Matthew Rodriquez
Secretary for Environmental Protection

Air Resources Board

Mary D. Nichols, Chairman
1001 I Street • P.O. Box 2815
Sacramento, California 95812 • www.arb.ca.gov

Edmund G. Brown Jr.
Governor

November 30, 2012

Dear Researchers:

The California Air Resources Board (ARB or Board) is soliciting draft research proposals from the academic and research communities as an initial step in the development of the 2013-2014 Annual Research Plan. The enclosed solicitation provides greater detail on ARB's priority research topics for the 2013-2014 Research Plan.

If you are interested in submitting a draft proposal to address any of the research topics described in this solicitation, please submit your draft proposal no later than **January 31, 2013** through our proposal solicitation website at: http://researchplanning.arb.wagn.org/. Guidelines for developing your draft proposal are also included in this solicitation package and available at the solicitation website. Please note that ARB's research budget is approximately $5 million per year and typically supports 15-25 projects with two to three year durations. There is no specified minimum or maximum project budget, but typical budgets range from $50,000-$650,000. Projects that provide co-funding will be evaluated more favorably.

We expect to select proposals by late February for further refinement and review by the Board and its Research Screening Committee. Final proposals would be needed by April for our target of executed contracts by July 1, 2013.

Prospective investigators are encouraged to contact ARB staff for any clarification on these topics. If you have any questions, please contact Annalisa Schilla at (916) 322-8514 or aschilla@arb.ca.gov.

Sincerely,

/s/

Bart E. Croes, P.E.
Chief, Research Division

Enclosures

cc: Annalisa Schilla
Research Division

2013-2014 SOLICITATION OF DRAFT RESEARCH PROPOSALS

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SCOPES OF WORK

EFFECTIVENESS OF SOUND WALL-VEGETATION COMBINATION BARRIERS AS NEAR-ROADWAY POLLUTANT MITIGATION STRATEGIES

I. OBJECTIVES

The objectives of the project are to obtain field measurement data in California to evaluate the impact of different features of sound walls in combination with vegetation, on levels of traffic pollutants (fine particular matter, ultrafine particles, black carbon, oxides of nitrogen, carbon dioxide, and carbon monoxide) at varying distances from the roadways, including any potential increased concentrations resulting from the use of the barriers. The project will identify different features of sounds walls in combination with vegetation that minimize the exposures from roadway pollution in residential areas located near heavily trafficked roads and freeways under different physical and meteorological conditions. The goal of this research is to provide information that can be utilized by the Air Resources Board (ARB) to advise local planners, agencies, and developers on effective measures to mitigate exposures for residents near highly trafficked roadways.

II. BACKGROUND

The Sustainable Communities and Climate Protection Act of 2008 (SB 375) and other State and local policies and programs are encouraging infill development in urban areas that may result in increased residential development near busy roadways. However, exposure to traffic emissions has been associated with a variety of serious health impacts in epidemiological studies, including exacerbations of respiratory and cardiovascular diseases, increased asthma and bronchitis in children, and increased risk of premature death. Children appear to be particularly vulnerable to the adverse effects of traffic emissions. Traffic pollutant concentrations near high traffic roadways have been found to be 2 to 10 times higher than levels at a distance from the roadways. Also, recent studies have shown elevated traffic pollutant levels at greater distances from the roadway than previously measured.

The State's current set-back requirement for schools (500 feet [ft.]; PRC 21151.8) and ARB's recommendations on siting for housing and other sensitive uses (e.g., 500 ft. from major roadways and 1000 ft. from busy distribution centers and rail yards; (CARB, 2500a)) are intended to help protect the public from exposure to traffic emissions. Various building and site mitigation approaches have been examined as potential additional means to further reduce exposure to traffic pollution near roadways in addition to the reductions in exposure achieved by set-backs. A review by ARB staff found that high efficiency filtration and reduction of indoor sources appeared to be effective measures.

Additionally, sound walls were found to reduce near roadway pollutant concentrations (within 15-20 m [49-66 ft.]) up to about 50 percent (Baldauf et al., 2008; Bowker et al., 2007; Hagler et al., 2012; Ning et al., 2010). However, higher levels of pollution were seen behind the barrier and at a distance from the sound walls and roadways, although in some of these studies the higher levels appeared to be related to other sources of pollution (Baldauf et al., 2008; Bowker et al., 2007; Hagler et al., 2012; Ning et al., 2010). In one of the few field measurement studies of sound walls, conducted along two Southern California freeways, Ning et al. (2010) found that concentrations at farther distances were typically greater for the portions of the roads with sound walls. Modeling and tracer studies (Finn et al., 2010; Heist et al., 2009) showed that barriers reduced air pollution downwind of the barrier, although in some cases trapping of pollution and increased levels on the road occurred (Finn et al., 2010; Hagler et al., 2011). Nearby buildings and structural barriers can also affect the attenuation and dispersion of pollution from roadways, but results vary with different meteorological conditions (Bowker et al., 2007; Hagler et al., 2012; Hagler et al., 2010).

Results for vegetation alone are more highly variable than those for sound walls, and reliable estimates of reductions have not been identified. Modeling studies have shown that vegetation may restrict dispersion and increase concentrations on-road in street canyons with closer spacing of trees, particularly in low wind conditions (Buccolieri et al., 2009; Gromke, 2011; Gromke & Ruck, 2007, 2009). In another study, investigators found different results depending on particle size and wind speed, and a non-linear increase of particle removal with increased leaf area density, which varies by tree species and season (Steffens et al, 2012). Gaps in vegetation barriers can have a significant negative impact on their effectiveness (Hagler et al., 2012), a critical factor in California because California roadside vegetation tends to be less dense than that in the eastern U.S., where most of the previous field studies have been conducted. Also, some types of vegetation can trigger asthma and allergy attacks, and some emit reactive volatile organic compounds (VOC) that contribute to the formation of ozone. These factors need to be considered in California if vegetation is to be considered for possible exposure reduction.

A combination of sound walls and vegetation used together has been shown to disperse pollutants more consistently and to greater distances than either alone, with up to about a 60 percent reduction in near roadway levels (Baldauf et al., 2008; Bowker et al., 2007).

Thus, while sound walls alone and sound walls combined with vegetation show promise, the increase in concentrations on-road and at a distance seen in some studies can result in increased exposures in those areas. Thus, these measures can redistribute, rather than remove, pollutants. Research is needed that identifies the specific conditions under which sound walls in combination with vegetation can consistently provide a reliable exposure reduction benefit while not increasing the burden of exposures to those living at a greater distance from the barrier. In particular, California field studies are needed because of the significant differences in California meteorology, building practices, and types of vegetation used, compared to those of the eastern U.S., and to confirm and refine validated models in literature estimates.

III. Scope of Work

This project will build on the sparse existing literature of the effects of sound walls with vegetation in California by obtaining measurement data that identify features which impact the level of exposures for residents near heavily trafficked roads. The study will provide reliable information on ambient pollutant concentrations for residents living near-road and at a distance from the roadway. In order to achieve these objectives the investigators will develop a detailed work plan in consultation with ARB staff, which will contain the following elements:

- A literature review on the impacts of sound walls and sound walls in combination with vegetation on near-roadway pollution and health. The different methods and techniques used to study the impacts of sound walls and sound walls in combination with vegetation should be investigated to aid in developing the final study design.

- Identification of the properties of roadways and roadside sound wall-vegetation combinations near residential areas, under different physical and meteorological conditions. Structural details of sound wall-vegetation combinations and roadway configurations, such as elevated and below grade roadways, will be examined to determine that the sites selected for study are representative of sound wall-vegetation combination and roadway properties in the air basin.

- Identification of at least three sites in different geographical areas of California. Ideally the combination of sound wall and vegetation buffer, as well as an adjacent roadside area without a barrier for comparison, will be located along the same roadway with similar traffic patterns and physical features. Sites with sound walls alone can be included for comparison purposes, if funding is available.

At a minimum, the factors listed below need to be considered during site selection:

  - Sites should be selected to be representative of roadside barriers likely to be feasible in residential areas. Sites will be selected in consultation with ARB.
  - The presence of a nearby high traffic volume freeway with well-characterized, reasonably predictable traffic volume flow characteristics is needed.
  - Avoid sites that have nearby structures or additional sources that will impact the transport and dispersion of pollutants emitted by the nearby traffic.
  - A suitable nearby fixed site for multiday meteorological monitoring is needed.
  - A suitable freeway orientation roughly perpendicular to consistent prevailing wind direction is needed for repeatable day to day exposure impacts.
  - Suitable sampling sites at varying distances from the freeway must be available.

- A pilot study of at least one of the candidate sites to test and finalize sampling methods and protocols. The selected site will be monitored under similar meteorological conditions for multiple pollutants in the multi-day pilot field study. The results of the pilot study must be reviewed and the final standard operating procedures (SOP) and sampling plan must be approved by ARB before conducting the study at the selected sites.

- The sampling must include, at a minimum, the following real-time field measurement data on multiple days, and during different commute periods for (1) Traffic-related pollutants: fine particular matter (PM2.5), ultrafine particles, black carbon, oxides of nitrogen, carbon dioxide, and carbon monoxide; (2) Meteorology data: wind speed and direction, temperature, and humidity; (3) Traffic activity patterns: traffic volume and speed, and fleet mix; and (4) Noise measurements to ensure that the sound walls are achieving their intended purpose. An additional option is the real-time measurement of polycyclic aromatic hydrocarbons, elemental carbon and organic carbon, and PM10.

- Development of a detailed sampling approach that includes upwind and downwind sampling. The downwind sampling must cover a range of distances from the freeway. Also, the investigators will develop a QA/QC plan and a data analysis plan that fully utilizes the data obtained to identify the sound wall-vegetation barrier characteristics that effectively reduce nearby concentrations and those that lead to increased concentrations.

- A field study at the selected and approved sites using the SOPs developed and tested in the pilot study, including data preparation and validation of the measurement data.

- Data analysis and preparation of draft and final reports.

IV. DELIVERABLES

- Quarterly progress reports
- Final report
- Validated measurement data collected from this study and other related factors will be provided to ARB by the end of the study.

V. TIMELINE

It is anticipated this project will be completed in 36 months from the start date. Note that this allows 30 months for completion of all work through delivery of a draft final report; the last 6 months are for ARB and RSC review of the draft final report and delivery of a revised final report and data files to the ARB.

References

ARB 2005a. Air Quality and Land Use Handbook: A Community Health Perspective. Califiornia Air Resources Board, April 2005. http://www.arb.ca.gov/ch/handbook.pdf

Baldauf, R, Thomas, E, Khlystov, A, Isakov, V, Bowker, G, Long, T, Snow, R, 2008. Impact of noise barriers on near-road air quality. Atmospheric Environment 42, 7502-7507.

Bowker GE, Baldauf R, Isakov V, Khlystov A, Petersen W. 2007. The effects of roadside structures on the transport and dispersion of ultrafine particles from highways. Atmospheric Environment 41 (37): 8128-8139.

Buccolieri R, Gromke C, Di Sabatino S, Ruck B. 2009. Aerodynamic effects of trees on pollutant concentration in street canyons. Science of the Total Environment 407 (19): 5247-5256.

Finn D, Clawson KL, Carter RG, Rich JD, Eckman RM, Perry SG, Isakov V, Heist DK, 2010. Tracer studies to characterize the effects of roadside noise barriers on near-road pollutant dispersion under varying atmospheric stability conditions. Atmospheric Environment 44: 204-214.

Gehring U, Wijga AH, Brauer M, Fischer P, de Jongste JC, Kerkhof M, Oldenwening M, Smit HA, Brunekreef B. 2010. Traffic-related air pollution and the development of asthma and allergies during the first 8 years of life. American Journal of Respiratory and Critical Care Medicine 181 (6): 596-603.

Gromke C and Ruck B. 2007. Influence of trees on the dispersion of pollutants in an urban street canyon – Experimental investigation of the flow and concentration field. Atmospheric Environment 41 (16): 3287-3302.

Gromke C and Ruck B. 2009. On the Impact of Trees on Dispersion Processes of Traffic Emissions in Street Canyons. Boundary-Layer Meteorology 131 (1): 19-34.

Gromke C, 2011. A vegetation modeling concept for Building and Environmental Aerodynamics wind tunnel tests and its application in pollutant dispersion studies. Environmental Pollution, 159: 2094-2099.

Hagler GSW, Thomas ED, Baldauf RW. 2010. High-resolution mobile monitoring of carbon monoxide and ultrafine particle concentrations in a near-road environment. Journal of the Air & Waste Management Association 60 (3): 328-36.

Hagler GSW, Tang W, Freeman MJ, Heist DK, Pery SG, Vette AF, 2011. Model evaluation of roadside barrier impact on near-road air pollution. Atmospheric Environment 45: 2522-2530.

Hagler GSW, Lin MY, Khlystov A, Baldauf RW, Isakov V, Faircloth J, Jackson LE, 2012. Field investigation of roadside vegetative and structural barrier impact on near-road ultrafine particle concentrations under a variety of wind conditions. Science of the Total Environment 419: 7-15.

Heist DK, Perry SG, Brixey LA, 2009. A wind tunnel study of the effect of roadway configurations on the dispersion of traffic-related pollution. Atmospheric Environment 43: 5101-5111.

Ning, Z, Hudda, N, Dasher, N, Kam, W, Herner, J, Kozawa, K, Mara, S, Sioutas, C, 2010. Impact of roadside noise barriers on particle size distributions and pollutant concentrations near freeways. Atmospheric Environment 44: 3118-3127.

Steffens, JT, Wang YJ, Zhang KM, 2012. Exploration of effects of a vegetation barrier on particle size distributions in a near-road environment. Atmospheric Environment 50: 120-128.

Cardiovascular Effects of Multipollutant Exposure: Mechanisms and Interactions

I. Objective

Many studies have reported a significant association between fine PM2.5 and adverse cardiovascular effects. In addition, several recent studies have suggested that ozone exposure, well-known to induce respiratory effects, may also have cardiovascular effects. There remain significant gaps in understanding the mechanistic pathways through which inhaled particulate matter and ozone exposure affect heart function. It is also unknown whether effects of concurrent exposure to PM2.5 and ozone are additive or synergistic. Therefore, the objectives of this study are to: 1) to elucidate the mechanistic pathways through which PM2.5 and ozone exposure induce cardiovascular effects, and 2) to determine whether there are additive or synergistic interactions between these two air pollutants.

II. Background

National ambient air quality standards (NAAQS), which are updated at five year intervals, are based on reviews of the scientific literature on the health effects of exposure to air pollutants. Among the six pollutants for which there are NAAQS, only those for particulate matter are primarily based on epidemiologic associations. Epidemiologic studies 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. While some published studies have provided important data that have addressed this issue, there remain substantial gaps and uncertainties in our understanding. To date, mechanistic studies investigating how inhaled PM induces adverse health effects have focused on generic, non-specific modes of action (e.g., oxidative stress and inflammation) that are not unique to air pollution.

In contrast, 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 have cardiovascular effects, which have not been appreciated to date; however, little is known about potential biological mechanisms for ozone-induced cardiovascular effects. In addition, although humans are exposed to a complex mixture of ambient air pollutants, little is known as to whether or not there are interactions or synergisms among various ambient pollutants.

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 suggest that inhaled PM2.5 may directly activate nerve fibers (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) has not been investigated. 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 United States Environmental Protection Agency (U.S. EPA), for the following reasons. First, the results of this study will strengthen the biological support for epidemiological associations between PM2.5 exposure and adverse health effects, and will reduce uncertainty in the database. Few studies have investigated biological pathways other than oxidative stress and inflammation, and even fewer have investigated whether or not there are interactive effects with concurrent exposure to multiple air pollutants. Therefore, studies, particularly in experimental animals, are needed to elucidate the biological pathways through which PM- and ozone-related health effects are mediated.

Second, the results of this study will contribute to ensuring that future revisions to the PM and ozone NAAQS are adequately health protective by strengthening biological support for, and reducing uncertainty in, our understanding of the relationship between exposure to PM and adverse health outcomes. In addition, the study will help to define the parameters of cardiovascular disease that increase vulnerability to air pollution exposure. Strong NAAQS and identification of vulnerability factors are both important components of ARB's mission to promote and protect public health.

Third, although the NAAQS are based on single pollutants, people are always exposed to mixtures of air pollution. Consequently, it is of particular interest to determine whether concurrent exposure to PM2.5 and ozone induces greater adverse cardiovascular effects than exposure to either pollutant alone. U.S. EPA has recently adopted a multipollutant perspective, particularly with reference to NAAQS implementation and development of emissions reduction regulations. Because PM2.5 and ozone have been identified as responsible for the majority of adverse health effects associated with air pollution exposure, this project will focus on these two pollutants. 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.

Finally, this study could potentially leverage findings from previous ARB-funded studies, for example by using established analytical techniques, exposure models, or baseline data from individual component studies.

III. Scope of Work

Submissions must provide the following elements:

- An hypothesized mechanistic pathway for PM2.5- and ozone-induced cardiovascular dysfunction. Submitters must include a detailed description or diagram of the hypothesized pathway, and a literature review supporting the hypothesis. They must also clearly indicate the parts of the mechanistic pathway their proposed study will address.

- Description of, and justification for, the proposed animal model(s). This section should also provide the number of groups of animals proposed, and the number of animals in each group.
- Description of the proposed exposure protocol using PM2.5, ozone and a mixture of both. The description should include method, duration, dose/concentration, and number of days of exposure.
- Description of the proposed endpoints and the methods for measuring them. Proposed endpoints may be biochemical and/or physiological, but must address the specific hypothesis proposed, and be oriented toward demonstrating the influence of PM2.5 and ozone exposure on cardiac function.
- Description of the statistical methodologies to be used to analyze the results. This section should include the specific statistical tests to be employed, and estimates of the statistical power of the analyses. Submitters should also describe the methods to be used to determine whether or not the data are normally distributed, and if not, what alternative statistical methods will be used. Evidence for participation of, or consultation with, a biostatistician is also required.

IV. DELIVERABLES

- Quarterly Progress Reports
- Final Report
- Additional deliverables to be determined in consultation with ARB

V. TIMELINE

It is anticipated this project will be completed in 36 months from the start date. Note that this allows 30 months for completion of all work through delivery of a draft final report; the last 6 months are for ARB and RSC review of the draft final report and delivery of a revised final report and data files to the ARB.

Collection of Activity Data from On-road Heavy Duty Diesel Vehicles

I. Objective

The objective of this research is to characterize the heavy-duty truck activity profiles (e.g., duty cycles, starts and soak time) for different types of vocational uses (line haul, drayage, delivery, etc.) with the specific goal of identifying what fraction of the vehicle operation may be such that Selective Catalytic Reduction (SCR) functionality is challenged. The research should also put these results in context of the emission certification test cycle and provide an analysis of the representativeness of the certification cycle to real world emissions of nitrogen oxide (NO_X) for the different types of heavy duty vehicles. The results will be used to improve heavy duty NO_X emissions models, and to take a critical look at whether certification and compliance procedures need to be updated to account for the functionality of SCR.

I. Background

For the State of California to meet upcoming ambient air quality standards for ozone and PM, considerable reductions in NO_X emissions are needed. To achieve some of these reductions the NO_X emission standard for heavy-duty on-road engines was reduced by 90 percent in 2010. Diesel engine manufacturers are in most cases using advanced engine exhaust aftertreatment, specifically SCR, to meet the new standard. 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 requirement is not met, such as right after engine start 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 type of vocation. In line-haul application a truck operates mostly with high load to maintain high-speed cruise, while the other trucks operate with frequent stops in local goods delivery application. As a truck activity changes, SCR functionality of the truck changes with implications for NO_X reduction using SCR. Therefore, it is critical to characterize heavy-duty diesel truck activity profiles including duty cycles, number of engine starts, and engine soak time distributions, for trucks by vocation. The heavy-duty diesel truck activity profiles are fundamental for updating emission inventories, quantifying real-world NO_X emissions from trucks meeting the new 2010 NO_X certification standard, and determining if the certification standard should be revised.

I. Scope of Work

The contractor should create a fully developed research plan and perform all tasks as described below.

Task 1. Screening analysis of identifying the magnitude of NO_X emissions by types of vocational uses for heavy-duty diesel trucks

California motor vehicle emission inventory model, EMFAC2011, categorizes medium (T6) and heavy (T7) heavy-duty diesel trucks by a combination of their geological operation boundaries and vocational uses (APPENDIX A). Further truck class categorization by the type of vocation is critical to understand truck activity profiles to estimate SCR functionality and to quantify emissions. For instance, current T6 instate heavy-duty trucks operate in multiple vocations including beverage distribution, mail delivery, local goods delivery and others. It is believed that activity profiles from a mail delivery truck, which may include multiple short trips (short soak time) with low exhaust temperature, will be different from a beverage distribution truck making longer soak duration while loading and unloading. Although the two trucks are in the same T6 instate truck category, the difference of their activity profiles may be statistically significant. The contractor should investigate types of vocations for each truck class in EMFAC2011, and conduct a screening analysis of identifying truck vocational use types by the magnitude of NO_X emissions. Based on this screening analysis results, Tasks 2 and 3 will be conducted.

Task 2. Conduct truck travel diary survey, and quantify number of engine starts and soak time distribution

This task requests that the contractor conducts a truck travel diary survey, and quantifies the number of engine starts per day and soak time distribution per day for each truck use type by vocation. The contractor should conduct a truck travel diary survey to collect truck, engine and activity information for as many trucks as feasible. Table 1 shows the list of information that shall be included in a developed truck travel diary survey form.

Table 1. Information Included in Truck Travel Diary Survey

Vehicle and Engine Information	Vehicle and Engine Activity Information
Vocational use	Engine start time
Vehicle type	Engine stop time
Axle configuration	Trip purpose
Vehicle model year	Odometer reading at the first engine start
VIN number	Odometer reading at each engine stop
Vehicle weight	PTO use time (if applicable)
Engine make	
Engine size	
Engine model	
Engine model year	

Task 3. Collect ECU/OBD data and develop truck activity profiles for each truck use type by vocation

This task requests that the contractor collect instantaneous engine operation data and develop truck activity profiles for each vocational use. Instantaneous engine operation data can be acquired by engine control unit (ECU) or on-board diagnostic (OBD) data loggers, and should be collected on at least five trucks. As the contractor collects ECU/OBD data from a truck, it is required to collect vehicle and engine information from the truck and to conducta truck travel diary survey for the truck. In addition to ECU/OBD data, if applicable, it is suggested to collect vehicle position data by global positioning system (GPS), which are time-synchronized with ECU/OBD data. Table 2 shows vehicle and engine information, and ECU/OBD/GPS data to be collected in this task. The contractor should develop truck activity profiles, which include duty cycles, the number of starts per day and the soak time duration per day for each truck use type by vocation, by using the vehicle and engine information and ECU/OBD data, and conduct comparison analysis of the truck activity profiles to the truck diary survey results obtained from the task 2. If GPS data can be collected, the contractor should develop GPS data-based duty cycles and vehicle operation time and speed profiles by road facility type. GPS data-based duty cycles can be developed through a modal modeling concept such as physical emission rate estimator (PERE) applied to U.S. EPA motor vehicle emissions simulator (MOVES).

Table 2. Vehicle and Engine Information, ECU/OBD/GPS Data

Vehicle and Engine Information	ECU/OBD/GPS Data
Vocational use	Vehicle speed
Vehicle type	Engine horsepower
Axle configuration	Engine RPM
Vehicle model year	Fuel rate
VIN number	Exhaust temperature
Vehicle weight	Truck location (optional)
Engine make	
Engine size	
Engine model	
Engine model year	

Task 4. Analysis of the representativeness of the certification cycle to developed duty cycles for each vocational use

The contractor should conduct the analysis of the representativeness of the certification cycle by comparing to the duty cycles developed in Task 3 for truck use types by vocation. The contractor should deliver the difference between the certification cycle and the duty cycle with statistics including speed, travel duration, acceleration, deceleration and others.

APPENDIX A. EMFAC2011 T6 and T7 Diesel Vehicle Categories

Truck Category	Description
T6 Ag	Medium-Heavy Duty Diesel Agriculture Truck
T6 CAIRP heavy	Medium-Heavy Duty Diesel CA International Registration Plan Truck with GVWR>26000 lbs
T6 CAIRP small	Medium-Heavy Duty Diesel CA International Registration Plan Truck with GVWR<=26000 lbs
T6 instate construction heavy	Medium-Heavy Duty Diesel instate construction Truck with GVWR>26000 lbs
T6 instate construction small	Medium-Heavy Duty Diesel instate construction Truck with GVWR<=26000 lbs
T6 instate heavy	Medium-Heavy Duty Diesel instate Truck with GVWR>26000 lbs
T6 instate small	Medium-Heavy Duty Diesel instate Truck with GVWR<=26000 lbs
T6 OOS heavy	Medium-Heavy Duty Diesel Out-of-state Truck with GVWR>26000 lbs
T6 OOS small	Medium-Heavy Duty Diesel Out-of-state Truck with GVWR<=26000 lbs
T6 Public	Medium-Heavy Duty Diesel Public Fleet Truck
T6 utility	Medium-Heavy Duty Diesel Utility Fleet Truck
T7 Ag	Heavy-Heavy Duty Diesel Agriculture Truck
T7 CAIRP	Heavy-Heavy Duty Diesel CA International Registration Plan Truck
T7 CAIRP construction	Heavy-Heavy Duty Diesel CA International Registration Plan Construction Truck
T7 NNOOS	Heavy-Heavy Duty Diesel Non-Neighboring Out-of-state Truck
T7 NOOS	Heavy-Heavy Duty Diesel Neighboring Out-of-state Truck

T7 other port	Heavy-Heavy Duty Diesel Drayage Truck at Other Facilities
T7 POAK	Heavy-Heavy Duty Diesel Drayage Truck in Bay Area
T7 POLA	Heavy-Heavy Duty Diesel Drayage Truck near South Coast
T7 Public	Heavy-Heavy Duty Diesel Public Fleet Truck
T7 Single	Heavy-Heavy Duty Diesel Single Unit Truck
T7 single construction	Heavy-Heavy Duty Diesel Single Unit Construction Truck
T7 SWCV	Heavy-Heavy Duty Diesel Solid Waste Collection Truck
T7 tractor	Heavy-Heavy Duty Diesel Tractor Truck
T7 tractor construction	Heavy-Heavy Duty Diesel Tractor Construction Truck
T7 utility	Heavy-Heavy Duty Diesel Utility Fleet Truck
PTO	Power Take Off

IV. Deliverables

- Quarterly progress reports
- Final report
- All data and analyses generated through the course of this project

V. Timeline

It is anticipated this project will be completed in 24 months from the start date. Note that this allows 18 months for completion of all work through delivery of a draft final report; the last 6 months are for ARB and RSC review of the draft final report and delivery of a revised final report and data files to the ARB.

Support for Advanced Clean Cars

I. Objective

Implementation of the recently approved Advanced Clean Cars program will result in various technologies emerging in the new vehicle market to meet the tighter requirements. Ongoing evaluation of these technologies and requirements from multiple perspectives is necessary to assess the progress towards meeting the program's goals. ARB seeks innovative approaches to understanding issues related to consumer acceptance, technological progress, as well as consumer, societal or economic impacts of the regulatory programs. Research findings will be used to inform future policy actions to facilitate compliance with the program or any amendments to light-duty vehicle emissions standards.

II. Background

The Advanced Clean Cars program is comprised of a suite of performance-based regulations intended to achieve significant criteria and greenhouse gas emissions reductions from new light-duty vehicles. By 2025 when the program is fully implemented, new automobiles will emit 34 percent fewer global warming gases and 75 percent fewer smog-forming emissions. Additionally, in coordination with Governor Brown's Executive Order B-16-2012, the Advanced Clean Cars program will result in more than 1.4 million zero-emission and plug-in hybrid vehicles on the road in California.

Auto manufacturers will continue to have flexibility in the types of conventional and advanced technologies they utilize while consumers will likewise have a diverse array of new vehicle offerings from which to choose. As compliance with the emissions standards is based on a manufacturer's fleet average of new vehicles, it will be important to monitor and understand the trends in the new car market. Trends of particular interest include the types, costs, and effectiveness of pure- or near-zero emissions technologies that emerge in the marketplace as well as consumers' willingness and ability to purchase these technologies. The resultant broader economic and societal impacts of these market trends will also require continued evaluation for direct and indirect effects. Lastly, the targets established for zero-emission vehicles are intended as a minimum volume. ARB and partner agencies will continue to foster development of this emerging vehicle market, which would be aided by additional research on incentives and market transformation.

III. Research Areas

Research proposals are requested to address any of the following research questions. Prospective investigators are encouraged to contact ARB staff for any clarification on these topics. Note that ARB will fund projects for only a few of these questions based on the quality of proposals received; proposals ARB is unable to fund may be shared with other organizations for potential funding.

- <u>New car market trends</u>. Beyond basic descriptive statistics on vehicle sales mix and technology penetration rates, researchers are asked for innovative or novel approaches, methods, etc. to characterize changes in the new vehicle fleet over time and how the Advanced Clean Car program affects those trends. These approaches, methods, etc. should allow for ongoing characterization of the existing new vehicle fleet as well as some ability to extrapolate, forecast, or project future trends.

- Advances in vehicle technology. Engineers, scientists, and inventors in the public and private sectors continue to explore new technologies or improve existing ones. Synthesizing research is needed that identifies exotic technologies, such as new or substitute materials, chemistries, or processes, and evaluates and compares their potential for contributing to compliance with the standards.
- Technology impacts on consumer welfare. Given the array of vehicle technologies that may be employed to comply with more stringent standards, a method and estimation are needed on the consumer response to vehicle technology changes resulting from the regulations. Do consumers like the new technologies with their associated fuel savings, or are the new vehicles undesirable? Is it possible to identify effects of the program on vehicle sales or consumers' choices among vehicles? Is there evidence of hidden costs of the new technologies? In addition to consumer satisfaction with these technologies, changes in consumer welfare may also occur from rebound effects -- that is, changes in miles driven due to vehicle technologies with lower operating costs -- independent of fuel price effects.
- Affordability of new vehicles. Projected increases in new vehicle prices may be offset by expected fuel savings. However, from the perspective of a new car buyer, an increase in upfront costs may pose a barrier to entering the new car market. A method is needed for quantifying or indexing new vehicle affordability and estimating the extent to which higher upfront costs limit market entry into various vehicle segments/types and the ways in which traditional or alternative leasing/purchasing mechanisms may evolve to address the combination of those higher upfront costs and reduced fuel expenditures. Further research is also needed to understand how affordability influences the dynamics between the new and used vehicle markets.
- Economic Impacts. California could become the center of the emerging ZEV industry, on both the vehicle or infrastructure sides. Research is needed that examines the structure of the ZEV industry within California and beyond to identify the highest value elements in the supply chain and to distinguish the current and future impacts of policies directly affecting regulated parties or affiliated businesses from indirect impacts to other sectors of the economy. Continued research is also needed on the current and future regional and national impacts of the regulatory program on overall economic output and employment.
- Impacts on vehicle manufacturing. OEMs and suppliers will be seeking improvements in manufacturing techniques to reduce cost and shorten product cycle times, while zero-emission technologies may create new supply chains or manufacturing processes. Research is requested to track manufacturing trends in response to the Advanced Clean Car Program. Of particular interest is the relationship between product lifecycles and manufacturing costs for vehicles, engines, transmissions, etc. as well as changes in and differences between manufacturing processes (and costs) for conventional and advanced technologies.
- Valuation of co-benefits. ZEVs and other advanced vehicle technologies may offer consumers with benefits that do not necessarily have a market price. Research proposals are requested that develop and estimate the co-benefits related to greater ZEV adoption, such as home charging convenience, avoided oil spillage and water quality impacts, reduced military expenditures, improved grid reliability through vehicle-to-grid connectivity, or greater motivation for residential energy conservation.

- Incentives based on behavioral economics. Ongoing developments in the field of behavioral economics suggest that incentives could be structured in an alternate manner to be more effective at persuading consumers to adopt new vehicle technologies or behaviors. Research proposals are requested that rigorously evaluate possible incentives for purchasing near or pure zero-emission vehicles based on principles of behavioral economics.
- Innovative approaches to transform the new vehicle market. A sustainable market cannot rely indefinitely on publicly-funded incentives. Research proposals are requested evaluating innovative approaches to increase consumer awareness and demand for zero-emission vehicles beyond conventional strategies such as financial incentives or vehicle perks (free parking, HOV access). Approaches may include, but are not limited to, the use of social media, alternative vehicle ownership or financing structures, or demonstration projects.

IV. DELIVERABLES

- Quarterly progress reports
- Final report
- Additional deliverables to be determined in consultation with ARB staff.

V. TIMELINE

It is anticipated that projects will be completed in 36 months from the start date. Note that this allows 30 months for completion of all work through delivery of a draft final report; the last 6 months are for ARB and RSC review of the draft final report and delivery of a revised final report and data files to the ARB.

The Future of Drop-In Fuels

I. Objective

Advances in fuels that are derived from renewable feedstock are essential for California to meet its climate change and air quality goals. Although there are several types of renewable fuels, one that requires the least modifications to the existing infrastructure and vehicle fleet are drop-in fuels—that is, fuels that, once produced, are nearly identical to fossil-derived gasoline and diesel. This project should address the technology, feasibility, costs, and environmental impacts associated with producing these fuels on a commercial scale. The study would provide essential data that will be used to influence and shape the Low Carbon Fuel Standard (LCFS) policy. Additionally, the data could further support other climate change initiatives (within California and world-wide), the Federal Renewable Fuels Standard, and long-term air quality projects.

II. Background

ARB adopted the LCFS regulation in January 2010[1]. The first year was a reporting only year; full implementation began in 2011. The LCFS will reduce greenhouse gas (GHG) emissions from the transportation sector in California by about 16 million metric tons (MMT) in 2020. These reductions account for almost 10 percent of the total GHG emission reductions needed to achieve the State's mandate of reducing GHG emissions to 1990 levels by 2020. In addition, the LCFS is designed to reduce California's dependence on petroleum, create a lasting market for clean transportation technology, and stimulate the production and use of alternative, low-carbon fuels in California.

The LCFS is designed to provide a durable framework that uses market mechanisms to spur the steady introduction of lower-carbon fuels. The framework establishes performance standards that fuel producers and importers must meet each year beginning in 2011. One standard is established for gasoline and the alternative fuels that can replace it; a second similar standard is set for diesel fuel and its replacements. Each standard is set to achieve an average 10 percent reduction in the carbon intensity of the statewide transportation fuels mix by 2020.

The standards are "back-loaded"; that is, there are more reductions required in the last five years than the first five years. This schedule allows for the development of advanced fuels that are lower in carbon than today's fuels and the penetration of plug-in hybrid electric vehicles, battery electric vehicles, fuel cell vehicles, and flexible fuel vehicles.

The lynchpin of the LCFS is 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. If a low carbon intensity drop-in fuel were developed, it would aid in compliance without adding costs associated with fleet turnover and

[1] Codified at title 17, California Code of Regulations, sections 95480—95490. Additional changes went into effect in April 2010. Last amended February 12, 2012. Additional amendments, approved by the Board at its December 2011 hearing, are pending approval by the Office of Administrative Law.

additional infrastructure. But, in order to be commercially viable, the fuel needs to be available in sufficient quantities and available at competitive prices to its conventional counterparts.

Several industry studies[2,3,4] have contended that the fuels necessary to comply with the LCFS standards in the 2015 timeframe will not be available when they are needed. Not only are these studies pessimistic with respect to availability, but they also focus on the alleged large cost impact it will have on the consumer if these fuels are either unavailable or very expensive to produce.

In addition to the immediate need for LCFS compliance, there are several longer-term goals that will benefit from the data generated from this study. Reducing emissions in the transportation sector is key to attaining the State's air quality and climate goals. A recent ARB staff report[5] examined several technology-transformation scenarios needed to meet California's 2050 goals for the reduction of both GHG and criteria pollutant emissions. The scenarios in this report relied on the assumption that all liquid fuels are derived from renewable feedstocks by 2050, preferably in the form of drop-in fuels. While drop-in fuels are essential to meeting California's climate change and air pollution goals, the technology and infrastructure needed to develop commercially available renewable fuels still requires significant research.

Additional studies have also indicated that biofuels will be needed to achieve long-term energy and climate goals in the transportation sector, especially for aviation, shipping, and heavy-duty and off-road vehicles that cannot be easily electrified.[6]

III. Scope of Work

Drop-in fuels are in a research and development phase with pilot- and demonstration-scale plants under construction. Potential technology pathways include, but aren't limited to: (1) upgrading alcohols to hydrocarbons, (2) catalytic conversion of sugars to hydrocarbons, (3) fermentation of sugars to hydrocarbons, (4) hydrotreating algal oils, (5) upgrading of syngas (CO and H_2) from gasification, and (6) pyrolysis or liquefaction of biomass to bio-oil with hydro-processing.

The primary goals for this project are defined below.

[2] Andrew Chang & Company, LLC, "The Fiscal and Economic Impact of the California Global Warming Solutions Act of 2006," Commissioned by California Manufacturers & Technology Association, June 2012. http://www.cmta.net/pdfs/CMTA%20-%20Local%20Case%20Study%20Final.pdf.

[3] Stonebridge Associates, Inc., "The Impact of the Low Carbon Fuel Standard and Cap and Trade Programs on California Retail Diesel Prices," Commissioned by California Trucking Association, April 2012. http://caltrux.org/sites/default/files/CTALCFS.pdf

[4] Boston Consulting Group, "Understanding the impact of AB 32," Commissioned by Western States Petroleum Association, June 2012. http://www.cafuelfacts.com/wp-content/uploads/2012/07/BCG_report.pdf.

[5] Vision for Clean Air: A Framework for Air Quality and Climate Planning.' June 27, 2012. http://www.arb.ca.gov/planning/vision/docs/vision_for_clean_air_public_review_draft.pdf

[6] California Council on Science and Technology (2011) C*alifornia's Energy Future – The View to 2050,* available at (http://www.ccst.us/publications/2011/CEF%20index.php); California's Climate Challenge; or Yang et al (2009) Meeting an 80% Reduction in Greenhouse Gas Emissions from Transportation by 2050: A Case Study in California, USA, *Transportation Research Part D: Transport and the Environment*, Vol. 14, Issue 3, 147-156.

- Review the literature to gather existing information related to renewable drop-in fuels. Establish if data are available for life cycle analysis of various technology pathways and their related costs and environmental impacts.
- Analyze the technology, feasibility, costs, and environmental impacts at both demonstration and commercial scale. Estimate where facilities could potentially be located in order to maximize production while minimizing environmental impacts.
- Identify additional areas of research to facilitate the growing need for data related to technological advancement, costs, and environmental impacts.
- Identify barriers to the success of these technologies, and where applicable, strategies to overcome these barriers.
- Develop a strategy to monitor and track progress of these technologies as well as supplies and costs.

These results will provide data that will influence LCFS policy. 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 the California consumers. In the longer term, the data will inform many other initiatives of ARB that might support the need for drop-in fuels. In addition to benefits provided to the California's LCFS program, this research can also provide support to other jurisdictions world-wide that are developing their own LCFS-like programs.

IV. Deliverables

- Quarterly progress reports
- Final report
- Additional deliverables to be determined in consultation with ARB staff.

V. Timeline

It is anticipated that projects will be completed in 36 months from the start date. Note that this allows 30 months for completion of all work through delivery of a draft final report; the last 6 months are for ARB and RSC review of the draft final report and delivery of a revised final report and data files to the ARB.

The Feasibility of Renewable Natural Gas as a Large Scale, Low-Carbon Substitute

I. Objective

Alternative fuels that have low GHG and criteria pollutant emissions, such as renewable natural gas, are essential for California to meet its climate change and air quality goals. This project's goal is to determine the technological and commercial feasibility of producing large quantities of renewable natural gas fuels for use in California. Such an analysis should also address the costs, regulatory and infrastructure barriers, and environmental impacts associated with producing these fuels on a commercial scale. Results will provide essential data that will inform further refinements to the State's LCFS program and other climate change and air quality initiatives.

II. Background

ARB adopted LCFS regulation in January 2010, and its carbon intensity (CI) standards entered into effect in 2011. The LCFS is designed to reduce GHG emissions from the transportation sector in California by about 16 MMT in 2020. These reductions account for almost 10 percent of the total GHG emission reductions needed to achieve the State's mandate of reducing GHG emissions to 1990 levels by 2020. In addition, the LCFS is designed to reduce California's dependence on petroleum, create a lasting market for clean transportation technology, and stimulate the production and use of alternative, low-carbon fuels in California. This includes the use of renewable natural gas as a transportation fuel, both for light duty and heavy duty vehicle applications.

The LCFS incentivizes the production and sale of low carbon-intensity transportation fuels. The regulation does this 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. One set of carbon intensity standards is established for gasoline and the alternative fuels that can replace it; a second set of similar standards is set for diesel fuel and its replacements. Each standard is set to achieve an average 10 percent reduction in the carbon intensity of the statewide transportation fuels mix by 2020. Fuels generate deficits when they are sold in California with carbon intensities that are above the standard for a given year; such deficits must be reconciled within a year. By contrast, fuels generate credits, which can be banked indefinitely or bought or sold as the need arises, when the fuels have carbon intensities below the standard for that year.

The standards are "back-loaded;" that is, there are more reductions required in the last five years of the program than the first five years. This schedule allows for the development of advanced fuels that are lower in carbon than today's fuels and the penetration of plug-in hybrid electric vehicles, battery electric vehicles, fuel cell vehicles, and flexible fuel vehicles.

In order to be commercially viable, renewable natural gas needs to be available in sufficient quantities and at competitive prices relative to its conventional counterparts, both petroleum diesel and fossil natural gas. This is particularly true given the currently low market prices for conventional natural gas due to substantial increases in the use of innovative gas extraction techniques, such as hydraulic fracturing ("fracking") and horizontal drilling. The LCFS regulation already incorporates a number of pathways for renewable natural gas (as CNG or LNG) derived from landfill gas and dairy digesters, and there's a pending pathway for renewable natural gas derived from high solids anaerobic digestion of organic wastes (HSAD). All these renewable natural gas pathways have substantially lower carbon intensity that both conventional diesel and fossil natural gas. Because renewable natural gas has a much lower carbon intensity than both of these conventional fuels, the value of LCFS credits associated with its production and sales in California, particularly in the latter phases of the LCFS program, will likely improve the competitiveness of renewable natural gas.

To maximize the market penetration of renewable natural gas, it is essential that technical, commercial, financial, marketplace, and regulatory barriers that are specific to renewable natural gas production be identified. The ARB's 2011 LCFS Program Review Report indicates that barriers to expanded natural gas usage include infrastructure, conversion of existing vehicles to use natural gas, the higher cost and more limited selection of original equipment manufacturer (OEM) vehicles, and vehicle conversion. Such barriers would presumably also apply to the use of renewable natural gas as a transportation fuel. However, there are barriers to the expanded production and use of renewable natural gas that are specific to this fuel. Such barriers include, but are not limited to, prohibitive interstate pipeline standards, lack of centralized biogas production facilities, uncertainty in biomass volume that realistically would be available for renewable natural gas production, and capital and recurring costs.

A current example of successfully producing renewable natural gas at scale for transportation use can be found at the Altamont landfill (California). The landfill gas-to-liquefied natural gas (LFG) facility is operated by High Mountain Fuels, LLC, a joint venture of Waste Management and The Linde Group. Waste Management, one of the largest waste collection operators, has over 1,000 natural gas waste collection vehicles in their fleet, a number of which are now fueled with very-low carbon intensity LFG produced at the landfill. Waste Management is currently in the process of constructing a second landfill natural gas facility in southern California.

III. Scope of Work

As noted above, the feasibility of widespread, large-scale production of renewable natural gas, especially for transportation use, remains uncertain, with a number of knowledge gaps that need to be filled to assist with appropriate policymaking. Accordingly, the primary goals for the project investigators are as follows:

- Review the literature to compile existing and developing information related to renewable natural gas production and distribution, particularly for transportation fuel use in California and elsewhere.
- With the literature review as a starting point, provide a workplan to:
  (1) Develop a map of current and potential sources for renewable natural gas production, both in California and elsewhere in the U.S., 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 should also include an assessment of issues with the pipeline or other transport

systems for feeding biomass to a renewable natural gas production facility, and co-siting or other optimization strategies for maximizing renewable natural gas production among separate biomass/renewable natural gas sources located near each other.

(2) Identify or estimate where such facilities could be located in order to maximize production of renewable natural gas while minimizing potential environmental impacts.

(3) For the significant actual or potential sources of renewable natural gas identified above, provide a preliminary estimate using CA-GREET, GREET, or other appropriate model(s) of the lifecycle GHG emissions as well as localized emissions of criteria and toxic air pollutants. Provide preliminary assessments of other potential environmental and public health impacts that are of significant concern.

(4) Identify barriers to the successful expansion of renewable natural gas production, and where applicable, strategies to overcome these barriers, including but not limited to, suggested refinements to the LCFS regulation itself.

(5) Identify additional areas of research to help fill the growing need for data related to technological advancement, costs, and environmental impacts.

Results of this study will provide essential data needed to inform future refinements to the LCFS program, as well helping to inform other air quality or environmental programs.

IV. Deliverables

- Quarterly progress reports
- Final report
- Additional deliverables to be determined in consultation with ARB

V. Timeline

It is anticipated that projects will be completed in 36 months from the start date. Note that this allows 30 months for completion of all work through delivery of a draft final report; the last 6 months are for ARB and RSC review of the draft final report and delivery of a revised final report and data files to the ARB.

ADVANCING SOCIAL EQUITY IN REGIONAL TRANSPORTATION PLANNING

I. OBJECTIVE

The objective of this project is to promote the state goal of social equity in the integrated regional plans that address transportation, land use, and housing patterns. This project will advance our understanding of the social equity impacts of transit-oriented development in California and will identify strategies to minimize displacement as a result of transit investment. The results of this project will be useful to Metropolitan Planning Organizations (MPOs) in advancing the equity performance analyses of their Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS). It will also provide local and regional governments in California with information to help them evaluate and advance the adoption of land use strategies and other approaches to minimize displacement. The results of this project will contribute to ensuring low-income communities also share in the benefits of transit-oriented development.

II. BACKGROUND

SB 375 requires MPOs in California to develop a SCS that demonstrates how they will meet regional greenhouse gas reduction targets set by ARB. Transit-oriented development is one of the strategies being adopted by regions as they work toward SB 375 goals. For instance, the Southern California Association of Governments' (SCAG) recently adopted 2012-2035 RTP/SCS assumes that 51 percent of new housing developed between 2008 and 2035 will be within High Quality Transit Areas. Similarly, the Sacramento Area Council of Governments' (SACOG) 2012-2035 MTP/SCS assumes that 38 percent of new dwellings in their region will be in Transit Priority Areas by 2035.

While transit-oriented development is seen as a strategy to reduce greenhouse gas emissions and achieve other health co-benefits, there remains concern that improving transit services and concentrating growth around transit services may have unintended social equity impacts, including the direct and indirect displacement of current low-income residents. Introducing or improving transit services and increasing development investment in existing neighborhoods may increase the desirability of the area, raising rent and housing prices, placing additional financial pressure on current residents or forcing current residents to relocate to more affordable areas.

In response to these concerns, two MPOs attempt to explore issues of displacement in their RTP/SCS. SCAG developed a methodology to track demographic changes over time in those areas designated as key growth areas; however, this method does not estimate potential impacts of their plans and cannot assess the potential displacement impacts of the land use scenarios they consider. The Bay Area analyzed risk of displacement among the five scenarios they were considering by identifying areas with a high percentage of financially strained renters and high percentage of projected growth. Neither of these methods takes into account the type and magnitude of transit and development investment nor do they address market conditions and other complex factors.

To adequately address the potential adverse effects of future sustainable communities strategies on social equity, a stronger understanding of the potential for displacement, including the ability to quantify the potential magnitude of displacement, and the identification and evaluation of solutions is needed.

To address this need, this project will advance our understanding of the relationship between transit-oriented development and displacement; analyze the extent and magnitude of this relationship; create an off-model displacement assessment methodology to inform the planning process; and identify solutions that can be employed in California to reduce the potential adverse displacement effects. The project will result in information and a displacement assessment methodology that can be used by MPOs to supplement their analysis of the equity impacts of their regional plan and Sustainable Communities Strategies. The methodology may also be included in other impact assessment models employed by regionals and local governments (RapidFire, Urban Footprint, etc.). The project will help ARB minimize potential negative social equity impacts of implementing sustainable communities strategies.

III. Scope of Work

Building upon the state of the science conducted on transit-oriented development and displacement, this project will determine the extent and magnitude of the relationship between transit-investment, neighborhood characteristics, property and rent values, and displacement in California. This information will then be used to develop a method to assess the potential for displacement due to planned transit investment. Finally, real-world strategies to minimizing this displacement will be identified.

- Review the literature to identify operational definitions and measures of displacement and gentrification as well as to identify indicators of neighborhood vulnerability to displacement. The literature review should also explore the relationship between transit-oriented development and displacement, including a review of studies attempting to quantify impacts of transit investment and land use policies on property and housing values and direct and indirect displacement;
- Analyze the extent and magnitude of neighborhood change due to transit-oriented development in California. This analysis will take into account impacts of transportation investment of differing type and magnitude. It will also, to the extent possible, take into account other influencing factors, like market dynamics.
- Develop off-modeling methods for analyzing potential displacement impacts of scenarios and final RTP/SCS. Taking into account data availability, geographic scale, and data limitations, this displacement assessment methodology should look at neighborhood indicators of displacement, and link public investment type and magnitude to predict level of neighborhood change. To the extent possible, the method should capture/account for market pressures. If possible, this methodology should be created for easy uptake into employed visioning and impact assessment tools;
- Explore the benefits, barriers, and magnitude of impact of land use, transportation, and/or housing strategies to minimize displacement from transit-oriented development investment. This can be done through a set of case studies within or applicable to California, or can take another form to be determined in consultation with ARB.

IV. Deliverables

- Quarterly progress reports

- Final report
- Additional deliverables to be determined in consultation with ARB

V. Timeline

It is anticipated that projects will be completed in 24 months from the start date. Note that this allows 18 months for completion of all work through delivery of a draft final report; the last 6 months are for ARB and RSC review of the draft final report and delivery of a revised final report and data files to the ARB.

GUIDELINES FOR PREPARING AND SUBMITTING DRAFT PROPOSALS

PROPOSAL PREPARATION GUIDELINES

The technical proposal portion of the draft proposal should be clear and concise, no more than approximately 25 pages in length. To conserve paper, please use single or one-and-a-half spacing. The technical proposal should be paginated as a stand alone document using the "Page xx of xx" format in the top right corner.

The technical proposal must include the following parts:

- Title page. The purpose of this page is to provide in one location information needed by our administrative staff. It must contain all of the following items (see Example A):
    - the title of the draft proposal
    - the name of the principal investigator
    - a statement that the draft proposal was prepared for ARB's Research Division
    - the name and address of the university
    - the date of the draft proposal
    - check box if proposed research uses human or animal subjects
- Table of contents.
- Abstract. A one-page abstract of the proposed research briefly summarizing the main points of the various sections of the draft proposal.
- Introduction. Several paragraphs should be dedicated to explaining the relevance of this project. This section should include a brief description of research that has been conducted or is currently underway by the applicant and others in areas related to the draft proposal.
- Objectives. Describe the objectives of this project and how the results will be beneficial to ARB.
- Technical plan. This shall include at least the following topics:
    - A description of experimental techniques or research methods to be employed, including requirements for test specimens, laboratory animals, or human subjects.
    - A discussion of the major tasks to be conducted and how those tasks will be performed. Provide sufficient detail to allow technical reviewers to compare your proposal to others submitted in response to the same project solicitation. This section should demonstrate that adequate facilities and appropriate equipment are available to complete the project and describe protocols to ensure quality control and quality assurance.
    - A data management plan that identifies the data to be collected, the sample size required to assure statistical validity of the data, equipment or instrumentation that will be used, and approach to addressing quality assurance of the data.

- If applicable, a description of proposed human or animal subjects, including criteria for inclusion/exclusion, overview of recruitment plans, and need plans for Institutional Review Board (IRB) approval.
- References to publications describing similar work done by applicant(s) or others.

The proposal package must also include:

- Project schedule
  - List each task specified in the technical plan. Addressing each task, display the estimated timespan, with beginning and ending dates, of each individual task over the life of the contract. If tasks are extensive, they may be subdivided. Denote progress review meeting dates and dates of deliverables such as the draft final report (see Example B). Keep in mind that the draft final report must be provided to ARB six months prior to the contract end date in order to allow time for review by ARB staff and RSC.
- Curricula vitae or résumés of the key scientific personnel.
- Preliminary cost proposal.
  - Include the estimated cost breakdown by task (see Example C). Note that ARB's research budget is approximately $5 million dollars per year and typically supports 15-25 projects with 2 to 3 year durations. There is no specified minimum or maximum project budget, but most project budgets range from $50,000-$650,000. Projects that provide co-funding will be evaluated more favorably.

Proposal Submission Guidelines

- All materials comprising the draft proposal must be consolidated into a single Microsoft Word or Adobe pdf file.
- To submit your draft proposal, please visit our proposal submission website to upload your file: http://researchplanning.arb.wagn.org/.

EXAMPLE A: SAMPLE DRAFT PROPOSAL TITLE PAGE

Page 1 of xx

DRAFT PROPOSAL

Concentrations of Volatile Organic Compounds
in Urban Homes

Principal Investigator:
Joanna Phillips

Prepared for:

State of California Air Resources Board
Research Division
PO Box 2815
Sacramento CA 95812

Prepared by:

University of California, Davis
One Shields Avenue
Davis, CA 90210
(888) 555-4433

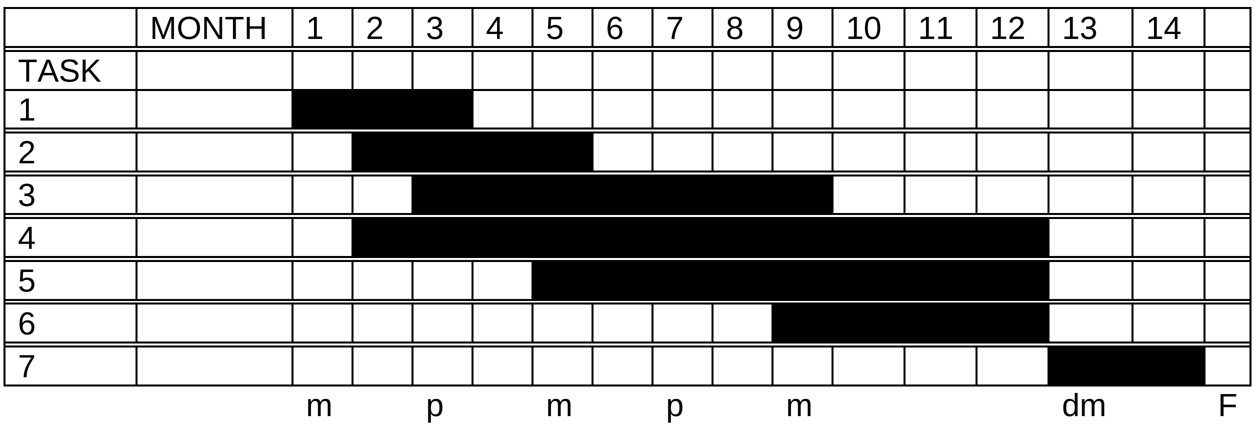
August __, ____

Check if applicable:
Animal subjects _______
Human subjects _______

EXAMPLE B: SAMPLE PROJECT SCHEDULE

PROJECT SCHEDULE

Task 1: Purchase equipment
Task 2: Install equipment
Task 3: xxxxx
Task 4: xxxxx
Task 5: xxxxx
Task 6: Draft final report
Task 7: Amend final report



p = Quarterly progress report
d = Deliver draft final report (to be submitted 6 months prior to contract expiration)
f = Deliver final report
m = Meeting with ARB staff

EXAMPLE C: ESTIMATED COST BY TASK

Task	Labor	Employee Fringe Benefits	Subs, Consultan ts	Equip	Travel Subsist	EDP	Copy Print	Mail Phone Fax	Materials and Supplies	Analyses	Misc.	Overhead	Total
1	$4,200	$1,260	$0	$5,200	$4,240	$0	$15	$5	$25	$0	$0	$840	$15,785
2	$5,000	$3,000	$5,430	$0	$0	$0	$45	$60	$34	$0	$0	$2,000	$15,569
3	$10,000	$1,500	$0	$0	$0	$450	$10	$10	$66	$365	$0	$1,000	$13,401
4	$8,000	$102	$0	$72	$340	$0	$5	$10	$52	$1,024	$0	$68	$9,673
5	$4,500	$1,350	$0	$0	$0	$0	$10	$10	$52	$0	$0	$900	$6,822
6	$340	$2,400	$0	$0	$0	$0	$0	$0	$0	$0	$245	$1,600	$4,585
	$32,040	$9,612	$5,430	$5,272	$4,580	$450	$85	$95	$229	$1,389	$245	$6,408	$65,835