STATE OF CALIFORNIA
AIR RESOURCES BOARD

MEETING OF THE
RESEARCH SCREENING COMMITTEE

November 15, 2024
10:00 a.m.

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

California Air Resources Board

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

November 15, 2024
10:00 A.M

Agenda

California Air Resources Board

Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Sacramento, CA 95814

September 23, 2024
10:00 A.M

Minutes

Research Screening Committee Meeting Members in Attendance via Teleconference:

Dr. Roya Bahreini
Dr. Mary Johnson
Dr. Sam Silva
Dr. Aly Tawfik

I. Approval of Minutes of Previous Meeting

May 2, 2024

II. Discussion of Research Proposals

1. "Enhancing Health Impact Assessment in California: Integrating High-Resolution Air Quality Modeling and Community Characteristics," University of California, Los Angeles, $800,000

The Research Screening Committee (RSC or Committee) provided the following comments and suggestions for consideration:

- The Committee suggested including Assembly Bill (AB) 617 community organizations on the Technical Advisory Group at the start of the project and throughout the ground-truthing phase.
- The research team proposes air quality simulations from 2018 to be used as the baseline concentration data. Some Committee members expressed concerns regarding the number of wildfires that year and their potential impact on baseline measurements.
- Committee members expressed concerns regarding the data availability from PurpleAir monitors due to restricted historical data, which requires specific requests and additional costs. Committee members were concerned about the long-term planning for data access and availability, especially for models that rely on this data.

- Committee members were concerned about the long-term planning for data access and availability, especially for models that rely on this data.
- The Committee suggested that the research team work with the California Air Resources Board (CARB) staff to investigate whether the demographic shifts across the US and California during the pandemic years 2020-2022 could significantly impact the statewide CT-level Standardized Mortality Ratios adjusted for age and sex, and the health data results.

Motion: Move to recommend that CARB accept the proposal, subject to the inclusion of revisions based on comments from the Committee.

The Committee approved the motion.

2. "Dust on the Horizon: Assessing Current and Projecting Future Health Risks from the Shrinking Salton Sea," University of California, San Diego, $930,000

   Committee members postponed discussion of this item to a future meeting.

3. "Residential Appliances in Diverse California Communities: Emission, Exposure, and Health Impacts of Toxic Air Contaminants (RESPECT)," University of California, Los Angeles $926,365

   The Committee recognized that the proposal was comprehensive and well-designed. The Committee provided the following comments and suggestions for consideration:

   - Include some questions in the survey to collect health information of the occupants in the test homes.
   - Add more diffusive samplers indoors if budget allows to capture the air pollution concentration variation due to different locations of appliances.
   - Consider including rehabilitation specialists to serve in the Technical Advisory Group or collaborating with them as Community Partners.
   - Provide homeowners with information on available federal and state funding and incentives for cleaner appliance replacements and upgrades.

   Motion: Move to recommend that CARB accept the proposal, subject to the inclusion of revisions based on comments from the Committee.

   The Committee approved the motion.

III. Other Business

1. Update on Research Planning

CARB staff provided the Committee with the following update regarding ongoing Research Planning efforts:

Fiscal Year 24-25: Final proposals for FY24-25 will be reviewed by the Committee at the November Committee meeting. FY24-25 projects will kick off early next year.

FY25-26: Earlier this year, CARB sent out a survey to solicit proposed research concepts and comments. Research Program staff received over 100 public and internal concepts and comments. CARB has completed its internal Research Program review and is nearing the end of the CARB-wide review. The project concepts will be discussed with leadership from other CARB programs in the coming weeks. The internal review will help prioritize a top 20 to 30 projects that will be presented to the public in mid-November for final public input. That input will help finalize a proposed list of projects to be funded in FY25-26. The final list will be presented to CARBs Executive Office for final approval. This will result in a solicitation of pre-proposals in Spring of 2025.

5-Year Plan: CARB is in the process of collecting future research priorities from various partners to help write a 5-Year Strategic Research Plan that will cover years 2025-2030 and will inform annual research projects in that time period. CARB has contracted with seven (7) community-based organizations (CBO) to incorporate environmental justice in all the research areas CARB funds. With their collaboration, CARB is hosting seven (7) research roundtables, six (6) in person and one (1) virtual. So far CARB and it's CBO partners have hosted meetings in Bombay Beach near the Salton Sea, Santa Ana, Los Angeles, Lamont near Bakersfield, East Palo Alto and a final meeting in Richmond. So far the meetings have been well attended and engaging. Public input into the 5-Year Plan will close in mid-November. All public input will be considered as CARB staff finalize the plan over the winter. In February 2025, CARB staff hope to release a draft public version of the plan for a 30-day comment period and then present the plan to the Board in March 2025.

The Committee had no comments. No motion or vote was required for this item.

Item No.: II.1
Date: November 15, 2024
Proposal No.: 2884-314

Staff Evaluation of a New Research Project

Title:	Dust on the Horizon: Assessing Current and Projecting Future Health Risks from the Shrinking Salton Sea
Contractor:	University of California, San Diego
Principal Investigator:	Amato Evan, Ph.D. Alexandra Heaney, Ph.D. William Porter, Ph.D. Adeyemi Abebiyi, Ph.D. Shu-Hua Chen, Ph.D. Paolo D'Orico, Ph.D. Enuha Hoh, Ph.D. Jasper Kok, Ph.D.
Budget:	$930,000
Contract Term:	30 Months

For further information, please contact Dr. Patrick Wong at (279) 208-7295 or *Pat.Wong@arb.ca.gov*

I. Summary

Dust storms are common in the Imperial and Coachella Valleys, where the arid landscape combines with frequently gusty winds to loft dust into the atmosphere. The shrinking Salton Sea is also driving an increase in dust emissions from the growing dried sediment (playa). This represents a unique challenge for the communities of the region, particularly since dust emitted from the playa may be enriched with contaminants from historical agricultural and industrial activity. Prior research by U.S. Geological Society and academic researchers has identified the presence of legacy contaminants such as organochlorine and organophosphate pesticides and heavy metals. People living in communities near Salton Sea report a high incidence of respiratory problems, including asthma, and there is growing concern about public health impacts from exposure to dust from Salton Sea. Dust emissions are predicted to further increase because of climate change impacts, including the likelihood of regional dust storms that could mobilize very large quantities of contaminated dust from Salton Sea playa. This research project will quantify the amount of dust being emitted from

different dust sources in the Salton Sea region, including desert, playa and agricultural emissions. The investigators will also collect and analyze playa and airborne dust for contaminants of concern and characterize the potential for health effects from exposure to Salton Sea dust during different wind events. These results will be extrapolated to provide information about possible effects from dust storm conditions statewide using computer models. Actions to reduce human exposure to dust will also be identified and discussed.

II. Technical Summary

Objective

In this project, the contractor will address the following objectives:

- Quantify dust emissions from different dust sources in the Salton Sea region using existing data sources and conducting air sampling;
- Model the transport of dust emissions under a variety of scenarios to predict impacts under different weather conditions, including dust storms;
- Identify and quantify chemical contaminants of dust and sediment from Salton Sea;
- Characterize the potential for human health effects from exposure to dust from Salton Sea under different environmental conditions;
- Assess potential human health impacts from exposure to contaminants in the dust from Salton Sea, including vulnerable population subgroups; and
- Identify actions people can take to mitigate dust exposures.

Background

Salton Sea is the largest lake in California and acts as an agricultural sump, receiving runoff from irrigated agricultural land in Riverside and Imperial counties. There is no outlet to Salton Sea, so chemical contaminants in the irrigation run-off have accumulated in the lake water and sediment. Over the decades, numerous sampling events have identified a wide range of chemicals in Salton Sea environmental media. Due to fertilizers in runoff entering Salton Sea, the pH of the lake water has risen to the point where animal life is severely limited, with only a small number of species able to tolerate the extreme saline conditions. As such, periodic die-offs occur of migratory birds that visit Salton Sea during winter migrations. The environmental situation of Salton Sea is affecting all who live in the region and calls to action

have been made over the last 10-15 years. One of those clarion calls is from residents and community-based organizations who are concerned about health impacts on families from breathing in dust from Salton Sea that is contaminated with pesticides and heavy metals. To date, there has not been a comprehensive study on this longstanding environmental health issue. This project is the first step towards providing community members with information about what's in the dust and how it could affect them over time, including under future environmental conditions caused by climate change impacts, as well as information on ways to reduce dust exposures and protect their children. In order to address community concerns and advance knowledge about dust emissions from the Salton Sea, the investigators will address the following research questions (RQs):

- Task 1: What is the current state of scientific knowledge about chemical contaminants in Salton Sea playa and dust, public health issues in Salton Sea-area communities, and regional dust emissions from multiple sources?
- Task 2: What do residents in Salton Sea-area communities want researchers to focus on, within the scope of the study, and how can residents provide input into the research methodology, including dissemination of the results of the study?
- Task 3: What are region-specific environmental and health data sources that could be accessed for this study? What chemical contaminants are in Salton Sea dust and playa?
- Task 4: How much dust are people living around Salton Sea exposed to, including under modelled dust storm conditions and environmental conditions resulting from climate change?
- Task 5: How does exposure to dust from Salton Sea relate to the number of Emergency Room visits for a range of conditions and is there an association between dust exposure and adverse birth outcomes, particularly in vulnerable communities? Do any of the chemicals detected in Salton Sea dust pose a concern for human health?
- Task 6: What actions can people take to mitigate dust emissions and reduce exposures? What research gaps remain and how could these be addressed?

Proposal Summary

Task 1: Assess Current Knowledge of Environmental and Public Health Issues in Salton Sea Area

The investigators will conduct a thorough literature review on meteorological conditions of the region, regional dust emissions, chemical contaminants in Salton Sea environmental media, and public health issues in Salton Sea-area communities. The results from this literature review will be used in Tasks 3-5.

Task 2: Community Engagement Plan

The research team will partner with a community-based organization in Imperial County, Los Amigos de la Communidad, Inc. located in Brawley, with the goal of mutual sharing of information about the research project, including project planning, development of public meetings, and creating informational materials. The research team will also identify other opportunities to present information about the research project to residents and other stakeholders in the Salton Sea region, including AB 617 community meetings and local air district meetings.

Task 3: Data Acquisition

The research team will collect data covering numerous parameters, including meteorological and air quality, surface soil characteristics and regional dust emissions, emergency room visits, birth outcomes, and demographic and socioeconomic characteristics using multiple data sources, including direct dust and playa sampling. Dust and playa samples will be collected from at least eight (8) sites around Salton Sea and analyzed for pesticides, heavy metals, and other contaminants identified through the literature review.

Task 4: Estimating Dust Concentrations in Air of Salton Sea-area Communities

The research team will use chemical transport modeling (WRF-Chem) to track dust emissions and run simulations to derive spatially resolved dust emissions and human exposure estimates. Factoring in several key variables, the optimized model output will provide dust concentrations by receptor location at the zip code level, as well as initial dust origins – including future changes in dust emissions resulting from continued shrinking of Salton Sea and increased playa exposure.

Task 5: Health Impacts Assessment from Salton Sea Dust Exposure

Modeled air dust concentrations will be analyzed for association with emergency room visits and birth outcomes at a one (1) kilometer square resolution, incorporating sensitivity analyses. Communities most at risk of health effects from dust inhalation, including future dust exposures, will be identified, including vulnerable population subgroups within those communities. Potential health risks related to exposure to chemical contaminants in Salton Sea dust and playa will also be characterized.

Task 6: Actions to Potentially Mitigate Exposure to Salton Sea Dust, Knowledge Gaps Identified

In the final report and in public meetings, the research team will present information about steps local communities can take to reduce exposure to dust. Knowledge gaps will be identified, with future research objectives outlined. In addition, the investigators will provide training to CARB staff and management on use of the model, including how it can be adapted for use in other dust emitting parts of the state.

III. Staff Comments

This proposal was solicited by CARB in response to a research concept submitted by the primary Principal Investigator (PI), Dr. Amato Evan (University of California, San Diego[UCSD]).

The initial proposal was reviewed by a committee that included staff and managers from the Research Division (RD), Office of Community Air Protection, Air Quality Planning and Science Division, Industrial Strategies Division, and the Office of Environmental Health Hazard Assessment. RD staff and management met with the PI (Dr. Amato Evan, UCSD) to convey and discuss the committee's comments and requests, and to answer questions.

The review committee agreed that the proposal meets CARB's intended goal of responding to Salton Sea community members' long-standing concerns about public health effects from exposure to dust from Salton Sea, including during future dust storm events precipitated by climate change impacts and the shrinking Salton Sea. The reviewers consistently commented that the proposal is comprehensive, and the research team appears highly qualified. This

multi-campus collaboration showcases the wide-ranging expertise of the research team, with access to the best laboratory facilities available in the University of California (UC) system.

Members of the research team are widely published in their respective disciplines, with PI Dr. Evan a recognized expert in the physics of dust storms. Since 2019, Dr. Evan has operated a research station near the western shoreline of Salton Sea, where he monitors dust storm conditions. Dr. William Porter (UC Riverside) has conducted prior research on health outcomes and air pollution in the Salton Sea region and is very familiar with changing environmental conditions and ongoing dust issues related to the shrinking water body and exposed playa. This background and the connections between researchers provide the necessary expertise to undertake this multi-faceted research study.

CARB reviewers provided comments on various sections of the proposal, including requests for clarification about dust and soil sampling methodology and more information about emissions modeling. There was a general request that researchers share data with CARB at the end of the study and provide recommendations for where mitigating activities might be most useful for reducing human exposures to dust. Regarding the community engagement plan, there were questions about how the partnering CBO will be chosen and a recommendation that the PIs seek out "new voices", as appropriate. There were also recommendations on how to communicate the results of the study to the public both during and at the conclusion of the project. Questions and concerns were expressed about the proposed method of characterizing health risks from dust exposure and recommendations were made on more appropriate approaches to take that will better account for cumulative exposures over time.

The investigators then submitted a revised proposal that sufficiently addressed comments and feedback from the review of the initial proposal. Overall, CARB RD staff and management are satisfied that the comments were adequately addressed and needed revisions made.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this proposal for a total amount not to exceed $930,000, subject to any changes and additions specified by the Committee.

Item No.: II.2
Date: November 15, 2024
Proposal No.: 2885-314

Staff Evaluation of a New Research Project

Title:	Reducing Exposure with Air Cleaners and Technology (REACT) in At-Risk Communities
Contractor:	University of California, Davis
Subcontractor:	University of California, San Francisco Brightline Defense BVHP Commnity Advocates
Principal Investigator:	Chelsea Preble, Ph.D.
Budget:	$850,000
Contract Term:	24 Months

For further information, please contact Dr. Patrick Wong at (279) 208-7295 or *Pat.Wong@arb.ca.gov*

I. Summary

The Bayview-Hunter's Point (BVHP) community is a historically and persistently impacted community that has experienced disproportionate air pollution and health burdens. Mitigation strategies that create protective indoor environmental spaces are critical to reducing exposures and benefiting health. This study will evaluate indoor air quality in the BVHP community and ways to improve air quality and health protection. Using an interrupted time series design, the study will evaluate the impact of air filtration devices (cleaners) on indoor PM2.5 exposures and respiratory health outcomes. In addition, using a multistage randomized control trial design, the study will assess how inputs like indicators from low-cost PM2.5 sensors and technical assistance can increase the use and effectiveness of air cleaners. Using segmented regression models, the investigators will estimate how information from indoor air quality monitors, air cleaner use, and targeted assistance affect indoor air quality and health symptoms. This study will assess the effectiveness of these individual-level interventions, guiding future policymaking and advocacy efforts to improve indoor air quality for over-exposed communities.

This study will characterize indoor and outdoor PM2.5 trends in the BVHP community and assess the efficacy of low-cost PM2.5 sensors and air cleaners to reduce exposures and improve health outcomes. Furthermore, behaviors that could be modified to further improve these indoor air quality (IAQ) and health benefits will be explored. This is community-centered, with meaningful partnerships between UC researchers, local policy and advocacy experts, and community members. The results of this study can offer guidance for future policymaking and advocacy strategies to mitigate the harmful effects of poor air quality in at-risk communities.

II. Technical Summary

Objective

The primary objective of the study is to investigate the air quality and health impacts of deploying portable air cleaners and air quality sensors at 100 residences in the BVHP community. Also, it is known that when used properly, portable air cleaners are effective in lowering indoor PM2.5 levels; however, little is known about how to maximize the efficacy of these devices. Accurate estimation of exposures to air pollutants in impacted communities like BVHP, and determining what methods are effective in reducing those exposures is essential to achieving CARB's goal of protecting all communities from the harmful effects of air pollution.

Background

Across the United States and in California, environmental justice (EJ) communities carry a disproportionate burden of exposure that has significant impacts on health, including mortality. BVHP – an EJ community experiences disparate pollution and health burdens. Local sources of PM2.5 include heavy industrial activity, commuter traffic, heavy-duty diesel trucks, freight trains, and port and maritime activities. Health-protective guidance in these highly impacted communities would improve if there was a better understanding on the impacts of indoor infiltration of outdoor air pollution, especially during extreme events like Spare the Air Days and wildfire smoke periods and strategies to reduce the impacts of these outdoor as well as indoor air pollution sources.

Proposal Summary

This study will be a collaborative partnership between UC Berkeley (UCB), UC San Francisco (UCSF), and local community organizations, BVHP Community Advocates (Advocates) and Brightline Defense (Brightline). An interrupted study design is proposed to assess the effectiveness of air cleaners to improve IAQ and health in BVHP. PurpleAir sensors will be used to quantify PM2.5 concentrations before and after air cleaners are distributed. Using a multistage randomized controlled trial design, the study team will also evaluate how additional information, and training can impact participant use of the air cleaners.

For the study, 100 households residing in BVHP will be recruited. Each household will be randomized to receive a PurpleAir PM2.5 sensor with (n = 50) and without (n = 50) an indicator that shows the air pollution level. After a 30-day baseline PM2.5 monitoring period, all households will receive an air cleaner. After an additional 30 days, households not consistently using air cleaners (<50% of average logged use) will receive additional technical assistance. All participants will complete in-the-moment surveys twice weekly to capture general behaviors and respiratory symptoms.

The study will have six (6) primary tasks:

Task 1. Community Outreach and Engagement Plan (Leads: Advocates & Brightline, Q1–Q2)

Existing partnerships will be leveraged for the community outreach and engagement plan, including for the recruitment of the Community Advisory Board (CAB). The CAB will be formed in Q1 of the study and will follow a hybrid model that includes both key stakeholders and organizations who work in the community as well as BVHP residents.

Advocates and Brightline are leading the community engagement plan, including development and writing, with support as needed from UCB and in collaboration with CARB and the CAB.

Task 2: Literature Review (Leads: UCB & UCSF; Q1–Q4)

The literature review will review recent publications and prior studies of PM interventions, along with those that capture the local indoor and outdoor air pollution sources, health, and housing characteristics that may be pertinent to BVHP.

Task 3: Questionnaire Development (Leads: UCB & UCSF; Q1)

Questionnaires will gather information about demographics, household characteristics, and baseline health status. In-the-moment surveys will be sent by SMS twice per week, and the validated Breathlessness, Cough, and Sputum Scale will be used to assess respiratory symptom changes.

Task 4: Participant Selection & Recruitment (Leads: Advocates, Brightline, & UCSF; Q2–Q4)

In collaboration with the CAB, the aim is to recruit 100 households from BVHP to receive PurpleAir sensors and air cleaners.

Advocates and Brightline will lead participant recruitment by leveraging their existing outreach and engagement activities and through the working partnerships with our CAB members and other partner organizations. Advocates will develop informational and educational materials and events to inform the overall community about the project and recruit eligible households.

Task 5: Air Cleaner Intervention & Field Study (Leads: UCB, UCSF, Brightline, & Advocates; Q2–Q4).

Conduct an interrupted time series intervention study over a 90-day period for each household, during which the researchers will monitor indoor PM2.5 concentrations continuously and collect in-the-moment health and behavior data twice weekly.

UCB and UCSF will train outreach team members from Brightline and Advocates to conduct home visits, including installing the PurpleAir sensors in Phase I, installing the air cleaners in Phase II, administering the questionnaires at the start and end of the monitoring period, resolving typical issues with general troubleshooting protocols, and conducting follow-up visits for hands-on training in Phase Ill.

Task 6: Modeling & Analysis (Leads: UCB & UCSF; Q5–Q6)

Assess changes in PM2.5 and self-reported health outcomes over the intervention periods relative to the baseline.

Task 7: Reporting (Leads: UCB, UCSF, Brightline, & Advocates; Q6–Q8)

The multidisciplinary team will engage directly with the BVHP community and stakeholders through existing partnerships, including the Community Emission Reduction Program and the Community Steering Committee, and share the results of the study so that the key insights and conclusions can immediately be incorporated into ongoing policy and advocacy work.

Project Deliverables

- One (1)-Page project summary to share with the public
- Literature review – recent publications and prior studies of PM interventions, along with those that capture the local indoor and outdoor air pollution sources, health, and housing characteristics that may be pertinent to BVHP.
- Draft Final Report – detailed report of project and results
- Plain-language fact sheet and outreach materials
- Plain-language seminar
- CARB Research seminar

III. Staff Comments

The proposal was reviewed by CARB staff in the Research Division, Enforcement Division, and externally by the California Department of Public Health (CDPH) and discussed with staff from CARB's Office of Community Air Protection. Only minor comments and edits were suggested, and the investigator addressed all concerns and comments before submitting the final proposal.

The study team is multidisciplinary and is uniquely qualified to successfully conduct this proposed work. Their expertise includes air quality engineering (Delp, Preble, Sugrue), respiratory health (Thakur), epidemiologic data analysis (Thakur, Nguyen), community engagement and outreach (Ahn, Correa, Pierce, Preble, Sugrue, Thakur), and environmental

justice policy and advocacy (Ahn, Correa, Pierce, Thakur). The research team has extensive experience with community-partnered air quality monitoring and health assessments using low-cost sensors and surveys. They have previously completed an indoor monitoring study using PurpleAir sensors that quantified overall IAQ and the infiltration of outdoor PM2.5 into indoor residences across single-room occupancy hotels in San Francisco and investigated modifiable behaviors that may impact IAQ. Study staff worked with Single Room Occupancy (SRO) Tenant Leaders to recruit participants, and installed a PurpleAir sensor with each resident that was matched to an outdoor PurpleAir sensor. This prior experience motivates the proposed study framework to both quantify the impact of air cleaners on IAQ and health improvements and understand how to increase their usage and effectiveness.

The subcontractors are also well qualified. UCSF is the leading UC institution for health-related research and has previously conducted studies that follow the proposed work here. BVHP Community Advocates and Brightline Defense are essential for the success of this study and approximately a third of the budget is allocated to these organizations. Without their expertise in community organizing, outreach, and education, along with their deep ties to the BVHP community, it will not be possible to effectively engage with the community and recruit participants.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this proposal for a total amount not to exceed $850,000, subject to any changes and additions specified by the Committee.

Item No.: II.3
Date: November 15, 2024
Proposal No.: 2886-314

Staff Evaluation of a New Research Project

Title:	HEAT – Health Equity and Adaptation to Extreme Temperature
Contractor:	University of California, Merced
Subcontractor:	Stanford University
Principal Investigator:	Sandie Ha, Ph.D.
Budget:	$600,000
Contract Term:	36 Months

For further information, please contact Dr. Barbara Weller at (916) 277-0971 or *Barbara.Weller@arb.ca.gov*

I. Summary

Extreme heat is a significant consequence of climate change, and its effects vary greatly across California's regions and communities. Several state agencies and programs provide funding to support heat adaptation strategies aimed at fostering more resilient communities; however there is limited information on the specific health impacts of these local actions. To better inform CARB's climate programs and policies, a study is needed to assess the health-related impacts of community heat adaptation strategies, particularly in vulnerable communities experiencing climate health disparities. The University of California, Merced (UCM), has assembled an interdisciplinary team of university researchers and community partners to conduct this study using a community-based participatory research design. The overarching goal is to evaluate the health benefits of selected adaptation strategies for addressing rising temperatures and extreme heat in Kern County, a region with disproportionately higher climate health risks and social vulnerability. Leveraging long-standing relationships with local community partners, the project will develop the research plan and select a heat adaptation strategy for a case study. This case study will quantitatively estimate health benefits (such as improved birth outcomes, reduced emergency department visits for cardiopulmonary diseases, and decreased heat-related illnesses) resulting from the heat intervention strategy. If feasible, the project will also assess additional co-benefits, such as reduced energy costs, and explore interactions with other interventions. Collaborating with community partners,

methods will then be used to ground-truth these health benefits by incorporating the perspectives of the community residents on the heat adaptation strategy, employing both qualitative and quantitative research methods (e.g., survey, interview, focus groups). Furthermore, the project will include an evaluation of the cost-effectiveness of the intervention by analyzing the economic impacts of the population-level health outcomes alongside the costs of implementation. The team will develop both community-specific and state-level recommendations based on their findings, guiding future directions and investment in the relevant heat adaptation strategies. Finally, the results of this project will be disseminated through a variety of formats tailored to different audiences, including communities, government agencies, and researchers. The insights gained from this project will help the state prioritize local heat adaptation strategies that maximize health benefits while addressing the needs of vulnerable and priority communities across California.

II. Technical Summary

Objective

The project's overarching goal is to quantitatively assess the health benefits and related impacts of selected heat adaptation strategies among populations at risk of health disparities in Kern County (such as low-income groups, older adults, and racial and ethnic minorities) and to ground-truth these benefits through a combination of quantitative and qualitative methods, incorporating community input.

Background

California is making major efforts to address the growing challenges posed by climate change, including more frequent and prolonged periods of extreme heat. Several state agencies and programs, such as California Climate Investments, are providing funding for heat adaptation strategies aimed at reducing heat impacts and building climate-resilient communities. These heat-risk reduction efforts are particularly important in overburdened communities that are disproportionately affected by climate change. While there are state-level estimates of health benefits from some heat reduction strategies, a comprehensive look at local benefits of specific measures, including the community perspectives and benefits, has not yet been conducted.

Heat exposure directly affects human health and can worsen pre-existing conditions, especially in vulnerable and disadvantaged populations. Kern County is a priority area for addressing rising temperatures and extreme heat due to its higher rates of mortality and health disparities compared to state averages, its socially vulnerable populations, and a significant number of residents lacking proper air conditioning. Although initiatives like cooling centers, sheltered transit stops, heat alerts, and tree canopy programs have been implemented, it remains unclear whether the community is aware of these strategies and how effective they have been in mitigating heat-related health issues and disparities.

In response, UCM has assembled an interdisciplinary team of university researchers to collaborate with community partners (including MLKCommUNITY Initiative, American Cancer Society, Central California Public Health Consortium, and AgSafe) on a community-based participatory research project. This project will provide valuable insights into the effectiveness of local heat adaptation strategies in reducing heat-related health risks and disparities. It will highlight the health benefits, economic impacts, and community perspectives related to the implementation of these strategies. The findings will inform CARB's climate programs, helping to improve the effectiveness of heat adaptation efforts and enhance community resilience to extreme heat, particularly for populations most at risk.

Proposal Summary

Task 1. Co-Develop the Overall Research Project Plan and Specific Case Studies by Investigators and Community Partners

Given the nature of community-based participatory research, the investigators will collaborate closely with community partners, with whom they have built long-standing relationships, to co-develop a research plan for this project. Together, the investigators and community partners (the Project Team) will engage in trust-building and capacity-building activities, following equity-based collaboration principles, to identify heat adaptation strategies for evaluation. The strategies will be selected through a structured approach based on established criteria and eligibility requirements. CARB liaisons will actively participate in the process and assist the Project Team in identifying appropriate heat adaptation strategies. Once the Project Team has collectively agreed on the heat adaptation strategy(ies), the investigators will lead the development of an evaluation plan. This will include the analysis of

health benefits and associated impacts (detailed in Task 2), the ground-truthing process (detailed in Task 3), the estimation of cost-effectiveness (detailed in Task 4), and corresponding recommendations on heat adaptation strategies (detailed in Task 5). The Contractors and community partners will review the community engagement process across all project tasks to ensure effective collaboration and identify areas for improvement, further strengthening their long-term relationship.

To illustrate the methodology outlined in the following tasks, the cooling center initiative will serve as an example.

Key Deliverables: A comprehensive work plan outlining community engagement activities, evaluation methods, and communication and dissemination strategies.

Task 2. Estimate the Health Benefits of the Heat Adaptation Strategies

The project will develop a quantitative estimate of the health benefits of the heat adaptation strategy using an interrupted time series design, comparing rates of various health outcomes before and after the intervention during a potential timeframe of 2019-2023 (depending on the intervention and data availability). Health outcomes across the lifespan—including preterm birth, emergency department visits, and hospitalizations related to asthma, cardiovascular diseases, psychiatric outcomes, and heat-related illnesses—will be obtained from the California Office of Vital Statistics and the California Office of Health Care Access and Information. Data on outdoor temperatures, heat events (e.g., heat days and heatwaves), and potential confounders (e.g., air pollution) will be drawn from regional regulatory monitors, supplemented by the PurpleAir Citizen Science monitor network. The analysis will compare zip-code-level rates of specific health outcomes during the warm season (April-October) and during heat events before and after the intervention. Multiple metrics and cut-offs for heat day and heatwave definitions will be explored to inform policy decisions.

Poisson regression models will be utilized to estimate pre- and post-intervention differences in the quantitative estimates of various health endpoints and heat indicators. These models will also account for potential neighborhood effects (e.g., proximity to cooling centers in the case where cooling centers are the intervention selected), other accessibility measures (e.g., hours of operation), and lag effects. Additionally, the project will include analyses by various

socioeconomic indicators at both the individual and community levels (e.g., CalEnviroScreen scores).

Key Deliverables: A detailed report documenting the approach and study findings, including the estimated health benefits and associated impacts of the selected intervention.

Task 3. Ground-truth the Health Benefits of the Heat Adaptation Strategies and Assess Community Perspectives

The investigators will employ both qualitative and quantitative methods, such as key informant interviews, focus groups, and community surveys, to ground-truth the health benefits and associated impacts of the selected intervention. The ground-truthing activities will focus on:

a) Determining the extent to which the intervention is functioning as planned;
b) Evaluating community members' knowledge, behaviors, and attitudes towards the intervention; and
c) Identifying and measuring the health benefits, co-benefits and any unintended consequences, as well as their impacts on health disparities for the intervention selected.

Quantitative data will be analyzed using regression models, while qualitative data will be conducted using content analysis to systematically transform text into well-organized summaries of key findings.

Key Deliverables: The findings from the ground-truthing activities, including aggregated survey data and key themes emerging from the qualitative and quantitative data.

Task 4: Perform Cost-Effectiveness Analysis of the Heat Adaptation Strategies.

Incorporating results from Tasks 1 to 3, UCM will conduct a cost-effectiveness analysis of the selected intervention using microsimulation models. These models, widely used in public health, simulate individual behaviors, preferences, and health outcomes over time, enabling the quantification of the population-level health impact (e.g., disability-adjusted life years [DALY]) of the intervention across a range of scenarios. The analysis will proceed in the following steps:

a) Creating a baseline scenario using demographic data to calculate accumulated DALYs without the intervention;

b) Integrating intervention scenarios using estimated health impacts for various health endpoints from Task 2 to calculate accumulated DALYs attributable to the intervention; and

c) Assessing the cost-effectiveness of the intervention by simulating different behavioral responses (informed by data from Task 3).

Key Deliverables: A written summary of the simulation methods and results will be provided, including extensive sensitivity analyses related to the cost-effectiveness analysis.

Task 5. Recommend Heat Adaptation Strategies in Response to Health Benefits and Community Perspectives

Based on the findings from Tasks 1 to 4, the Project Team will develop recommendations tailored to both the community and the state level, focusing on the selected intervention's health outcomes at both levels and implications for development of future heat adaptation projects. These recommendations can inform future directions and investments in heat adaptation strategies. Additionally, the investigators will suggest approaches for ongoing, systematic, and sustainable ground-truthing activities (such as employing community members to monitor cooling center usage and hours of operation) ensuring consistent monitoring over time.

Key Deliverables: An overview of the benefits of the selected intervention, along with recommendations for informing, prioritizing, and implementing heat adaptation strategies that maximize health benefits and address the needs of the community.

Task 6. Disseminate and Translate Research Findings

The Contractors will submit quarterly progress reports, a final report with associated data, and all data analysis results to CARB. Furthermore, they will create a one-page project summary and plain-language fact sheets summarizing scientific publications for use in public outreach.

III. Staff Comments

A research concept to evaluate the health benefits of extreme heat adaptation strategies using a community-based approach was proposed and subsequently developed into a detailed scope of work for the CARB Fiscal Year 2024-2025 Research Project Solicitation, directed to the Universities of California or California State Universities. This team of investigators was selected to move from preproposal to full proposal development because the preproposal was well aligned with CARB's suggested scope of work. CARB collaborated closely with partner agencies, including CDPH and the California Office of Environmental Health Hazard Assessment, to review the research concept, preproposals, and the full proposal. Reviewers' feedback primarily focused on clarifications, particularly the need for more detailed technical information and clearer definitions of the roles of community partners. These comments have been addressed in the current proposal.

In the current version of the project, the Prime Contractor (UCM) will oversee the entire project and take primary responsibility for Task 2, which involves analyzing health benefits. The Subcontractor (Stanford) will lead the remaining tasks (Tasks 1, 3, 4, and 5) focused on community engagement, leveraging their long-standing relationship with the community partners. While the Prime Contractor will co-lead Tasks 1, 3, 4, and 5 alongside the Sub-Contractor, there is an imbalance in budget allocations—41% for the Prime Contractor and 59% for the Sub-Contractor due to the funding allocated through Stanford to community partners.—CARB has discussed this issue with both the Prime Contractor and Sub-Contractor, and it's understood that the budget imbalance is necessary, particularly for reimbursing the community partners. Since the community partners have a long-standing relationship with the Stanford PIs and are already set up with Stanford as a subcontractor, using Stanford's established institutional mechanisms for timely payments and administrative management minimizes the burden on community partners. This approach aligns with the equity principles that the proposal seeks to address.

Investigator Qualifications

The PI, Sandie Ha PhD, MPH, is an Associate Professor of Department of Public Health, UCM. Dr. Ha's research focuses on studying how various environmental exposures (e.g., air pollution, extreme temperature, pesticides) affect pregnancy and perinatal health outcomes

including but not limited to gestational complications, stillbirth, preterm birth, and birth defects. Her other research interests include cardiovascular complications, asthma, cancer, and health disparity. Dr. Ha has conducted extensive research on how various climate change indicators (including heat) impact health across the lifespan.

The Co-PI, Manali Patel, MD, MPH, MS, Fellow of the American Society of Oncology (FASCO), is an Associate Professor at Stanford University in the Division of Oncology. She is a health services researcher and directs a research program that focuses on improving equitable delivery of value-based health care. She uses principles of community-based participatory research and healthcare redesign in her work. Dr. Patel will lead the community engagement activities for this project, including fostering and maintaining partnerships, heading the Community Advisory Boards, and conducting ground-truthing analyses.

Staff believes that the PI and co-PI's expertise in environmental epidemiology and community engagement, along with their established collaborations with community partners- MLKCommUNITY Initiative, American Cancer Society, Central California Public Health Consortium, and AgSafe, make them well-qualified to lead this community-collaborative research project.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this proposal for a total amount not to exceed $600,000, subject to any changes and additions specified by the Committee.

Item No.: II.4
Date: November 15, 2024
Proposal No.: 2887-314

Staff Evaluation of a New Research Project

Title:	Quantifying Greenspace Impacts on Human Health and Ecosystem Services in California
Contractor:	University of California, Davis
Principal Investigator:	Peter James, ScD
Budget:	$697,493
Contract Term:	24 Months

For further information, please contact Dr. Barbara Weller at (916) 277-0971 or *Barbara.Weller@arb.ca.gov*

I. Summary

Urban greening is a key action included in CARB's Scoping Plan to achieve net-zero greenhouse gas emissions, and increasing urban forests is one strategy to achieve this goal. In addition to their role in reducing greenhouse gas emissions, urban green spaces provide a variety of health and ecosystem service benefits to the communities of California. However, urban greenness is not distributed equally, and vulnerable communities and communities of color have less access to green space, as demonstrated in the qualitative analysis in the Scoping Plan. Preliminary research funded by CARB examined the health benefits of urban greenness and found substantial health benefits. This current proposal will use open access databases to develop a tool to quantify the human health and ecosystem service benefits of greenspaces, as well as economic impacts including the differential impacts in vulnerable communities. This tool will be able to analyze the impact of current levels of urban greening and future projections of urban greening at the state, regional, and possibly at the local level. This study will support CARB's Nature-Based Solution programs to increase green space in California communities, such as through street, neighborhood, and schoolyard greening efforts, including those related to Assembly Bill (AB) 1757 which is designed to increase nature-based solutions. This project will be developed in close collaboration with the staff of CARB and will also be informed by engagement with a Community Advisory Group (CAG).

II. Technical Summary

Objective

The objectives of this proposal are to create a repeatable and transferable process using remotely sensed data that will: 1) quantify the health benefits of greenspaces, including economic impacts; 2) quantify the ecosystem services benefits of greenspaces, including downstream economic impacts; and 3) estimate how the benefits of greenspace impact vulnerable communities. The study will develop methodologies that can be applied to both current levels of urban greenness and future projections of urban greening under climate change to assess the health benefits and ecosystem service benefits at the state, regional, and possibly local level. The project will result in a spatially defined tool CARB staff can update and continue using for future assessments of health impacts, ecosystem service impacts, and their respective economic impacts under different greening scenarios.

Background

Research increasingly indicates that greenspaces may benefit health by reducing exposures to air pollution, noise, and extreme heat and mitigating the impacts of these exposures on health. Additionally, greenspaces promote physical activity, encourage social interaction, reduce stress, and restore cognition. Substantial evidence suggests that greenspaces provide ecosystem services benefits, including cooling and energy savings, carbon sequestration, stormwater runoff control, and reductions in air pollution. Collectively, these health and ecosystem benefits may have substantial economic impacts on the state. However, there are still large knowledge gaps in quantifying how changing greenspaces are related to changes in both human health and ecosystem services, as well as the potential economic benefits impacts of these changes. Moreover, greenspace is not equally distributed, and underserved and overburdened communities may obtain greater benefits from greenspaces.

Prior research from CARB has estimated that increasing greenspace statewide could lead to large benefits for health; however, these analyses were limited using non-specific satellite vegetation indices. More work is required to quantify urban greenspaces based on typologies, numbers of trees, access, location, and tree canopy cover metrics. These future analyses are fundamental to meet CARB's urban greenspace modeling needs. Furthermore,

linking these novel greenspace metrics to underserved communities will aid CARB in estimating health equity concerns related to greenspace.

In response, this project will develop methodologies to fill these gaps in quantifying the human health and ecosystem service benefits of greenspaces and to support CARB's Nature-Based Solution programs to equitably increase greenspace in California communities. These methodologies will be able to be applied to both current levels of urban greenness and future projections of urban greening under climate change to assess the health benefits and ecosystem service benefits at the state, regional, and possibly local level.

Proposal Summary

Task 1. Development of a Work Plan for the Study

The research team will work with both CARB and the Community Advisory Group in the development of this work plan. This work plan will include all aspects of the project including overall analysis of the project, data sets for health and ecosystem services, methods for quantifying health and ecosystem service benefits and economic quantification of such benefits. The datasets to be used and the methods need to be transferable and open access for staff to be able to continue to use this tool in the future.

Key Deliverables: A complete work plan for the study will be developed in consultation with CARB staff and with input from the CAG to include the study design and all aspects of this study.

Task 2. Literature Review of the Health Impacts of Greenness and the Methods used to Quantify Health Benefits

The research team will conduct a systematic search of the greenspace and health literature. Researchers will summarize study findings, including but not limited to those from CARB-funded projects, and will annotate the methodologies applied across studies. Close attention will be paid to exposure assessment, to ensure that the most accurate and specific metrics of greenspace exposure have been identified. Findings will be summarized for important vulnerable subgroups, including age groups, race/ethnicity, neighborhood SES, linguistic isolation, and urbanicity/population density.

Key Deliverables: Comprehensive reviews of the literature on the health impacts of greenness and the methodology and tools currently used to quantify the health benefits of greenness.

Task 3. Data Collection for Exposure and Health Impact Analysis

The researchers have collected large scale spatial exposure data including high resolution remote sensing data on landcover classification and statewide individual tree monitoring maps. A clear methodology for the development of exposure assessment using open-source data will be completed. Data used will be collected in collaboration with CARB staff and using a current CARB project with the California Natural Resources Agency and the National Aeronautics and Space Administration. Detailed information on remote sensing data and how this data will be incorporated into this project and what spatial deliverables will result directly from incorporating this remote sensing data will be provided.

The researchers also have access to a large amount of health data, which may include mortality data, hospital and emergency room visits, and birth outcomes data. The project will provide a clear, comprehensive plan of how all the variables/attributes will be synthesized and fit together to conduct the health analysis.

Key Deliverables: An easy-to-use dataset of all relevant data needed to perform all aspects of the exposure and health benefits analysis.

Task 4. Development of Methodology to Quantify Health Benefits of Current and Future Urban Green Space Levels in California

The greenness layers for current levels of tree canopy will be mapped at a high resolution using a variety of datasets, including remote sensing data. Then the project will develop dose response functions, for health outcomes using current health data and the mapped greenness layers. These dose response relationships can then be used to calculate the impacts of future projections of greenness. CARB staff will work with the investigators to select the final health outcomes to be used based on the resolution of the health data set to be used, and the ability of the datasets to account for differences by race and ethnicity. The health points to be studied could include mortality, life expectancy and birth outcomes, and confounding factors will be accounted for in the analysis. The economic valuation will be

conducted for the project, such as cost of illness and loss of productivity. The team will build on previous work to estimate the changes in health outcomes from different urban green space scenarios in California. The methodology will provide health impacts by racial/ethnic subgroups in addition to population averages. The methodology will include an analysis of the health impacts of greenness at a fine spatial scale if possible that can provide information on the distribution of impacts in vulnerable communities to identify areas that can most benefit from increased greenness. The methodology will be developed for application at a statewide, regional, and possibly local level. The methods developed will be designed to assist staff in calculating the health and economic benefits of increased greenness and will not be a public facing tool.

Key Deliverables: A method to quantify health impacts for current and projected levels of greenness by racial/ethnic subgroup to the extent possible. The method will also include calculation of the economic benefits to health. These methods will be able to assess effects statewide, regionally, and possibly locally and will be used to analyze the distribution of impacts in vulnerable communities in California.

Task 5: Quantification of Health Benefits for Current and Future Projected Levels of Greenness in California

Using the methods developed in Task 4, the investigators will calculate the health and economic benefits of both current and future projected levels of greenness in California. The benefits will be calculated, both statewide and for regional and possibly local areas of the state and will be calculated annually. The specific years to be analyzed and the scenarios for greenness used will be determined through collaboration with CARB staff. The project will provide details regarding how the future projection modeling will work, including model inputs and outputs, processing required, what drivers of change are included, and other details that will show the modeling satisfies CARB's needs.

Key Deliverables: Quantification of the health and economic benefits for both current and future projected levels of urban green space in California at the statewide, regional, and local level and for vulnerable communities for the years and scenarios specified by CARB staff.

Task 6. Literature Review on Ecosystem Service Benefits for Greenness and the Methods Used to Evaluate Them

The research team will conduct a systematic review of the literature on ecosystem services for greenspace and various outcomes related to greenspace, including carbon sequestration, reducing air pollution, energy use reduction, reduction of urban heat island and the promotion of local biodiversity limited to plant and tree species. The ecosystems that have the largest, quantifiable economic and social impacts will be prioritized. Tools and techniques used to quantify and qualify ecosystem benefits from greenspace in California, including possible impacts to priority communities, will be reviewed.

Key Deliverables: A comprehensive literature review on the ecosystem impacts and the methodology and tools currently used or available for future use to quantify and/or qualify the benefits of greenness and to assist in the development of the methodology for the project will be completed.

Task 7. Collection and Analysis of Data for Ecosystem Service Benefits

The researchers will provide and describe a plan for data and analysis aspect of the ecosystem service benefits. The team will narrow the scope to ecosystem services with the largest, quantifiable economic and social impacts, such as air pollution impacts, heat island reduction (energy savings), and impacts on heat-related illnesses (avoided health costs). Other ecosystem services can be included, but a direct plan for spatially quantifying impact and economic impact will be provided. The impacts to be evaluated and necessary data will be developed in collaboration with CARB staff.

Key Deliverables: Easy-to-use datasets and analyses to evaluate ecosystem service impacts using quantitative tools will be provided.

Task 8: Development of Ecosystem Services Analysis Methods

This task will result in development of methods to evaluate the selected ecosystem service benefits with the largest, quantifiable economic and social impacts. Methods will need to be adaptable to allow an assessment of the benefits for both current levels of greenness and for future projected levels of urban greenness in California. These methods will be able to assess effects statewide, regionally, and possibly locally. The methods will also be used to analyze

the benefits within vulnerable communities and between vulnerable communities and other communities in a spatially and temporally explicit way.

Key Deliverables: Deliverables will include quantitative methods to evaluate selected ecosystem services benefits and economic outcomes for impacts. Methods, including necessary code, will be well documented, open, transparent, and reproducible.

Task 9: Assessment of Ecosystem Service Benefits

Using the analytical methods developed in Task 8, the Project Team will quantify the selected ecosystem service benefits for both current and future levels of greenness. The spatial scale to be used for this analysis will be decided in consultation with CARB staff. The assessment of ecosystem services, including their economic impact, should also be quantified via future greenness projection modeling, so that analysis is consistent throughout the proposal.

Key Deliverables: A quantitative analysis of selected ecosystem service benefits for both current and future projected levels of urban green space in California will be completed. The future scenarios and years to be assessed will be determined through collaboration with CARB staff and will be at the statewide, regional, and possibly local levels. The deliverable will include an analysis of the distribution of benefits within vulnerable communities and between vulnerable communities and other communities.

Task 10: Community Focused Advisory Group

A CAG of six (6) to eight (8) individuals will be recruited in collaboration with the UC Davis Center Towards Health, Resilience and Environmental Equity (THREE) Community Engagement Core to expand the expertise of the research team, in particular in the areas of equity-oriented research methodologies, ground truthing of health and ecosystems services modeling, modeling for equitable benefits distribution, and research-to-policy and community action translation.

Key Deliverables: The Advisors will provide comments on the methodology and the workplan and on the results of the study to be included in the final report.

Task 11: Meeting, Reporting, Methods Transfer, and Preparation of Draft and Final Report

The team will work closely with CARB staff on all tasks, meeting regularly and providing appropriate deliverables before moving onto the next Task. The team will share all code, documentation, and analyses with CARB staff. In addition, all data and code necessary to update the methods will be provided to CARB staff in clean, understandable, and well documented formats with the appropriate tutorials and meta-data.

Key deliverables: The contractor will ensure successful execution of the methods developed during this contract on CARB IT systems. A draft final report will be due 6 months before the end of the project and will be reviewed and modified according to input by CARB staff.

III. Staff Comments

A research concept to quantifying greenspace impacts on human health and ecosystem services in California was proposed and subsequently developed into a detailed scope of work for the CARB Fiscal Year 2024-2025 Research Project Solicitation, directed to the Universities of California or California State Universities. This team of investigators was selected to move from preproposal to full proposal development because the preproposal was well aligned with CARB's suggested scope of work. CARB collaborated closely with other agencies, including the California Department of Public Health and the California Office of Environmental Health Hazard Assessment, to review the research concept, preproposals, and the full proposal. Reviewers' feedback primarily focused on the major gaps in information needed, particularly on the ecosystem benefit, economic analysis, future modelling, remote sensing data and health outcome analysis. We received a revised version of the proposal that will be extensively reviewed before the RSC meeting and results of this review will be presented. Below are comments that have been at least partially addressed in the revised proposal.

- Development of a work plan which was added as a task
- Increased specificity was provided on the ecosystem benefits including a plan for data and analysis aspect of the project and narrowing the scope to ecosystem services with the largest, quantifiable economic and social impacts, such as air pollution and heat impacts

- More detail was provided on the health analysis and the economic analysis
- Concerns on green space mapping issues, such as access to the space by the public, were discussed, and more detail on how the greenness maps will be developed from the many datasets mentioned was included.
- The role of biodiversity was redefined within the scope of the project to plant and tree species.

While additional information was provided, some questions remain in the following areas:

- While some additional detail was provided, more detail regarding how the future projection modeling will work, including model inputs and outputs, processing required and drivers of change could be added.
- Some information on remote sensing datasets was included but more detail on the incorporation of remote sensing data in this project and what spatial deliverables will result directly from incorporating this remote sensing data needs to be further addressed.
- The project continues to need to address open access for the data.
- More detail is needed on how this study will be built on previous work to estimate the changes in health outcomes from different urban green space scenarios in California.
- More detail has been provided but additional clarity is needed on the resolution of the health data sets to be used and which health points will be included and how the confounding factors will be handled.

Investigator Qualifications

Peter James (PI) has substantial expertise in greenspace epidemiology, including developing spatial metrics of greenspace and linking these data to large prospective cohorts to study associations with health outcomes. He has led multidisciplinary research teams developing novel metrics of greenspace and has modeled how these exposures are associated with health outcomes.

Alessandro Ossola (Co-I) is the lead of the Urban Science Lab at UC Davis with experience in research aimed at quantifying the fine-scale distribution and change of urban green spaces and tree canopy cover.

Michael Springborn (Co-I) co-leads the Natural Resource Economics (NatuRE) and Policy Lab at UC Davis conducting research at the intersection of public health, economics and ecosystems.

Irva Hertz-Picciotto (Co-I) is Director of the UCD Environmental Health Sciences Center (EHSC) THREE: Towards Health, Resilience and Environmental Equity which develops collaborative research to advance understanding of environmental contributors to health, and translation of results into policies or practices to improve public health.

Jonathan K. London (Co-I) co-directs the Community Engagement Core (CEC) of the UCD EHSC THREE and is a nationally recognized expert in Community-Based Participatory Action Research (CPBAR) in environmental health and justice.

Shosha Capps (Co-I) has experience on action-oriented, policy relevant research addressing health, access, and exposure disparities experienced by low-income communities and communities of color in California's Central Valley.

Noli Brazil (Co-I) is an Associate Professor and Vice Chair in the Department of Human Ecology at UC Davis and has extensive expertise on applying spatial data to solve problems in human health and ecology.

Staff believe that the PI and co-PI's expertise in environmental epidemiology, plant science, economics and community engagement, along with their established collaborations with community partners, THREE, make them well-qualified to lead this research project. However, staff are asking that additional experience with remote sensing be added to the team.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this proposal for a total amount not to exceed $697,493, contingent upon receipt of a proposal that incorporates all changes recommended by staff, and subject to inclusion of any changes and additions specified by the Committee.

Item No.: II.5
Date: November 15, 2024
Proposal No.: 2888-314

Staff Evaluation of a New Research Project

Title:	Assessing Health Impacts of Brake and Tire Wear Emissions in Overburdened Communities of the San Joaquin Valley
Contractor:	University of California, Berkeley
Subcontractors:	University of California, Davis University of California, Los Angeles Baylor University
Principal Investigator:	Jason Su, Ph.D.
Budget:	$850,000
Contract Term:	24 Months

For further information, please contact Dr. Barbara Weller at (916) 277-0971 or *Barbara.Weller@arb.ca.gov*.

I. Summary

Traffic-related air pollution has been a focus of CARB rules and programs due to the well-known health effects and impacts on air quality associated with vehicle pollution in California. Traffic pollution includes pollution from both tailpipe emissions as well as non-tailpipe emissions and predictions suggest that non-tailpipe sources will soon dominate both PM2.5 and PM10 traffic emissions. This is an active area of research, but the health impacts of non-tailpipe emissions such as brake and tire wear (BTW), particularly in ambient air, have not been well studied. A recent CARB funded study in Los Angeles found adverse birth outcomes associated with metals from brake and tire wear emissions, and particles were found to be more toxic in disadvantaged neighborhoods. However, metals associated with BTW can also be associated with other sources, and relying on metals alone as markers for BTW can lead to high uncertainties in the exposure assessment. The proposed study will develop methods to identify and measure exposures to BTW in ambient air with a reasonable degree of uncertainty. This study aims to assess the spatial and temporal distribution of BTW concentrations across the San Joaquin Valley (SJV) and their potential health impacts on vulnerable communities. The research will apply advanced techniques to quantify BTW

profiles and develop a high-resolution exposure model. Source profiling will be enhanced by using profiles of known brake and tire wear samples by working with CARB's ongoing and previously funded studies, and by using a sampling campaign in the region of study. Additionally, assays that measure the toxicity of the particles will be used to quantify the health risks associated with brake wear (BW) and tire wear (TW) emissions. Health analyses will be conducted by linking BW and TW concentration data to health outcomes, such as respiratory, cardiovascular and birth outcomes. The formation of a Technical Advisory Group (TAG) will ensure scientific and community engagement in the project and, along with CARB, will help to develop a work plan for the project. The results of this study will help CARB understand the impacts of BTW emissions on health, particle toxicity, and exposure disparities for areas exposed to higher level of non-tailpipe emissions.

II. Technical Summary

Objective

The objective of this study is to conduct an analysis of the exposure and health risks for brake and tire wear emissions in PM2.5 and PM10. The study will be focused on a region with overburdened communities in the SJV with high exposures to non-tailpipe pollution. The findings of this project will enhance CARB's understanding of how non-tailpipe particles affect cardiovascular, respiratory and birth outcomes in a region with overburdened communities. It will increase the understanding of the impacts of brake and tire wear particles on outdoor air and their role in particle toxicity and provide evidence for government agencies of the need to reduce such exposures through policies and programs.

Background

Traffic pollution includes gaseous pollutants and particulates from both tailpipe and non-tailpipe emissions. While tailpipe emissions have been reduced due to CARB's regulations and the increase in number of zero emission vehicles in the state, non-tailpipe emissions such as BTW have not been regulated and the adverse impacts are not well studied. BTW particles may be potentially more toxic per unit of PM2.5 mass due to their increased ability to produce oxidative stress, which has been linked to increased adverse health effects. Many overburdened communities are exposed to high levels of roadway emissions including BTW. While there have been several studies by CARB and other agencies to better understand the

chemical composition of brake and tire wear, these studies are mostly from directly sampled sources, and more study is needed to understand the impacts of BTW on ambient air exposures and health. This research need has been recognized by CARB and other organizations.

In response, this study will coordinate with and build on previous and ongoing research projects to conduct an assessment for BTW from on road emissions in ambient air, particularly in understudied areas of SJV. This study will develop methods, including sampling and modeling methods, to develop exposure profiles to BTW PM2.5 and PM10 from ambient air with a reasonable level of uncertainty, and will use these exposure profiles to determine the health risk (particularly respiratory, cardiovascular and birth outcomes) in overburdened communities with high exposures in SJV.

The research team will work in collaboration with CARB staff in developing the study methods, including a workplan for the study. The information provided by this study will inform policies and programs, including mitigation strategies to reduce the impacts of BTW, in regions with vulnerable communities in California.

Proposal Summary

Task 1. Literature Review (UCLA)

The research team will conduct a comprehensive review of BTW emissions and their contribution to air quality, expanding to include recent findings on the spatial distribution and variability of these emissions, and modeling techniques. This review will explore the differences in BTW emissions across vehicle activity data (e.g., stop-and-go traffic), vehicle type, road types, and brake characteristics, to understand their relative contributions compared to exhaust emissions. The literature review will also cover the epidemiological and toxicological literature on BTW particles and their association with specific health outcomes, particularly respiratory and cardiovascular diseases. The team will review the most recent advances in oxidative stress research and the role that the chemical composition of BTW particles plays in their varying degrees of toxicity. Studies that explore the heightened risk of exposure for vulnerable populations will be emphasized.

In addition, the team will review state-of-the-art techniques for measuring BTW particles, including advancements in receptor modeling, elemental analysis, and real-time monitoring technologies. Researchers will focus on studies that have successfully isolated BTW particles from other PM sources, providing insights into best practices for source apportionment in regions like the SJV. The review will also highlight uncertainty quantification methods in source apportionment studies and identifying gaps in existing methodologies.

This comprehensive review will ensure that the study is grounded in the latest scientific findings, providing a strong foundation for methodology, data collection, and analysis plan for the proposed study.

Key Deliverables: A completed literature review with the current scientific information on the health effects of non-exhaust emissions related to BTW particles and the methods used in exposure development.

Task 2. Development of a Workplan for the Study (UCB)

The investigators will develop a work plan in consultation with CARB staff by the end of the second quarter of the contract for the tasks to be accomplished in the study. The investigators will invite input from the TAG before the workplan is finalized. The workplan will include the following:

- Plans for convening the TAG including community and academic representatives, and who will be included in the TAC.
- The methods selected for exposure modeling for BTW and the modeling tools used to produce an exposure map for the region (Task 3) as well as limitations of those methods.
- PM2.5 and PM10 monitoring methods, locations, and duration of the sampling campaign that will inform the study.
- Methods that will ensure the chemical speciation of BTW in the study will be representative of the California BTW profile.
- The health analysis approaches and methods to be used for linking health outcomes and oxidative stress to non-tailpipe exposure for the region and overburdened

communities (Task 6), including the health outcomes to be studied and datasets to be used (Task 5).

- Limitations and uncertainties in the methods and ways to account for and correct these limitations will be an important aspect of the workplan

Key Deliverables: A complete workplan for the study will be developed in consultation with CARB staff and with input from the TAG by the end of Quarter 2 to include the study design and all aspects of this study.

Task 3. Regional exposure assessment and monitoring campaign for PM2.5 and PM10 linked to BTW emissions

The researchers will work with CARB to determine the sampling and modeling methods to characterize ambient exposure levels for PM2.5 and PM10 associated with BTW. Data for source apportionment will be processed at several sites and sources including through a main monitoring site in Fresno, from samples of known brake and tire wear from other studies, and from samples collected through a field sampling campaign across the SJV. Sampling will be conducted during the dry season and the wet season and sites will be sampled during both the dry and wet seasons to capture any seasonal variability in BTW emissions. To compare the developed source profile to known tire and brake wear source profiles, the researchers will also add PM samples from CA representative brake pads and tires and conduct a chemical speciation analysis using methodologies such as Positive Matrix Factorization (PMF) and the Multilinear Engine to develop CA unique profiles for BW and TW. Roadside deposited BW and TW and how much TW particles will be generated from asphalts will also be considered.

EMFAC model will be used to estimate BW and TW emissions. Modeling will incorporate roadway-level traffic data, vehicle types, and environmental factors such as road surface conditions, weather patterns, and vehicle braking behavior. The WRF-Chem model will provide a detailed understanding of how BW and TW concentrations vary across the SJV, contributing to a comprehensive assessment of population exposure at a high spatial resolution. Regular validation of model outputs against field measurements will ensure robustness and accuracy and sensitivity analysis will reduce error.

Key Deliverables: Development of an exposure model for the exposures to BTW in PM2.5 and PM10 particles in the study region to produce an exposure profile for the region at a 100 m resolution.

Task 4: Exposure analysis for oxidative stress levels (UCLA)

The research team will conduct a detailed analysis of the non-tailpipe PM's ability to generate reactive oxygen species and/or induce oxidative stress to determine their impact on oxidative stress in overburdened communities. Researchers will use a previously developed hydroxyl (OH) assay to analyze samples collected from high-traffic areas and sites. Following sample analysis, the team will apply the PMF source apportionment model to identify and quantify the major sources contributing to the oxidative potential of particles. PMF will be instrumental in isolating the influence of BW and TW particles from other sources and estimating their relative contribution to the oxidative stress observed. The team will correlate these findings with the oxidative stress biomarkers to evaluate how the presence of BW and TW particles affects oxidative stress levels. Statistical analyses will be performed to determine significant correlations and quantify the strength of the association between BW and TW exposure and oxidative stress.

Key Deliverables: Oxidative stress levels of the particles will be linked to the exposure profiles to see if brake and tire wear exposures are associated with oxidative stress levels across the region and in overburdened communities. The result of this analysis will be an oxidative stress profile for the region.

Task 5. Identify and secure health datasets to be linked to exposure data (UCB)

The researchers will identify health outcomes to be evaluated, including respiratory and cardiovascular hospitalizations, emergency department visits and birth outcomes, and secure needed health datasets. The researchers have previously collected emergency department visit and hospitalization data from the Health Care Access and Information for type 2 diabetes patients under another CARB-funded project and will apply for chronic respiratory and cardiovascular health endpoints for this new study. Additionally, pre-term birth and low birth weight data have been collected from CDPH for a separate CARB-funded

initiative and will be used for this study. The health outcome data needs to be in a resolution to pair with the exposure data to identify non-tailpipe emissions related health impacts.

Key Deliverables: Development of a health database for the same region covered by the exposure assessment for the health impact analysis.

Task 6. Analysis of health effects of BTW for the region and overburdened communities (UCB)

Health impact analyses will be conducted by linking high-resolution BTW concentration data to health outcomes, such as emergency department visits and hospitalizations for respiratory and cardiovascular conditions, and adverse birth outcomes like pre-term births and low birth weight. These analyses will use a case-crossover design to assess short-term impacts, and Poisson or negative binomial models will be applied to evaluate hospitalization duration. Logistic regression models will be used to study preterm birth and low birth weight. The investigators will quantify the associations and produce dose response functions for the region and for overburdened communities in the region.

Key Deliverables: The investigators will produce quantified results for the health impacts of non-tailpipe emissions in the region and in overburdened communities.

Task 7. Technical Advisory Group and Community Engagement (UCB)

The research team will establish a TAG to provide expert guidance and ensure the success of the study. The TAG will consist of five (5) members, equally divided between community representatives and academic experts specializing in brake and tire wear research. At the beginning of the project, the TAG will convene to review and offer recommendations on the study's design and workplan, including methodologies for exposure assessment and health analysis. The TAG will reconvene later in the project to discuss preliminary research findings and provide feedback. In addition, community meetings and lay person outreach material will contribute to the community involvement in the study.

Key Deliverables: The TAG will provide comments and input on the methodology and on the results of the study and community outreach will inform the contract methods and goals and will be included in the final report.

Task 8. Meeting, reporting, preparation of draft final report (All)

The team will work closely with CARB to develop the project and will have meetings with CARB on an as needed basis to develop and conduct the research. Quarterly progress reports to CARB will be submitted detailing the project's status, advancements, and any challenges encountered. The researchers will prepare a draft final report, which will include a comprehensive section on methodological limitations. Additionally, the researchers will organize a lay-oriented kickoff meeting and a lay-oriented review of findings to engage the community. A lay-oriented fact sheet summarizing the project's findings will also be prepared to ensure clear communication with the broader public.

Key Deliverables: Submission of a quarterly progress report, final report with associated data, and all data analysis results to CARB. Interim deliverables will be produced annually to track and report on project progress.

III. Staff Comments

A research concept to assess the health impacts of brake and tire wear emissions in overburdened communities of the San Joaquin was proposed and subsequently developed into a detailed scope of work for the CARB Fiscal Year 2024-2025 Research Project Solicitation, directed to the Universities of California or California State Universities. This team of investigators was selected to move from preproposal to full proposal development because the preproposal was well aligned with CARB's suggested scope of work. CARB will collaborate closely with the investigators in the development and progress of this research project. The California Office of Environmental Health Hazard Assessment has assisted in the review of the research concept, preproposals, and the full proposal. Reviewers' feedback primarily focused on clarifications, particularly sampling process, analysis of filters and more detail on health analysis. Below are comments that will be addressed in the revised proposal.

Major comments include the following recommendations:

- Analysis of filters from Soot Particle Aerosol Mass Spectrometer (SP-AMS) and concerns about the process of using SP-AMS and how to reconcile the chemical composition profiles from collected filters to those measured with the SP-AMS

- More detail on the health analysis is needed, including the specific health endpoints to be studied
- Details of the methods to be used in the development of the exposure profiles and the methods to account for and control uncertainty in the models will be provided

Investigator Qualifications

The PI, Dr. Jason Su brings together a diverse array of expertise in environmental health, air pollution modeling, and community engagement, and is well-qualified to tackle the challenges of this project. Dr. Su's research group is at the forefront of spatiotemporal air pollution modeling, and a key focus of his research is identifying health disparities among the most impacted communities, ensuring that those who are disproportionately affected by pollution are prioritized in health assessments.

Co-Is, Dr. Michael Jerrett and Dr. Yifang Zhu, both esteemed researchers in environmental health, bring extensive experience in monitoring design and lab analysis.

Co-I, Dr. Suzanne Paulson, a leading expert in studying the oxidative stress potential of particulate matter, including those from tire and brake wear, adds another critical dimension to the team.

Co-I, Dr. Qi Zhang, a recognized expert in source apportionment with direct experience in Fresno, will lead the project's efforts to accurately identify and attribute sources of air pollution of BTW emissions.

Co-I, Dr. Yang Li's expertise in WRF-Chem modeling will be instrumental in simulating the dispersion, transport, and chemical transformations of BTW pollutants.

In addition to academic expertise, the team is deeply committed to community engagement and equity. Tim Tyner, Co-Executive Director of the CCAC, brings a wealth of experience in environmental equity programs and community-based research.

Staff believes that the PI and Co-PI's expertise in environmental health, modeling, and community engagement, along with their established collaborations with community partners CCAC make them well-qualified to lead this research project.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this proposal for a total amount not to exceed $850,000, subject to any changes and additions specified by CARB staff and the Committee

Item No.: III.1
Date: November 15, 2024
Contract No.: 22STC017

Staff Evaluation of a Draft Final Report

Title:	Understanding Travel Demand and Built Environment Factors to Optimize Increased ZEV Access in Underserved Communities
Contractor:	University of California, Davis
Principal Investigator:	Scott Hardman, Ph.D. Jesus Barajas, Ph.D.
Budget:	$599,978
Contract Term:	31 Months

For further information, please contact Natalie Reavey at (279) 895-5683 or *Natalie.Reavey@arb.ca.gov*

I. Summary

CARB creates and implements regulations and other policies designed to increase zero-emission vehicle (ZEV) sales in California. CARB also administers programs intended to reduce the number of miles people drive to reduce pollution from transportation. The objective of this research is to increase CARB's understanding of the transportation needs of underserved communities and how ZEVs can cost-effectively meet these needs. It also looks at how CARB can refine existing programs or develop new ones to benefit these communities. Finally, this research project will inform CARB on how additional policies can address available housing stock and infrastructure that, if not addressed, can limit how ZEVs can work for these communities.

Problem Statement

To date, new light-duty ZEVs have largely been bought by higher-income, single-family home-owning households. Growing the ZEV market to meet the Governor's Executive Order N-79-20 goal of 100% ZEV sales by 2035 and achieving the long-term air quality and climate goals will require expanding ZEV access and usage to all California drivers. Accelerating this access to historically underserved communities is especially important to ensure that those

communities can enjoy the air quality benefits of these vehicles and have access to economic opportunities that may become available with improved transportation options.

Objective/methods

To investigate travel demand and built environment factors to optimize increased ZEV access in underserved communities in California, the Contractor:

- Assembled an advisory committee of organizations working in transportation and equity including community-based organizations.
- Held seven (7) community listening sessions in two (2) underserved communities in California.
- Collected primary data from residents of underserved communities in California using a survey administered via mail and online.
- Analyzed data using descriptive statistics and statistical models. Analysis included investigating variation between and within regions.
- Compiled findings in a report, policy brief, and presentations that include policy recommendations.

This research includes one of the first large-scale surveys to randomly sample households in California's priority populations (i.e., disadvantaged communities, low-income tracts, and tribal census tracts) to understand their specific issues related to ZEV adoption. Previous research had not focused on this population in such a comprehensive manner, making this study unique in its approach to targeting and analyzing underserved communities.

The research also used both qualitative (listening sessions) and quantitative (statewide survey) methods to gather data. This combination allows for a more in-depth understanding of the transportation needs and perceptions of underserved communities, as well as the potential policy interventions to increase ZEV adoption. This mixed-methods approach adds a layer of contextual richness and helps bridge the gap between individual lived experiences and broader statistical trends.

Actual Results for Final Reports

Below are the key findings from this research project:

- Perceptions of ZEVs in Underserved Communities can be Improved with Targeted Education Efforts: Negative perceptions of ZEVs are still prevalent in underserved communities, primarily due to high costs, limited charging infrastructure, and lack of knowledge about ZEV benefits. However, what's new is the finding that as knowledge of ZEVs increases, perceptions about some barriers—such as driving range—improve. This suggests that targeted education efforts could help reduce some of the perceived barriers to ZEV adoption.
- Home Charging as a Key Barrier: Lack of home charging infrastructure, especially for people living in apartments, condos, or rented homes, is a significant barrier to ZEV adoption. It finds that home or workplace charging is far more influential on ZEV consideration than public charging infrastructure alone. This underscores the critical need for charging solutions tailored to multi-unit dwellings and renters, which has been underemphasized in previous studies.
- Home Type and Ownership Play a Bigger Role in ZEV Uptake: Home type and ownership (such as renting versus owning) play a bigger role in ZEV adoption than the geographic location (urban versus rural). While rural households are currently less likely to adopt ZEVs, they could become equally likely as urban households in the future, suggesting that rural areas may become more viable markets for ZEVs with the right policy interventions. This challenges assumptions that rural areas are inherently less suitable for ZEV adoption.
- Importance of Tailoring Policy Interventions: Existing programs and policies, which often focus on geographic areas like disadvantaged census tracts, may need to be restructured to target specific household characteristics (e.g., income level, housing type, and vehicle ownership). This is a shift from previous strategies that predominantly targeted regions based on census tract data alone.
- Low Engagement from the Lowest-income Households: The lowest-income households, while eligible for many ZEV incentives, tend to be unengaged with ZEVs. They exhibit neutral or minimal interest, suggesting that financial incentives alone may

not be enough. This highlights the need for more robust outreach and engagement strategies tailored to these populations.

Regulatory or Policy Implications

There are many policies and programs in California designed to increase ZEV access in priority populations. Many of the policy recommendations relate to continuing, expanding, and/or improving these existing efforts. The policy recommendations include:

Charging infrastructure access:

- Increase access at home and work as primary locations for charging.
- Continue and expand programs that offer incentives, funding, or install charging at people's homes.
- Provide home charging incentives at point of payment for charging installation and cover all costs associated with home charging installation (including panel upgrades, charging equipment, and installation costs).
- Expand programs that allow the right to install charging by including more dwelling types, parking situations, and homes with rent control.
- Explore establishing a program that allows priority population households to request charging installation if they own a ZEV or are considering one.
- Explore introducing minimum requirements for installation of ZEV charging at existing buildings.
- Continue and expand programs that provide incentives (e.g., charging cards) that offset charging costs, especially for households that cannot charge at home.
- Continually fund infrastructure programs, i.e., identify sustainable and continuous sources of funding such that there are no gaps in funding for priority populations.

Incentives:

- Continue to provide incentives that offset upfront cost of ZEVs for priority households.
- Continually provide incentives (i.e., identify sustainable and continuous sources of funding such that there are not gaps in funding for priority populations).
- Reduce the administrative burden of incentive applications and continue to fund programs that assist consumers in navigating the application processes.

- Make program design decisions based on data, including program evaluation surveys and the data from other projects. Explore returning to the prior 400% of the Federal Poverty Level (FPL) rather than the 300% FPL criteria for the Clean Cars 4 All (CC4A) program to include more low-income households whose purchase is dependent on incentives.
- Explore expanding the availability of incentives to sales that occur outside of dealerships.

Engagement:

- Continue and expand funding for programs and organizations that engage with communities.
- Continue and expand funding to support education and awareness about ZEVs and ZEV incentive programs.

Supply side issues:

- Lengthen and increase mileage limits of ZEV warranties (e.g. to 10 years and 150,000 miles) to support low-income ZEV owners who may experience a battery failure. Although this may not encourage more ZEV purchases, it may reduce the risk of a ZEV being a financial burden.
- Continue and expand programs to support adoption of used ZEVs (including those outlined above) and programs that support the market for used ZEV.
- Consider programs that incentivize the sale of efficient and affordable ZEVs (e.g., through revisions to Advanced Clean Cars II (ACC2) that encourage affordable and efficient ZEVs).

II. Technical Summary

Objective

The aim of this project is to understand the mobility needs of underserved communities and understand whether and how ZEVs can cost-effectively meet those needs. To achieve this aim, the contractor conducted listening sessions (like focus groups) and an online survey, supplemented with secondary data. The sessions and survey covered mobility needs, travel behavior, perceptions of ZEVs, the impact of different interventions on increasing ZEV

consideration, and barriers to ZEV adoption. The results address the following RQs as they pertain specifically to underserved communities:

1) What are the mobility needs of underserved communities, are these being met, and how are they met? (e.g. where do they travel, by what travel mode, etc.)
2) What are households' awareness, knowledge, and perceptions of ZEVs?
3) How do attributes of ZEVs (price, range, charging time, etc.) impact the viability of their adoption?
4) How do attributes of the built environment impact ZEV viability (including house type, home charging access, public charging access, walkability, etc.)?
5) What can be done to increase ZEV adoption potential in these communities?

Background

The ACC2 rulemaking and Low Carbon Transportation Funding Plan development revealed gaps on how to optimally increase ZEV access within low-income and disadvantaged communities. In 2018, CARB staff examined barriers to clean transportation access for low-income residents pursuant to the Clean Energy and Pollution Reduction Act of 2015, Senate Bill (SB) 350 (De León, Chapter 547, Statutes of 2015). CARB also previously sponsored research on designing light-duty vehicle incentives for low- and moderate-income households that focused on household vehicle ownership patterns and travel models. Since then, increased ZEV model offerings in both the new and used vehicle markets, as well as an expansion of available infrastructure and improved vehicle characteristics, required updated research that reflects this quickly changing landscape. While CARB has recently launched several equity pilot projects such as the Clean Mobility Options Voucher Pilot Project and the Sustainable Transportation Equity Project that provide funding for community transportation needs assessments, these assessments are broader in scope and not focused on evaluating ZEV viability for these communities. Further, while other statewide travel demand surveys or vehicle market research covers the relevant topics, they typically do not include statistically significant sample sizes on the populations of interest, including lower-income households, disadvantaged communities, or those who may not currently own personal vehicles and instead rely on other transport modes.

Project Summary

This research project enhances CARB's understanding of the mobility needs of underserved communities by assessing: the extent to which a community's mobility needs may be currently unfulfilled using traditional travel demand metrics, how built environment factors may limit fulfilling these needs with ZEVs, and gaps in community's knowledge about ZEV technologies and refueling costs and opportunities. The contractor carried out six (6) tasks to complete the project.

Task 1: Assemble Project Advisory Committee

The contractor, in conjunction with CARB, assembled a committee from community-based organizations, public agencies, and non-profit organizations working on related issues in underserved communities across California. The committee provided guidance on the project methodology and deliverables.

Task 2: Develop Data Collection Methodology

The project partners, Transform and SelfHelp Enterprises, held multiple community listening sessions in low-income and racially diverse communities in the Bay Area and in the Central Valley to understand the related topics of interest from community members to inform the development of the questionnaire survey. The contractor developed the survey instrument and protocol. Surveys are necessary since the required data on ZEVs and underserved communities is not available in existing databases. The contractor identified underserved communities using California Climate Investments definition of "Priority Populations," which include households in disadvantaged communities and those in low-income communities and low-income households.

Task 3: Collect Data

The contractor surveyed a representative sample of priority populations in California spanning different geographic regions of the state as well as different types of regions (e.g., urban, suburban, rural). The survey was administered between December 2023 and June 2024 to a random sample of priority population households throughout California. The sample was randomly drawn from the USPS database and was stratified by census tract and tract priority type (disadvantaged community tracts including tribal tracts, low-income tracts, and households that are low income in non-priority tracts). The sample was stratified to ensure

a sufficient sample size from all priority tract types. Included in the draft final report is analysis of 2151 survey responses.

Task 4: Data Analysis

The analysis of interviews and survey data focused on answering three (3) research questions: 1) Are mobility needs being met in underserved communities; 2) How can ZEVs meet the mobility needs of underserved communities; and 3) What barriers exist in ZEV purchase and use in underserved communities? The contractor conducted data analysis on the survey and secondary data to understand general trends and factors associated with the questions, such as built environment, travel behavior, household characteristics, and perceptions and knowledge of ZEVs and ZEV infrastructure. The analysis investigated differences between locations (e.g., by county, city, or region), and between different socio-economic and cultural groups.

Task 5: Policy Recommendations

Working with the project partners, the project advisory committee, and CARB, the contractor drafted policy recommendations using the results from the listening sessions and data analysis. These included recommendations on ZEVs (both private and shared), and other mobility modes including transit and micromobility. These focused on how existing programs can be improved and how new initiatives could address the needs of underserved communities.

Task 6: Reports

The contractor synthesized results from Tasks 1-5 and outlined methodologies, survey results, analysis, and policy recommendations.

III. Staff Comments

Dr. Hardman and Dr. Barajas provided CARB with a draft final report on July 15, 2024. CARB staff representing the Sustainable Transportation and Communities Division, the Mobile Source Control Division, and RD, as well as staff from the California Energy Commission and the Governor's Office of Business and Economic Development, reviewed a draft final report and provided comments to Dr. Hardman and Dr. Barajas. Dr. Hardman and Dr. Barajas

provided an updated draft final report on October 4, 2024, with a summary of how staff's comments were addressed.

As one of the first large-scale surveys to randomly sample households in California's priority populations—specifically disadvantaged communities, low-income tracts, and tribal census tracts—this research project provided valuable insights into the transportation needs and barriers to ZEV adoption among underserved communities. While the findings largely align with existing knowledge, such as the findings in the SB 350 Report from 2015 Overcoming Barriers to Clean Transportation Access for Low-Income Residents, they offer important validation of key principles we have long understood. Although the conclusions may not be entirely new, the research adds value by confirming the challenges and needs of these communities.

IV. Staff Recommendations

Staff recommends the RSC recommend that CARB approve this draft final report for $599,978, subject to any changes and additions specified by the Committee.

Item No.: III.2
Date: November 15, 2024
Contract No.: 20RD004

Staff Evaluation of a Draft Final Report

Title:	Plume Capture Measurement of Vehicle Emissions at the Caldecott Tunnell for Heavy-Duty Emission Program Development and Verification
Contractor:	University of California, Berkeley
Principal Investigators:	Thomas Kirchstetter, Ph.D. Robert Harley, Ph.D.
Budget:	$449,571
Contract Term:	48 Months

For further information, please contact Dr. Seungju Yoon at (279) 842-9159 or *Seungju.Yoon@arb.ca.gov*

I. Summary

Heavy-duty diesel vehicles (HDDV) are significant sources of pollutants, such as oxides of nitrogen (NOx) and black carbon (BC), that affect air quality and human health. Despite substantial improvements in emissions from diesel vehicles with the increased use of diesel particulate filters (DPF) and selective catalytic reduction (SCR) aftertreatment systems, monitoring real-world emissions is necessary to estimate long-term changes in emission trends and evaluate the performance of aging engines and emission controls. This study tracked the final phases of California's Truck and Bus Regulation, which mandates 2010-compliant engines for heavy-duty vehicles (HDV) by 2023. Over three (3) years (2021, 2022, and 2023), three (3) field campaigns were conducted at the Caldecott Tunnel, measuring fuel-based emission factors (EF) from over 1,000 HDDVs annually. The measurements focused on BC, nitric oxide (NO), nitrogen dioxide (NO2), NOx, ammonia (NH3), and nitrous oxide (N2O). While fleet emissions continued to decrease overall, the contribution from high emitters increased, and deterioration of aftertreatment performance was observed. A small fraction of high-emitting HDDVs continued to be responsible for the majority of emissions: 10% of HDDVs were responsible for 75% NOx and 85% BC.

II. Technical Summary

Objectives

The project quantified emission rates of gas- and particle-phase pollutants from HDDVs using a plume capture system at the Caldecott Tunnel in Oakland, California. Fuel-based EFs were reported to assess real-world emissions of NOx, NO, NO2, NH3, N2O, and BC. This work continued the record that began at this site in 2010 with three (3) new campaigns from 2021 through 2023, covering the final stage of the Truck and Bus Rule, and aimed to quantify the real-world NOx emissions benefits of the requirement for 2010-compliant (typically equipped with SCR) engine HDVs by January 1, 2023. The potential increase in NH3 and N2O emissions with increasing SCR use was assessed.

Background

HDDVs are major sources of diesel particulate matter (PM) and NO_X in California. Many areas in the State are not in attainment of National Ambient Air Quality Standards for PM2.5 and O3, and air pollution mitigation plans call for sharp reductions in NOx from HDDVs. However, many studies, including previous research at the Caldecott Tunnel, have found that in-use NOx emissions from HDDVs are higher than would be expected based on applicable emission standards.

The Truck and Bus Rule requires that nearly all trucks and buses in the state have 2010 or newer model year engines as of January 2023. Since 2020, the registration of HDVs with the California Department of Motor Vehicles has been contingent on Truck and Bus Rule compliance. Most HDVs in California incorporate SCR aftertreatment to meet 2010 engine standards. Real-world SCR performance must be monitored to estimate the emissions benefits of the full Truck and Bus Rule. Additionally, previous work at this site has shown increased emissions of N2O and NH3, which should continue to be monitored as SCR adoption increases.

As the final phase of the Truck and Bus Rule is implemented, CARB has developed a Heavy-Duty Inspection & Maintenance Program, as directed by SB 210 (2019). Both of these programs will benefit from the measurement of real-world HDDV emissions.

Project Summary

Three (3) field campaigns measured fuel-based emissions from HDDVs at the Caldecott Tunnel, one (1) each in calendar years 2021, 2022, and 2023. Valid EFs matched to observed license plates were quantified for 1,047 unique HDDVs in 2021, 1,000 in 2022, and 1,027 in 2023. EFs for individual vehicles were linked to attributes such as Engine Model Year (EMY) and emission control technology by matching vehicle license plates to available vehicle registration databases. In 2010 (pre-regulation), 15% of HDDVs were equipped with DPFs, and only 2% had SCR. With continued implementation of the Truck and Bus Rule, DPF and SCR controls are now ubiquitous in HDDVs monitored at the Caldecott Tunnel. By 2023, over 99% of HDDVs had DPFs, and 98% had SCR, and fleet-average BC and NOx EFs have decreased by 92% and 75%, respectively, since 2010. However, there is evidence of increasing NOx emissions from older 2010 technology HDDVs, which would involve engine and aftertreatment aging. Most BC EFs for 2010 and newer model engine HDDVs were below the corresponding PM emission standard.

Key findings include:

- NOX emissions: NOX emissions from HDDVs increased as engines and SCR systems aged, with 2010-2012 EMY HDDVs showing 5.6 times higher average NOx emissions compared to 2016 and newer OBD-compliant HDDVs. Across all engine groupings (2010-2012, 2013-2016, and 2017 and newer EMYs), fleet NOx emissions increased 1.8-2.6 times from 2021 to 2023 field campaigns.
- N2O Emissions: SCR-equipped HDDVs have elevated N2O emissions compared to pre-2010 EMY HDDVs. The average N2O emission rate for 2014-2018 EMY HDDVs was 1.6 times greater than 2019 and newer EMY.
- NH3 Emissions: Most SCR-equipped HDDVs had near-zero NH3 emissions, but a few high emitters were responsible for the majority of NH3 emissions. OBD-compliant HDDVs showed a 2.2 times higher NH3 emission rate than 2010-2012 EMY.
- BC Emissions: BC emissions from HDDVs equipped with both DPF and SCR were 88% lower than 2007-2009 EMY with DPFs only. The 2007-2009 EMY HDDVs showed a substantial increase in BC emissions due to aging. For most HDDVS equipped with

2010 and newer engines emitted well below 0.06 gPM/kgFuel, which is comparable to the 0.01 gPM/bhp-hr engine certification standard.

- Contribution of the highest emitting HDDVs to fleet emissions: A small fraction of the fleet contributes disproportionately to overall emissions, as the EF distributions for NOx, N2O, NH3, and BC are highly skewed to a small fraction of the fleet, e.g., 10% of HDDVs were responsible for 75% NOx and 85% BC. It is worth noting that the highest-emitting HDDVs for one pollutant are typically not the highest emitters for other pollutants. For example, there is little overlap between the highest emitters of NOx, NH3, and N2O, while HDDVs with the highest BC emissions tend to have low NOx emissions.

III. Staff Comments

The draft final report was reviewed by staff in RD, the Mobile Source Control Division, the Mobile Source Laboratory Division, and the Air Quality Planning and Science Division. The project team addressed all comments from CARB staff in the current version of the draft final report. The project has met its measurement and analysis objectives. The report adequately describes the methods and instrumentation used to quantify EFs. The methods were well-established and had been used previously in similar settings. The data analysis results, as well as the underlying data, were provided in the final report to CARB and will be used for further data analysis for mobile source programs. The results provide valuable insights into emission trends based on vehicle age and aftertreatment control technologies.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this draft final report for $449,571, subject to any changes and additions specified by the Committee.

Item No.: III.3
Date: November 15, 2024
Contract No.: 21RD008

Staff Evaluation of a Draft Final Report

Title:	Alignment of Planned Transportation Investments with Climate and Equity Goals
Contractor:	University of California, Los Angeles
Principal Investigators:	Brian D. Taylor, Ph.D., FAICP Gian-Claudia Sciara, Ph.D.
Budget:	$199,950
Contract Term:	36 Months

For further information, please contact Dr. Sarah Pittiglio at (279) 842-9115 or *Sarah.Pittiglio@arb.ca.gov*

I. Summary

The Assembly Bill 285 Report found that Metropolitan Planning Organizations (MPOs) and other institutions have been given key responsibilities for meeting climate and equity goals but do not have the appropriate levers to fulfull those responsibilities. Transportation projects continue to be proposed and funded to increase road capacity, which is usually associated with growing vehicle miles travel. Such projects often impose disproportionate effects on low-income and minority populations in the form of added noise, vehicle crashes, and vehicle emissions, all of which negatively affect public health and quality of life. This report examines how California's MPOs evaluate proposed transportation projects for inclusion in their Regional Transportation Plans (RTP) and Transportation Improvement Programming (TIP) documents. The study investigates how and to what extent MPOs incorporate state climate and equity goals into selecting transportation projects. Conclusions from this report highlight that MPOs need more support from the state to address climate change and equity concerns effectively and must provide MPOs with additional resources for planning and evaluation, developing more robust climate and equity evaluation criteria, and increasing transparency and accountability in project selection processes.

II. Technical Summary

Objective

This report investigates how California's MPOs evaluate transportation projects for inclusion in their RTPs and TIP documents. The study aims to determine how MPOs incorporate state climate and equity goals into project selection and provide CARB with recommendations for advancing more equitable outcomes in the Sustainable Communities Strategies (SCS) evaluation process.

Background

Federal and California state legislation and administrative codes require that transportation planning and investment consider the environmental and equity effects of transportation policies, plans, and projects to mitigate their potential harms and achieve targeted future outcomes. Much of that planning and investment is overseen by California's MPOs, which are regional organizations that sit between the federal and state governments and above county, municipal, and special purpose agencies below them in the governmental hierarchy. SB 375 requires MPOs in California to develop SCS as part of their multimodal long-range transportation plans, which aim to align transportation, housing, and land use decisions to achieve greenhouse gas emissions reduction targets set by CARB. To better understand the extent to which MPOs comply with SB 375 and incorporate social equity principles into their planning and programming, this report examines how the surveyed MPOs consider these issues in selecting and evaluating transportation projects before they are approved and funded.

Project Summary

This report examines the transportation planning activities of seven (7) California MPOs (i.e., the four (4) largest MPOs and three (3) smaller ones) and associated County Transportation Commissions and Regional Transportation Planning Agencies. The study focuses on MPO planning and programming to meet climate goals mandated by SB 375 and advance state equity goals. The study gathered, reviewed, and synthesized relevant federal and state administrative rules and regulations regarding MPO functions and public documents specific to the seven (7) MPOs' plans. Researchers also interviewed MPO staff, board members, and external stakeholders who advocate for climate and equity considerations in regional

planning processes. The findings reveal that MPOs face challenges incorporating climate change and equity concerns into their planning and programming processes. Despite state mandates, MPOs often need more resources and expertise to conduct rigorous project evaluations. Additionally, the influence of local governments and funding constraints can limit MPOs' ability to prioritize climate and equity goals. The report concludes that MPOs need more significant support from the state to address climate change and equity concerns effectively. Recommendations include providing MPOs with additional resources for planning and evaluation, developing more robust climate and equity evaluation criteria, and increasing transparency and accountability in project selection processes.

III. Staff Comments

An earlier version of this draft underwent an extensive review process by CARB staff from RD and the Sustainable Transportation and Communities Division as well as staff from Caltrans and the California Transportation Commission. Comments have been positive, and CARB staff have used preliminary findings to inform CARB comments on the recent update of RTP guidelines. Additional comments have revolved around requests to make factual corrections and provide further information. The PIs have made revisions accordingly. The most recently revised draft final report was submitted to CARB on October 11. Any additional review from previously engaged internal and external staff will be concurrent with the RSC review. The contract manager will review the revised draft and collect any additional internal and external comments by November 11, 2024. The contract manager will provide updates, especially if any concerns emerge.

IV. Staff Recommendations

Staff recommends the RSC recommend that CARB approve this draft final report for $199,950, subject to any changes and additions specified by the Committee.