation will lead to alteration of autonomic nervous system control of the heart, which will be manifested as decreased heart rate variability (HRV). Further, concomitant exposure to PM2.5 and O_3 will lead to greater averse responses in all endpoints in SH rats, compared to normal rats**.**

Three weeks prior to exposure, normal and spontaneously hypertensive rats will be surgically implanted with telemetry units that record both the electrocardiogram and breathing pattern. Groups of animals (10 per group) will be exposed for six hours to one of four conditions: 1) filtered air; 2) 0.50 ppm O_3; 3) 50 ug/m^3 flame generated PM2.5; or 4) a combination of 0.50 ppm O_3 and PM2.5 50 ug/m^3 flame generated PM2.5. There will be four groups of 10 normal animals, and four groups of 10 SH animals, for a total of 80 rats.

Platelet-related endpoints will include platelet activation, formation of platelet-monocyte and platelet-leukocyte aggregates, microthrombi, and the release of platelet-derived bioactive lipids. The influence of pulmonary C-fiber activation will be assessed by examining breathing pattern and heart rate variability, release of thromboxane-2 and serotonin, as well as immunocytochemical analyses of heart and lung tissues. Pathological analyses of lung tissues will include airway epithelial changes, extent of inflammation, number of immune cells in the lung inflammatory exudate, density of

visible particles, vascular wall changes in the pulmonary arterioles, and density of platelets in arteriolar lumens. Pulmonary arteriolar constriction will be evaluated through assessment of vascular wall thickness. Heart tissues will be evaluated for myocyte and vascular lesions. All endpoints will be examined using well established, standard methods.

Data will be analyzed using standard methods, and will take into account whether or not the data are normally distributed. A qualified statistician is available for consultation.

III. STAFF COMMENTS

Staff reviewed two previous versions of this proposal, and the present version has adequately addressed the comments raised by ARB and U.S. EPA staff. The National Institute of Environmental Health Sciences and the Health Effects Institute reviewed abstracts of the project, and verified that they are not currently funding similar studies.

The project is the first to address a complex, comprehensive hypothesis for how inhaled PM2.5 and O_3 individually and together influence cardiovascular function. Consequently, the investigators have selected key endpoints representing each part of the hypothesized pathway that will validate the hypothesis, rather than attempting to investigate all aspects of the hypothesis at this time. Although this approach includes potential for investigation of a vast number of endpoints, the endpoints chosen are the key ones for determining whether or not the hypothesized mechanistic pathway is correct.

The study is well designed and adequately powered to achieve the objectives stated. The investigators are experienced with, and have published previous studies using the experimental methods to be employed, all of which are standard. Dr. Tablin has been studying platelet function for over thirty years. Dr. Schelegle has been studying various aspects of the mechanisms of O_3-related health effects for over thirty years, and has performed most of the published research on the role of C-fibers in O_3-related health effects. Dr. Wilson is a board-certified pathologist, and has many years of experience assessing pathological changes in the cardiovascular and pulmonary systems. The investigators have each been investigating topics related to the focus of the proposal for

many years. They have also successfully completed several previous ARB-funded projects on related topics, and have published their results.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $600,782, 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 NEW RESEARCH PROJECT
ITEM NO.: III.8
DATE: May 17, 2013
PROPOSAL NO.: 2764-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Cardiovascular Effects of Multi-Pollutant Exposure: Mechanisms and Interactions
PRIME CONTRACTOR:	University of California, Irvine
PRINCIPAL INVESTIGATOR:	Michael T. Kleinman, Ph.D.
TOTAL AMOUNT:	$583,621
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

For further information, please contact Dr. Alvaro Alvarado at (916) 445-4843.

I.SUMMARY

The general public is typically exposed to a complicated mixture of air pollutants, although little is known about whether or not any of the pollutants have interactive or synergistic effects on health endpoints. Many studies have reported a significant association between PM2.5 and adverse cardiovascular effects, and recent studies have suggested that O_3 exposure, well-known to induce respiratory effects, may also have cardiovascular effects. Recently there has been interest is exploring the health effects of multi-pollutant exposures, primarily with the goal of developing efficient emissions reduction approaches that target more than one pollutant at a time, and thus provide broader health benefits. Because PM2.5 and O_3 are associated with the largest proportion of adverse health effects relatable to air pollution exposure, initial efforts to investigate the health effects of concurrent exposures have targeted these two pollutants. This proposed study will investigate three hypotheses relating to multi-pollutant exposure and adverse cardiovascular health effects: 1) Concurrent exposure to concentrated ambient fine particles (CAPs) and O_3 will induce greater acceleration of atherosclerosis and reduction in heart rate variability (HRV) than will exposure to either

CAPs alone or O_3 alone; 2) CAPs generated during periods of high ambient photochemical activity (i.e. summer) will accelerate atherosclerosis progression more than CAPs generated during periods of low ambient photochemical activity (i.e. winter); and 3) removal of organic constituents from PM2.5 using a thermal denuder will block the atherosclerotic effects of PM, while atherogenic effects related to O_3 will persist. The investigators will measure markers of inflammation, size of and lipid incorporation into arterial atherosclerotic plaques, serum lipids and low density lipoprotein associated cholesterol (LDL), oxidized LDL, and will monitor changes in heart function using implanted electrocardiographic transponders in mice genetically susceptible to developing atherosclerosis. The results of the study will provide insight into: 1) the relative importance of primary versus secondary PM; 2) the role of semi-volatile components of the PM2.5 fraction; and 3) the extent of interaction or synergy between PM2.5 and O_3 for development and progression of atherosclerosis. This knowledge will contribute to development of health protective ambient air quality standards, and may also contribute to development of new efficient emissions reduction approaches that target more than one air pollutant simultaneously.

II. TECHNICAL SUMMARY

Objective

The objective of this study is to investigate the atherosclerotic potential of PM2.5 from the Irvine, California area, both intact and denuded of semi-volatile constituents of PM2.5, with and without concurrent exposure to O_3 in a mouse model of atherosclerosis. The principal goals are to elucidate the role of semi volatile components of PM2.5 in the progression of atherosclerosis, and the extent to which concomitant O_3 exposure interacts with disease progression.

Background

Previous research by this investigator and others has demonstrated that when mice from a strain having genetic impairment of lipid metabolism and increased susceptibility to development of atherosclerotic plaques are exposed daily for two months to concentrated ambient particles (fine and ultrafine) plaque development is accelerated. Also, there is a more rapid progression of atherosclerosis than in the same strain of mice exposed to clean air. The investigator's recently completed ARB-funded study

extended previous findings by examining the role of particle associated semi-volatile compounds in atherosclerotic progression. The results suggested that much of the atherosclerotic potential of ultrafine particles (UFP) lies in the semi-volatile constituents, in that removal of the semi-volatiles from the aerosol blocked acceleration of atherosclerotic plaque development. To date no studies have investigated the atherosclerotic potential of O_3 exposure, concurrent exposure to PM2.5 and O_3, or the role of PM2.5-associated semi-volatile compounds in conjunction with O_3 exposure.

Proposal Summary

This project will expand on the investigator's previous results, but in a different location (Irvine rather than downtown Los Angeles), this time using PM2.5, intact and denuded, with and without O_3 in the exposure mixture.

Acute and chronic cardiopulmonary inflammation, vascular injury and myocardial function will be examined using genetically susceptible mice (ApoE-/-) implanted with ElectroCardioGram (ECG) telemetry devices. The study will investigate three hypotheses: 1) Concurrent exposure to CAPs and O_3 will induce greater acceleration of atherosclerosis and reduction in Heart Rate Variability (HRV) than will exposure to either CAPs alone or O_3 alone; 2) CAPs generated during periods of high ambient photochemical activity (i.e. summer) will accelerate atherosclerosis progression more than CAPs generated during periods of low ambient photochemical activity (i.e. winter); and 3) removal of organic constituents from PM2.5 using a thermal denuder will block the atherosclerotic effects of CAPs but not those of O_3.

To address hypothesis one, the investigator will expose ApoE-/- mice to purified air, CAPs, CAPs + 0.2 ppm O_3, and 0.2 ppm O_3 without CAPs during a period of high ambient photochemical activity (O_3 0.07-0.12 ppm).

To address hypothesis two, the investigator will expose ApoE-/- mice to purified air, CAPs, CAPs + 0.2 ppm O_3, and 0.2 ppm O_3 without CAPs during a period of low ambient photochemical activity (O_3 0.03 – 0.06 ppm).

To address hypothesis three, the investigator will expose ApoE-/- mice to purified air, 0.2 ppm O_3, denuded CAPs, and 0.2 ppm O_3 + denuded CAPs during a period of high ambient photochemical activity (O_3 0.07-0.12 ppm).

In all instances, groups of 16 animals will be exposed for five hours per day, 4 days per week for 8 weeks to each of the exposure conditions using the investigator's in-vivo rodent exposure system, in combination with a VACES particle concentrator that incorporates a thermal denuder. Previous studies by this investigator using this exposure equipment indicate that the proposed exposure system and schedule produce exposures that significantly accelerate atherosclerotic plaque development and progression in the proposed animal model.

Endpoints will include markers of inflammation, histological examinations for evidence of vascular and myocardial pathology, ventricular hypertrophy and biomarkers of lipid, protein and DNA oxidation, all using standard methods. The *in vivo* biological responses will be correlated with physical and chemical composition of the particles and the *in vitro* potential of these particles to produce free radicals and induce cytotoxicity.

All analyses and assays will be conducted using appropriate and standard methods. The data will be analyzed using standard statistical methods, and a qualified statistician is available for consultation.

II. STAFF COMMENTS

Staff reviewed two previous versions of this proposal, and the present version has adequately addressed the comments raised by ARB and U.S. EPA staff. The Health Effects Institute and the National Institute of Environmental Health Sciences were consulted as to whether the proposed work was duplicative of ongoing research. No duplications were identified.

Staff found the study well designed and adequately powered to achieve the objectives stated. The investigators are experienced with, and have published previous studies using the experimental methods to be employed, all of which are standard. The principal

investigator has been investigating the health effects of O_3 and various sizes of PM in animal models for over thirty years. The lab manager has been employed in this capacity for over five years, doing work similar to her assigned role in the project. The co-investigator who will perform the particle speciation has been doing particle speciation for over ten years. Each of the investigators has been involved in previous, successfully completed ARB-funded projects as a team, and have published their results.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $583,621, 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 NEW RESEARCH PROJECT
ITEM NO.: III.9
DATE: May 17, 2013
PROPOSAL NO.: 2765-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Developing a New Methodology for Analyzing Potential Displacement
PRIME CONTRACTOR:	University of California, Berkeley
SUBCONTRACTORS:	University of California, Los Angeles Southern California Association of Governments
PRINCIPAL INVESTIGATOR:	Karen Chapple, Ph.D.
TOTAL AMOUNT:	$695,792
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	26 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Senate Bill 375 (SB 375) requires Metropolitan Planning Organizations (MPOs) in California to develop a Sustainable Communities Strategy (SCS) as part of their federally mandated Regional Transportation Plan (RTP), to demonstrate how, largely through reduced travel demand and vehicle miles traveled, they will meet regional passenger vehicle greenhouse gas reduction targets set by ARB. As California regions pursue more compact, transit-oriented development (TOD) to meet these targets, there is increasing concern that new transit investment and development may lead to displacement, preventing low-income communities from sharing in the benefits of this type of development. This project will examine the relationship between transit-oriented development, displacement, and travel behavior in California. Partnering with two MPOs, it will develop a set of tools that will examine the likely outcomes around TODs in planning processes. It will also analyze the impact of policies to minimize displacement.

II. TECHNICAL SUMMARY

Objective

The objective of this study is to advance our understanding of the relationship between transit-oriented development, the potential for displacement in California, and the impact it may have on travel behavior. This study also aims to advance how displacement is assessed in transportation and land use planning processes by developing a set of tools that can be used by MPOs, local governments, and other stakeholders. Finally, this project will analyze the effectiveness of policies at minimizing displacement.

Background

Pursuing more compact, transit-oriented development is a main strategy being pursued by regions to achieve regional greenhouse gas reductions from passenger vehicles set by ARB as required by SB 375. For instance, the Southern California Association of Governments' (SCAG) first SCS calls for significant investment in public transportation and directs substantial development and densification along light rail and public transit corridors; their 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy assumes that 51 percent of new housing developed and 53 percent of new employment growth between 2008 and 2035 will be within High Quality Transit Areas—areas that are located "within one-half mile of a well-serviced transit stop."[1] This trend is seen in other region's SCSs as well. The pursuit of these strategies has raised concerns about potential social equity impacts, including the potential for displacement. The concern is that transit investment and development will lead to higher housing and rent prices, displacing low-income communities out of the area. While some MPOs have attempted to assess the potential for this negative impact as part of the environmental justice evaluations of their RTP/SCS, current methods are nascent and do not take into account investment type and magnitude and market dynamics. In addition, there has been no analysis to date on whether displacement of public transit users with higher income, car-owning households, has potential implications for travel behavior, which may impact reduction benefits assumed to be achieved through the pursuit of transit-rich development.

[1] SCAG RTP/SCS

Proposal Summary

This analysis will specifically be conducted for the San Francisco Bay Area and Los Angeles County—both strong market regions with transit investment and the presence of TOD, which may create displacement pressures. The project will examine how transit investment and market factors have reshaped the socio-economic and physical profiles of the neighborhoods surrounding fixed-rail transit stations, compared to neighborhoods without such transit investment. Using census data and detailed parcel data that cover a 30 year period (1980-2010), the research team will build typologies of neighborhood transit investment type and amount, as well as neighborhood displacement in order to build a model that analyzes mobility for areas around rail stations, controlling for income and housing price appreciation levels. To establish whether displacement has in fact occurred, model results will be validated using neighborhood observations and informant interviews for three neighborhoods in the San Francisco Bay Area and three neighborhoods in Los Angeles County determined by the models to have experienced disproportionate displacement rates. The results of this analysis will be used to develop a set of tools to examine the likely outcomes around TODs. Specifically, this project will develop an off-model tool, as well as expand the capabilities of the PECAS and UrbanSim modeling tools used by SCAG and the Metropolitan Transportation Commission (MTC) respectively. These tools will help MPOs and local governments incorporate social equity into planning processes, including the development of their SCSs.

This project will also begin to examine the potential net impact displacement may have on travel behavior. Four different analytic approaches will be employed on pre-existing data sources to explore the net impact on neighborhood change on travel behavior, comparing travel behavior for those moving in and moving out of TOD areas both before and after their move.

Finally, this project will identify strategies with the potential to minimize displacement despite pressures from transit investment and TOD. Using the neighborhood change database developed in this project, outlier neighborhoods where displacement has been lower than expected and that contain policies to minimize displacement will be selected. A series of six case studies will be conducted to analyze the effectiveness of such

policies in different contexts. Since cities that have been successful at fostering inclusive transit neighborhoods are likely to be utilizing not just innovative policy tools but also more informal activities to leverage development, interviews with local elected officials, city planners, and community-based organizations will help identify the array of formal strategies, political coalitions, and negotiations that come together to minimize displacement in certain places.

III. STAFF COMMENTS

This project incorporates comments from ARB staff in both the Research and Planning and Technical Support Divisions. In addition, it also reflects feedback obtained from Caltrans and the Department of Housing and Community Development. The Governor's Office of Planning and Research, as well as several MPOs were notified of this proposed project and in some cases, provided feedback.

This proposal will conduct the research in collaboration with the Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG) and with SCAG. As a result of their interest in this work and recognition of its utility, the partnering MPOs are providing significant co-funding and in-kind contributions of data access and staff time. In particular, the proposal has received co-funding from MTC/ABAG in the amount of $50,000 through the Bay Area Regional Prosperity Plan[2] to support the project's work on the off-model displacement assessment methodology. In addition, MTC/ABAG will dedicate $200,000 towards community engagement to transform the off-model methodology into its planned regional early warning system for displacement. SCAG will be contributing access to its newly transformed parcel-based database and mapping tool, CalLOTs, which was supported by a $300,000 grant from the Strategic Growth Council. In addition, SCAG will be contributing $50,000 of staff time.

The proposal demonstrates the research team's knowledge and experience in the subject area and in translating academic work into decision-making tools for

[2] The Prosperity Plan is a $5 million grant project funded by the US Department of Housing and Urban Development through the Sustainable Communities Partnership Program which aims to integrate housing and jobs planning, and build a clean energy economy.

policymakers. The research team has past experience working with both MTC/ABAG and SCAG on their RTP/SCS, providing important knowledge of the context through which this research will be applied.

Dr. Karen Chapple, the principal investigator, has conducted pioneering research on gentrification and affordable housing transit-oriented development for the San Francisco Foundation, the Association of Bay Area Governments, the University of California Transportation Center, and Center for Housing Policy. She has advised MTC/ABAG on the affordable housing allocation for their Sustainable Communities Strategy and as part of the Great Communities Collaborative, has provided technical assistance on linking affordable housing and transit to over twenty cities in the Bay Area. Dr. Daniel Chatman has significant experience focused on smart growth strategies and travel patterns, the economy, immigration, and mortgage policy. He is the principal investigator for the ARB contract titled “Analyzing the Economic Benefits and Costs of Smart Growth Strategies,” and Dr. Chapple is a member of the research team. Dr. Anastasia Loukaitou-Sideris has collaborated with SCAG, LA Metro, and Caltrans on a series of transit studies including studies of TOD along light rail lines in LA County. Dr. Paul Ong has conducted extensive research on spatial inequality related to neighborhoods, housing and transportation, and has advised the Bureau of the Census, California Employment Development Department, and other agencies on data design. He has worked with the California Department of Housing and Community Development to evaluate effects of TOD on commute distance and with Southern California Association of Non-Profit Housing to develop baseline information around TODs. Dr. Paul Waddell researches the impacts of land use regulations and transportation investments on outcomes such as spatial patterns of real estate development and prices, travel behavior, emissions, and resource consumption. He is currently working with MTC to apply his UrbanSim land use model, a software-based simulation system for supporting planning and analysis of urban development, to analyze the impacts of alternative land use and transportation policies for the Bay Area Sustainable Communities Strategy.

This project will result in a series of planning tools with differing levels of sophistication that can help MPOs, local jurisdictions, community-based organizations, and other stakeholders. In addition, the evaluation of the impact of displacement on travel

behavior can lead to a better understanding of the net travel reduction benefits of transit-oriented development strategies and may illuminate potential VMT benefits of preserving/augmenting affordable housing in transit-oriented areas. As a whole, this project will assist MPOs and local governments in better understanding the social equity impacts of land use and transportation planning decisions, as well as potential options for minimizing adverse displacement impacts. This project will help address social equity concerns in the development of Sustainable Communities Strategies.

IV. STAFF RECOMMENDATION

Staff recommend the Research Screening Committee approve this proposal for a total amount not to exceed $695,792, subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: III.10
DATE: April 15, 2013
PROPOSAL NO.: 2766-276

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Effectiveness of Sound Wall-Vegetation Combination Barriers as Near-Roadway Pollutant Mitigation Strategies
PRIME CONTRACTOR:	University of California, Los Angeles $338,765
SUBCONTRACTOR:	University of California, Riverside $177,374
PRINCIPAL INVESTIGATOR:	Suzanne E. Paulson, Ph.D.
TOTAL AMOUNT:	$516,139
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

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

I. SUMMARY

Although California has made tremendous strides in reducing vehicular emissions, a large body of evidence indicates increased exposure to traffic-related pollutants near busy roadways remains a concern. As California pursues infill development near transit as a greenhouse gas reduction strategy, there may be significant implications for near-roadway exposure. Strategies to reduce this exposure are needed; however, a stronger understanding of the effectiveness of potential mitigation options, and in particular sound wall (barrier) and vegetation combinations, is required. This project proposes a multi-basin, California-specific study to characterize the effectiveness of sound and vegetative barriers in dispersing and removing traffic-related pollutants. The results will provide insights into the value and best practices for siting and design of sound walls, and vegetation in combination with sound walls, to reduce downwind pollution from busy roadways.

II. TECHNICAL SUMMARY

Objective

The overall objective of this study is to provide state and local planners with information on potential mitigation options for near-roadway air pollution. More specifically, the investigators will evaluate the impacts of sound wall/vegetation combinations on downwind levels of traffic-related pollution including PM2.5, ultrafine particles, black carbon, and oxides of nitrogen. A comprehensive database, as well as look up tables and other decision support, will be developed using the collected data and summarized using a semi-empirical dispersion model.

Background

Recognizing the health impacts associated with nearby sources of pollution, including high traffic roadways, ARB published the Air Quality and Land Use Handbook in 2005, which recommends not siting sensitive receptors, including residences, within 500 feet of a high traffic roadway as a preventative measure. However, there are currently many people already living within this zone. In the Southern California region, 5.7 percent of the region's population lives within this 500 feet zone.[3] With the passage of Senate Bill 375, which encourages the pursuit transit-oriented development, there will likely be an increase in the number of people living near high traffic roadways. Indeed, the Southern California Association of Government's 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy forecasts an increase in the population living within this zone, with a projected 8 percent increase in the number of new households in High-Quality Transit Areas from 2008 – 2035. Although emissions near high traffic roadways are expected to decrease between now and 2035, primarily due to ARB regulations, it is anticipated that these areas near high traffic roadways will continue to have higher pollutant levels. While separating sensitive receptors from highly trafficked roadways is the most preventative and health-protective solution, other mitigation options (including sound barriers and vegetation) may also play a role in protecting these populations in cases where a protective distance is not feasible. However, further research is needed to understand the effectiveness of these mitigation options.

[3] Southern California Association of Governments. 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy

Several approaches have been suggested to mitigate the near-road impact of vehicle emissions. These include optimized noise barriers, roadside vegetation, road canopies in combination with methods to treat the pollutants trapped in the canopies, catalytic coatings on barriers, electrostatic precipitators, and dynamic traffic management. Noise (sound) barriers and roadside vegetation appear to be the most consistently used mitigation strategy. However, to date, studies of the effect of sound/vegetation barriers have not yet produced definitive results, and few studies have been performed for California's roadways and Mediterranean climate.

Proposal Summary

The focus of this study is to collect data on traffic–related pollutants adjacent and downwind of sound walls at four locations over two different air basins in California. These locations may include sites in the South Coast Air Basin, San Joaquin Valley, and Sacramento Valley. A pilot study will be conducted at each site, and the main field campaign will occur over 10 weeks divided among the four sites and five measurement periods encompassing all four seasons. Sampling is scheduled such that a large range of meteorological variability is covered. Sampling will include stationary monitoring (2 fully instrumented sites, with three additional UFP monitoring sites), a network of passive monitoring, meteorological monitoring, and mobile monitoring.

While the core of the study is to make measurements adjacent to sound wall/vegetation combinations, the data will also be statistically analyzed and used to develop a semi-empirical dispersion model and graphical use interface (GUI). This GUI-based model will estimate the dispersion of roadway emissions as a function of: average wind speed magnitude and direction; atmospheric stability; vegetation type; sound barrier height; and distance from roadway. In addition to the semi-empirical dispersion model and GUI, the data will be summarized by other methods as well in order to provide planners and decision makers with additional tools to evaluate and consider potential near-roadway air pollution mitigation options for existing and future development.

III. STAFF COMMENTS

This proposal has been reviewed by ARB staff (Research and Planning and Technical Support Divisions) and Caltrans. South Coast Air Quality Management District (AQMD) and U.S. EPA have also had the opportunity to review. Other interested agencies and organizations include Sacramento Metropolitan AQMD and Breathe California.

Although studies on the evaluation of sound barrier/vegetation have been conducted on the east coast, primarily by U.S. EPA, California-specific datasets are scarce. This study provides the most comprehensive data set on sound wall/vegetation measurements to date in California. As such, this proposal fills an important data gap and provides a strong foundation for future modeling work regarding sound and vegetation barriers adjacent to roadways. The results of this study are needed by Air Districts, local planners, and project leads in assessing potential methods to reduce near-road exposures to traffic-related pollutants. The research team will work closely and continuously with ARB staff and interested stakeholders to ensure the development of a useful product that will assist Air Districts and local planning agencies. Given the intensive monitoring aspect of the study, a QA/QC plan should be submitted for ARB review.

Professor Paulson and her research team bring decades of experience on both in monitoring/measurement and modeling to the project. Professor Paulson has extensive experience in near-road monitoring and has published multiple manuscripts focusing on mobile measurements in the community and near-road environment. These include the persistence of freeway gradients during early morning hours, and investigation of high pollutant levels in neighborhoods impacted by freeways. In addition, Professor Paulson has successfully completed several ARB studies. Professor Venkatram at the University of California, Riverside has nearly four decades of experience in air quality and meteorological modeling. His most recent publications include studies on performance and application of dispersion modeling for various scenarios, such as low wind speeds and estimating nocturnal boundary layer conditions. As a principal investigator, Professor Venkatram, has successfully completed previous ARB studies.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $516,139 subject to inclusion of appropriate additions and revisions in response to the staff comments, and any changes and additions specified by the Committee.