EXHIBIT A

SCOPE OF WORK

☒ Contract ☐ Grant

Does this project include Research (as defined in the UTC)? ☒ Yes ☐ No

PI Name: Jing Li

Project Title: **Res**idential A**p**pliances in Div**e**rse **C**alifornia Communi**t**ies: Emission, Exposure, and Health Impacts of Toxic Air Contaminants (**RESPECT**)

Project Summary/Abstract

The proposed RESPECT study aims to answer the following three questions with an environmental justice (EJ) lens: (1) What are the toxic air contaminant (TAC) emission profiles of residential heating and cooking appliances of concern in California? (2) How do these TAC emissions contribute to indoor and outdoor air quality in the state? (3) What are the disparities in exposure and health impacts attributed to TAC emissions between disadvantaged communities (DACs) and non-DACs? To address these questions, the University of California, Los Angeles (UCLA or Contractor) assembled a research team comprised of members from both academia and community-based organizations (CBOs). Together, the contractor proposes a systematic approach to (1) identify key residential appliances of concern, (2) examine their TAC emission profiles including composition, concentrations, and emission rates, for both fuel leakage and combustion exhaust, (3) estimate TAC emission contributions to indoor and outdoor air quality in the state, and (4) evaluate exposure and health impact disparities among communities. Results from the RESPECT study will improve community awareness of TAC exposures from residential heating and cooking appliances, as well as highlight the disparities in their associated health impacts. This knowledge will also assist CARB and other agencies in crafting comprehensive policies to address air pollution and climate change inequities.

If Third-Party Confidential Information is to be provided by the State:

☐ Performance of the Scope of Work is anticipated to involve use of third-party Confidential Information and is subject to the terms of this Agreement; ***OR***

☐ A separate CNDA between the University and third-party is required by the third-party and is incorporated in this Agreement as Exhibit A7.

Scope of Work

Statement of Significance

Residential fossil fuel appliances, such as water heaters, stoves, and furnaces, emit harmful substances such as formaldehyde, benzene, toluene, ethyl benzene, and xylene (BTEX), as well as other TAC species[1-7]. These emissions are a result of leaks and incomplete combustion, and they have been associated with various acute and chronic health effects, such as respiratory illness, cardiovascular disease, cancer, and premature death[8-11]. Additionally, these emissions contribute to both indoor and outdoor air pollution[1, 2, 12].

Many previous studies conducted in California have measured in-field emissions from residential appliances, with a focus on particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO_2), NO_x, carbon dioxide (CO_2), and methane[13-20]. Only a few studies have specifically examined the presence of TACs in these emissions[1, 2, 7]. However, these initial studies have already shown that residential appliances can emit high levels of TACs. For instance, the mean benzene emissions from gas and propane burners on high and ovens set to 350 °F ranged from 2.8 to 6.5 μg min^{-1}, which is 10 to 25 times higher than the emissions from electric coil and radiant alternatives[1]. In California, it was estimated that unburned natural gas (NG) from residential stoves emitted 4,200 (95% CI: 1,800-9,700) kg yr^{-1} of benzene, which is equivalent to the annual benzene emissions from nearly 60,000 light-duty gasoline vehicles[2]. Moreover, even when stoves and ovens are not in use, leaks from NG can still lead to indoor benzene concentrations that exceed the California Office of Environmental Health Hazard Assessment (OEHHA) 8-hour Reference Exposure Level (REL) of 0.94 ppb[2].

In line with the 2022 Scoping Plan for Achieving Carbon Neutrality, the California Air Resources Board (CARB) is currently developing and proposing zero-emission greenhouse gas (GHG) standards for new space and water heaters sold in California. These standards will not only reduce other air pollutants emitted by these appliances, such as TACs, but also contribute to California's efforts to meet both state and federal air quality standards while promoting public health benefits. To assess the co-benefits of implementing these zero-emission appliance standards, a comprehensive investigation is necessary to systematically understand the profile of TACs emitted by residential appliances. Furthermore, there is currently a lack of clarity regarding the disparities in TAC emissions, exposure, and health impacts from these residential appliances in different communities. While some studies have reported disparities and factors related to the use of cooking venting devices, such as range hoods, in California, and have found significantly higher rates of range hood use among homes with higher income and education levels[21-24], there is still a knowledge gap in directly profiling and examining these disparities. Addressing this gap is essential to inform potential future regulatory actions aimed at reducing TAC emissions from these appliances and ultimately protecting public health.

Here, the contractor proposes a systematic approach to profiling statewide emissions of TACs from the leakage and combustion of residential heating and cooking appliances, and to investigating disparities in the resulting exposure and health impacts. The systematic approach includes the following steps: (1) identifying key residential appliances of concern, (2) examining the TAC emission profiles of these appliances, including composition, concentrations, and emission rates, for both fuel leakage and combustion exhaust, (3) estimating the contribution of TAC emissions to indoor and outdoor air quality in the state, and (4) evaluating the disparities in exposure and health impact among communities. Through this approach, the proposed RESPECT study aims to address three key questions using an EJ lens: (1) What are the toxic air contaminant (TAC) emission profiles of residential heating and cooking appliances of concern in California? (2) How do these TAC emissions affect indoor and outdoor air quality in the state? (3) What are the disparities in exposure and health impacts attributed to TAC emissions between DACs and non-DACs? The research results will contribute to a better understanding of the effects of TAC emissions from heating and cooking appliances in California homes. Additionally, these findings will assist in evaluating the co-benefits of adopting zero-emission appliance standards and informing potential regulatory actions to limit TAC emissions from these appliances. Ultimately, this will help protect public health.

Project Tasks

Task 1 Literature Review

The contractor will conduct a literature review to gather information from various sources such as peer-reviewed articles, research institute reports, government reports, consumer product reports, product marketing materials, relevant databases, and case studies. The contractor initiated the literature search using keywords from the research questions outlined in the abstract. Additional terms related to, or similar to these keywords were informed by the initial search results and also included. A logic grid of search terms (see

Table 1) was used to find relevant resources. This grid organizes the search terms into different groups. Within each column, the words will be combined using the Boolean operator 'OR'. Then, the columns will be combined using 'AND'.

Table 1. Logic grid of search terms

Settings	Appliances[1]	TACs	Analyses
'indoor', 'residential', 'household', 'home'	'cook*', 'heat*', 'boil*', 'dry*', 'furnace', 'oven', 'stove', 'appliance', 'kitchen', 'gas', 'leak*', 'combust*', 'uncombust*', 'burn*', 'unburn*'	'toxic air contaminants', 'TACs', 'volatile organic compounds', 'VOCs', 'BTEX', 'benzene', 'toluene', 'ethylbenzene', 'xylene', 'formaldehyde', 'hydrogen cyanide', 'hexane', 'naphthalene', 'acetaldehyde'	'composition', 'concentration', 'emission', 'exposure', 'health effect', 'health impact', 'disparity', 'environmental justice'

[1]The asterisk (*) is used as a wildcard symbol in search queries to capture variations of a word or root, making the search more comprehensive. For example, using "heat*" is to capture results including "heating", "heater", etc., while using "combust*" is to capture results including "combustion", "combusted", etc.

With searching three databases including the Web of Science, PubMed, and Embase, the contractor found 6633 non-review records on August 7th, 2024. The contractor will further screen and exclude records that (1) focus on contaminants other than TACs, such as PM, biologicals, etc., (2) do not focus on cooking or heating appliances, but instead on smoking, e-cigarettes, cleaning products, printers, etc., and (3) focus on commercial buildings such as retail stores, grocery stores, and classrooms instead of residential environments.

The information that the contractor will review and summarize includes (1) the prevalence and usage of appliances in different geographic areas and different demographic groups (e.g., race/ethnicity, income level) across the state, (2) TAC emissions from residential space and water heating and cooking appliances in California, (3) associated impacts on air quality and public health, including factors such as building characteristics and appliance operation modes that influence them, (4) methods and instruments for sampling and analyzing TACs as well as assessing health impacts, including both field and laboratory methods and modeling, and (5) the disparities in exposure and health impact attributable to these appliances. One of the primary objectives of the literature review is to provide a comprehensive overview of the methods used to quantify TAC emissions in residential settings, including an examination of their limitations and constraints. This aims to inform the methodology development in the proposed RESPECT study. The contractor has preliminarily reviewed several studies and determined the instruments for collecting and analyzing TACs. Additionally, the contractor has proposed provisional methods for measuring TAC emissions from leakage and combustion of residential appliances. Details can be found in **Task 5.1**. Further literature review and pilot studies will be conducted to optimize experimental procedures.

Deliverables. A draft report summarizing the findings from the literature review will be provided by month 6. This report will also be included as part of the final report.

Task 2 Technical Advisory Group and Community Partners

Task 2.1 Technical Advisory Group (TAG)

The contractor will establish a TAG consisting of 5 experts from state and local government agencies, industry groups, academia, and community representatives who have extensive experience and expert knowledge related to emissions, technology, markets, and/or policies of residential appliances. The contractor has already collaborated and is currently collaborating with many colleagues who have complementary expertise related to this project, including Joshua Apte (UC Berkeley), Sean Armstrong (Redwood Energy), Chris Cappa (UC Davis), Nick Dirr (Association for Energy Affordability), Andrea Ferro (Clarkson University), Carlos Gould (UC San Diego), Kazukiyo Kumagai (California Department of Public

Health), Eric Lebel (PSE Healthy Energy), Arjun Makhijani (Institute for Energy and Environmental Research), Carmelita Miller (Rocky Mountain Institute), Brady Seals (Rocky Mountain Institute), Nina Prescott (Rocky Mountain Institute), Brett Singer (Rocky Mountain Institute), and Marina Vance (University of Colorado, Boulder), to name a few. A draft list of TAG members with their credentials and expertise will be submitted to CARB staff for approval by month 1, and all the TAG members will be on board by the second quarter.

The contractor will arrange a meeting with the TAG at the start of the project to gather their input on determining representative residential appliances in California, profiling the composition of TACs and their contribution to indoor and outdoor air quality, and estimating health disparities. TAG members will attend semiannual meetings throughout the project. These meetings will serve to guide the study design, review interim deliverables, and provide feedback on the interpretation of collected samples and data. Additionally, TAG members will be responsible for reviewing the final draft report and providing written scientific comments. Each meeting will have a meeting agenda, listing key topics for discussion, and a meeting minute documenting TAG members' feedback. This will ensure clear communication and effective collaboration.

Deliverables. A draft list of TAG members by month 1, and a final list of TAG members by month 6.

Task 2.2 Community Partners

In consultation with CARB staff, the contractor will establish collaborations with three community partners across the state as subcontractors for this project. The contractor has confirmed partnerships with San Francisco Bay Physicians for Social Responsibility (SF Bay PSR) and Central California Asthma Collaborative (CCAC) during the pre-proposal stage. They will collaborate as subcontractors, serving the field study in Northern California and the Central Valley, respectively. In Southern California, the contractor has previously collaborated with CBOs, including Breathe Southern California, Coalition For A Safe Environment, Comite Civico del Valle, Esperanza Community Housing Corp, Pacoima Beautiful, Physicians for Social Responsibility Los Angeles (PSR-LA), and Redeemer Community Partnership (RedeemerCP) to address various indoor and outdoor air quality issues. Currently, the contractor is reaching out to RedeemerCP and discussing details of collaboration in Southern California. A draft list of community partners will be submitted to CARB staff for approval by month 1, and all community partners will be on board by the first quarter.

These community partners will (1) review the study design, (2) guide the selection and testing of appliances that are representative of the appliance mix in DACs as designated by the California Environmental Protection Agency (CalEPA) for Senate Bill (SB) 535, (3) identify and recruit eligible households to participate, and (4) assist in conducting the field studies in recruited homes to analyze of exposure and health impact disparities. Budget details and justifications for personnel, travel, materials & supplies, etc. provided by subcontractors (i.e., SF Bay PSR and CCAC) can be found in Exhibit B. To ensure the smooth implementation of the field study, the contractor will develop a comprehensive standard operating procedure (SOP) for sample collection. This SOP will be rigorously tested in one to two homes in a pilot study before commencing the fieldwork. The SOP will also include a custom survey created by the contractor, which is specifically designed for the fieldwork. Community partners will undergo thorough training by the contractor to ensure they are proficient in executing the SOP and administering the survey in the field. For further details on the recruitment process and the fieldwork conducted in participant homes, please refer to **Task 5**. To ensure the quality and progress of sample collection and analysis, the contractor will organize regular meetings with community partners throughout the duration of the field study.

Deliverables. A draft list of community partners by month 1, and a final list of community partners by month 3.

Task 3 Study Design

Figure 1 presents a schematic overview of the study design, illustrating the logical progression of the proposed methods and incorporating results. It also displays the specific tasks associated with measurement and modeling efforts in this study, as well as summarizes the research deliverables. Arrows in **Figure 1** demonstrate the flow of information, indicating how each stage of data collection and analysis contributes to the final deliverables. Different stages are distinguished by color-coded rectangles, with 'Scoping' in purple, 'Pilot study' in green, 'Fieldwork' in orange, 'Data analysis' in light blue, 'Modeling' in red, and 'Deliverables' in dark blue. Additionally, the involvement of community partners (subcontractors) is denoted by a yellow color-coded dot.

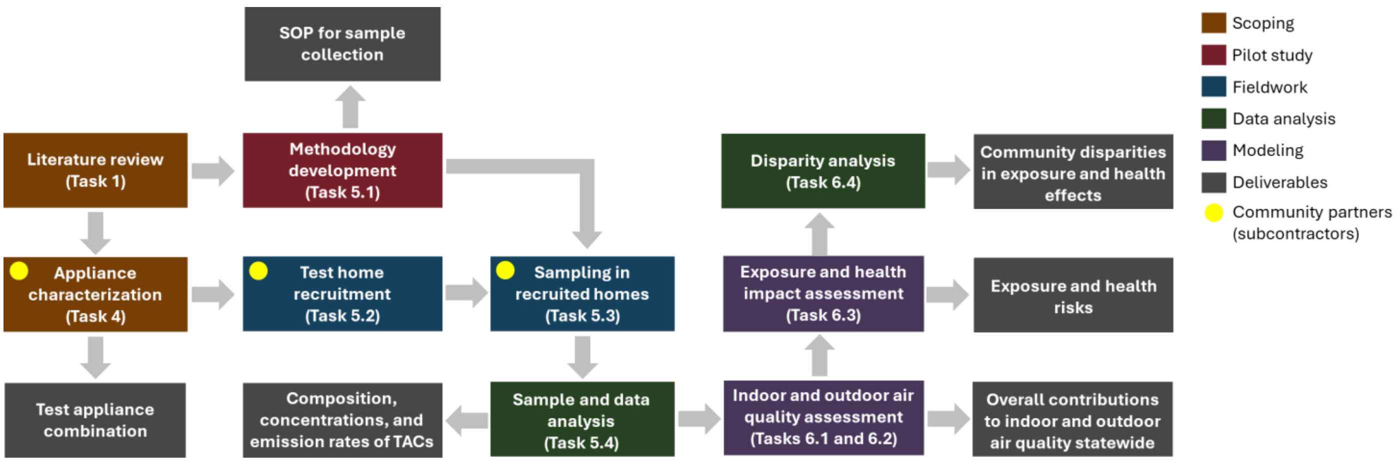

Figure 1. Schematic diagram of the overall study design

As depicted in **Figure 1**, during the scoping stage, the contractor will conduct a thorough literature review (**Task 1**) to inform the development of the methodology (**Task 5.1**) in the pilot study. The pilot study aims to develop an approach to measure TAC emissions and provide a SOP on sample collection for field study. Additionally, in the scoping stage, the contractor will work with community partners to characterize representative appliances for testing (**Task 4**). This will determine the combination of test appliances that effectively represent the appliance stock in DACs and non-DACs in California. The identified combination of test appliances will guide the selection and recruitment of tested homes in Northern California, Central Valley, and Southern California (**Task 5.2**), which will be carried out by the contractor and community partners. With the SOP for sample collection, the contractor and community partners will begin the field trips to measure TAC emissions in the recruited homes (**Task 5.3**). The analysis of samples and data will provide the TAC emission profile, including composition, concentrations, and emission rates resulting from the leakage and combustion of the tested appliances (**Task 5.4**). The contractor will then develop and validate methods to assess indoor and outdoor air quality (**Tasks 6.1 and 6.2**) and determine the statewide contributions of these TAC emissions to indoor and outdoor air quality. Using the results from the indoor and outdoor air quality assessment, the contractor will further evaluate the exposure and health impacts (e.g., carcinogenic risk, non-carcinogenic risk) in different communities (**Task 6.3**) for the subsequent analysis of community disparities (**Task 6.4**). Ultimately, the contractor will provide an assessment of the exposure and health impact disparities attributable to the most representative residential appliances between DACs and non-DACs in California. More technical details can be found in **Tasks 4, 5, and 6**. All technical plans will be further reviewed and optimized in consultation with CARB staff, TAG members, and community partners.

Task 4 Characterization of Representative Appliances for Testing

The contractor will use information about the California residential appliances stock provided by CARB and other available data to characterize the current appliance mix and determine the combination of appliances for testing. The proposed selection plan is as follows: (1) First, the contractor will identify the top 3-4 most commonly used heating and cooking appliances in California, such as gas stoves, water heaters, and space heaters, as the test appliance categories, (2) Second, within each category, the contractor will summarize the parameters including brands, models, energy sources, NO_x control levels and technologies, sizes, and fuel consumption, (3) Third, the contractor will classify appliance products based on key parameters such as energy sources, NOx controls, and sizes into various subgroups, (4) Fourth, the contractor will examine whether there are differences in popularity of these subtypes among different climate zones (e.g., California Energy Commission (CEC) Title 24 Climate Zones 1-16), housing types (e.g., single-family homes, multi-family homes, manufactured homes), homeownerships (rental or owned), etc., and (5) Finally, the contractor will select a combination of test appliances that effectively represent the appliance stock in California for different locations, climate zones, housing types, and homeownerships.

Deliverables. A draft report of appliance characteristic analysis and recommendations of the representative appliances to be tested will be provided by Month 10.

<u>Task 5 Compositions and Emission Rates</u>

Task 5.1 Methodology development

The contractor will conduct a pilot study in one or two households to develop a methodology for collecting and measuring TAC emissions and then validate it in 2-3 households in the beginning of the fieldwork. The development of the methodology will also consider the need to minimize disturbances to the community's households and simplify the sample collection process. In consultation with CARB staff, TAG members, and community partners, the pilot study will develop an approach for measuring TAC emissions and establish an SOP for sample collection in the subsequent field study. Additionally, the pilot study will provide valuable insights into the sampling timeline of the field study. Although the primary focus of the proposed project does not revolve around seasonality, the pilot study will examine and evaluate any potential seasonal variations. If any seasonality is observed, the contractor will make efforts to schedule all field work during the spring and winter seasons, as increased volatile organic compounds (VOCs) during the spring season[2] and the winter heating season[2, 6] have been reported in the literature.

Deliverables. A draft report summarizing the findings from the pilot study, a draft SOP for sample collection, and a draft questionnaire for home occupants will be provided by month 10.

Task 5.1.1 Instruments for collecting and analyzing TACs

Table 2 summarizes commonly used TAC sampling and analysis methods. Among these methods, the AROMA-ETO analyzer, being a bulky instrument, weighs approximately 50 kg (110 lbs), making it unsuitable for field use and inappropriate for conducting tests in residential settings. Therefore, the contractor is planning to deploy Summa canisters (see **Figure 2a and 2b**) for point-of-sampling and diffusion tubes (see **Figure 2c and 2d**) for long-term sampling in each home. Summa canisters will be used at the points of fuel leakage and combustion exhaust of each appliance to collect instant "grab" samples for 20-30 seconds. These samples will be analyzed for 74 TAC species using Gas Chromatography Mass Spectrometry (GC-MS) according to the U.S. EPA Compendium Method TO-15[25], and for methane following the U.S. EPA Compendium Method TO-3[26]. The samples collected by diffusion tubes will be analyzed for 65 TAC species using U.S. EPA Compendium Method TO-17[27].

Table 2. Common TAC sampling devices and analysis methods in literature

Sampler	Sampling time	Analysis instrument	Analysis method	Reference

Summa canister	20 seconds to 24 hours	GC-MS	EPA Method TO-15	2, 28, 29
Diffusion tube	4 hours to 4 weeks	GC-MS	EPA Method TO-17; EPA Method 325	30, 31, 32
AROMA-ETO analyzer	1 to 45 minutes	Cavity ring down spectroscopy	Real time	1, 33, 34, 35

Figure 2. Photos of the proposed sampling devices. (**a**) The Summa canister, (**b**) the Summa canister sampling in the field, (**c**) the diffusion tube, and (**d**) the diffusion tube sampling in adjacent outdoor residential areas, with the red circle indicating the diffusion tube.

Task 5.1.2 Measurement of emission rates of TACs in appliance leakage

The contractor will first measure methane (taking NG as an example; if the fuel type is other than NG, such as propane, then propane will be measured) emission rates attributable to appliance leakage and concentrations of TACs in unburned gas from appliances. Then, the contractor will calculate emission rates of TACs caused by appliance leakage using the following equation adapted from previous studies[1, 2, 16, 36]:

$$E_i = E_{methane} \times C_i\left(\frac{MW_i}{MW_{methane}}\right) \quad \text{(Eq. 1)}$$

where E_i is the emission rate of a specific TAC species i to be studied (μg min^{-1}), $E_{methane}$ is the emission rate of methane caused by appliance leakage (μg min^{-1}), C_i is the mole fraction of the TAC in the leaked gas to be tested (unitless), MW_i is the molecular weight of the TAC (g mol^{-1}), and $MW_{methane}$ is the molecular weight of methane (g mol^{-1}).

To measure $E_{methane}$ from steady-state-off leakage of the appliance, the contractor will use a multi-gas monitor equipped with integrated gas sensors, including methane, NO_2, NO, CO_2, VOCs, and others, to determine the area where each appliance has the highest leakage for sample collection. Once the area is identified, the contractor will use the regulator to fill a 6 L Summa canister for 15 minutes. The Summa canisters will be prepared, and samples will be analyzed by a commercial environmental testing laboratory called LA Testing (EMSL Analytical, Inc., Cinnaminson, NJ), located in Los Angeles. The samples will then follow the methane analysis (see **Task 5.1.1**). If the sample analysis proves that the collected sample is insufficient, the contractor will consider improving the sampling method by implementing specific sampling setups. For example, the contractor may restrict the sampling area by using plastic film[1, 2] or a plastic box to limit the volume of space and air change. The refinement of the sampling method will be confirmed during the pilot study.

To measure C_{TAC} in unburned gas, the contractor assumes that the fuel supply to various appliances within a single household possesses an identical composition of TACs and will collect a representative NG sample from the stove in each home using an established methodology[2, 6] This methodology involves a direct in-line connection between the NG outlet of the stove and the sample canister. Flexible Teflon-lined tubing will be used for this connection, and the 6 L canister will be filled within 20-30 seconds after turning on the gas flow knob. The sample analysis will include both methane analysis and analysis of 74 TAC species (see **Task 5.1.1**).

Task 5.1.3 Measurement of TAC emissions in appliance combustion exhaust

To measure the TACs emitted from appliance combustion, the key question is how long it takes for the emissions to reach a steady state. Lebel et al. (2022)[16] found that burners took 90 seconds to reach a steady state. It would be burdensome for community members to conduct extended sampling sessions within their households. Therefore, the contractor will determine the time in the pilot study. The contractor will use the 6 L Summa canister to collect instant "grab" samples for 20-30 seconds at various times: background ("steady-state-off" emission or 0 minutes), 5 minutes, 10 minutes, 15 minutes, and 20 minutes after turning on the appliance. By comparing the concentration trend between these timestamps, the contractor will determine the time it takes for each appliance to reach a steady state. multiple appliances will be tested in the pilot study to get the average steady state emission time for each type of appliance to be tested (see **Task 4**) to guide sampling collection in the field study.

Afterward, the contractor will use a regulator to fill the 6 L Summa canister with 15 minutes of "steady-state-on" emissions. The sample will then undergo the same analysis of the 74 TAC species (see **Task 5.1.1**). Similarly, if the sample analysis indicates that the collected sample is not sufficient, the contractor will consider implementing specific sampling setups. These setups may include using plastic film[1, 2] or a plastic box to limit the volume of space and air change, as described in **Task 5.1.2**. Additionally, the contractor will measure CO_2 emissions using a real-time sensor to calculate the energy usage in joules (J) and the TAC emissions per unit of energy used (ug TAC J^{-1} fossil gas burned)[1]. These data will be combined to calculate the emission rates of TACs from the combustion of each appliance (µg min^{-1})

Task 5.1.4 Measurement of indoor and outdoor concentrations of TACs

Diffusion tubes will be used to measure the long-term concentrations of TACs indoors and in outdoor adjacent areas. One diffusion tube will be placed in the living room, while another diffusion tube will be placed in the backyard as shown in **Figure 2(d)**. All diffusion tubes will be placed at a height of approximately 1.5 meters from the ground. The diffusion tube is a compact passive sampling device that will not disturb communities at all. The sampling duration is typically two weeks according to Rossner et al. (2021)[37]. These samples will be analyzed for 65 TAC species (see **Task 5.1.1**). In the pilot study, the contractor will verify if the 2-week sampling duration for diffusion tubes is sufficient. The data from diffusion tubes will reflect concentration levels of TACs both indoors and outdoors in the selected homes. This data will be used to validate the models that assess indoor and outdoor air quality.

Task 5.2 Home recruitment

Home recruitment will be prioritized in overburdened communities, particularly those designated by CalEPA for Seneta Bill (SB 535). CalEnviroScreen, a tool that assesses communities using different environmental, health, and socioeconomic indicators, including pollution burden, exposure, income levels, and racial demographics, will be utilized to identify these communities. According to CalEPA guidelines for SB 535, census tracts that score in the top 25% overall scores in CalEnviroScreen 4.0 are considered DACs.

In the proposed RESPECT study, at least 50% of the sampled homes will be in DACs. Based on the distribution of DACs in California, as shown in the map presented in **Figure 3**'s "Home Identification" box, the contractor will work with community partners to recruit approximately 15 homes in the Bay Area in Northern California, 30 homes in San Joaquin County in Central California, and at least 20 homes in Los Angeles County in Southern California, as outlined in the "Home Recruitment" box in **Figure 3**. In the Bay Area and San Joaquin County, at least half of the recruited homes will be from DACs, and community partners will be responsible for all recruitment from both DACs and non-DACs. In Los Angeles County, the community partner will be tasked with recruiting 15 DAC homes, while the contractor will be responsible for recruiting a minimum of 5 additional homes from non-DACs, which includes the one or two homes for the pilot study (**see Task 5.1**). This recruitment effort will allow the contractor to sample gas leakages and combustion exhausts from at least 200 appliances across the state.

Community partners will reach out to potential homeowners by phone calls. During the phone calls, community partners will collect basic information for screening purposes, such as if they have the appliances identified in **Task 4** and whether they can access the vents of these appliances, and also ask them to send photos of appliances and relevant household areas such as kitchens or utility rooms in their homes. The photos will be examined to verify the appliance types, energy sources, and models. The community partner, CCAC, already has existing participant pools in San Joaquin County from previous projects (see **Exhibit A6**). The contractor will assist other community partners who do not have an established network in designing flyers for distribution either in print or through social media.

In addition to accessibility to appliances for testing, each home enrolled in this study also need to meet the following eligibility criteria: non-smoking households, locations away from major outdoor pollution sources such as freeways and industrial sites, and homeowner agreements not to use outdoor grills or barbeques or engage in activities that generate additional indoor TACs, such as using strong cleaning agents, candles, or air fresheners during the sampling period. Priority will be given to homes with multiple appliances that meet the appliance selection criteria developed in **Task 4**. In each area, the contractor will strive to ensure a balanced selection of home types, including single-family homes, multi-family homes, and manufactured homes. However, the specific distribution of home types recruited may vary from locations to locations and be dependent on home availability.

Each recruited home will be visited three times (see the "Field: 3 visit/home" box in **Figure 3** for further information, which is provided in **Task 5.3**), and will receive a $50 VISA gift card as compensation after each visit, resulting in a total of $150 per recruited home. The contractor and community partners will keep a record of all payments issued, including the study consent forms that outline the purpose of the compensation, as well as the names and signatures of the recipients. These records will be submitted upon request by CARB.

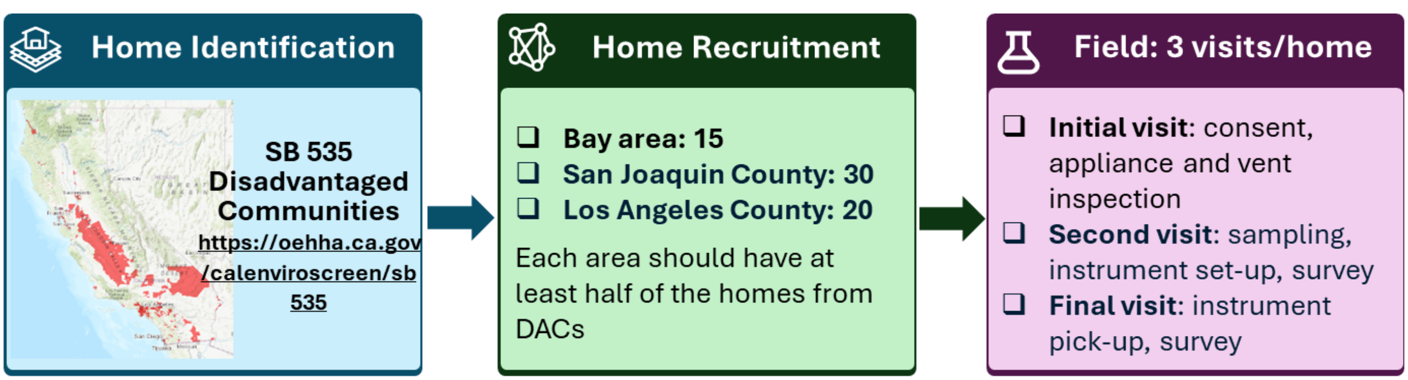

Figure 3. Schematic diagram of field measurements in the community (Tasks 5.2 and 5.3)

Task 5.3 Field work

As depicted in the "Field: 3 visit/home" box in **Figure 3**, for each home that is recruited, the contractor and community partners will plan three visits. Firstly, an initial visit will be conducted to obtain signed consent form from the homeowners and inspect the appliances, including identification of vent locations. Secondly, a second visit will be made to collect Summa canister samples, set up diffusion tubes for long-term sampling, and conduct the setup survey. Lastly, a final visit will be scheduled to collect the diffusion tubes and conduct the closing survey.

Task 5.3.1 Initial visit: appliance inspection and vent location

The contractor and/or community partners will schedule the initial visit to obtain signed consent form from the homeowners and conduct a thorough inspection of each appliance to locate the vents for sampling the combustion exhausts. The contractor and/or community partners might need to ask for the homeowner's consent to remove panels or access utility areas to locate the vents. Additionally, they will use a multi-gas monitor equipped with integrated gas sensors, such as methane, NO_2, NO, CO_2, VOCs, etc., to pinpoint the areas where the appliances are leaking the most, as mentioned in **Task 5.1.1**. This will help determine the best location for sampling the appliance's leakage.

Task 5.3.2 Second visit: sample collection, instrument set-up, and survey implementation

The contractor will travel to the Bay Area and San Joaquin County to train community partners, SF Bay PSR and CCAC, to conduct the fieldwork using the SOP developed in **Task 5.1**. This includes operating and setting up the samplers and conducting surveys. The contractor will accompany community partners to one to two homes to conduct the fieldwork together. Afterwards, the community partners will complete the remaining fieldwork for the remaining homes.

The sampling process involves collecting short-term Summa canister samples (see **Tasks 5.1.2 and 5.1.3**) and setting up diffusion tubes for 2-week sampling (see **Task 5.1.4**). After the Summa canister sampling is complete, the community partners will store the canisters at room temperature and ship them to the contractor within a two-week timeframe for sample analysis. Throughout the fieldwork period, the contractor will maintain constant communication and hold regular meetings with the community partners to guarantee the successful completion of sample collection and the survey. Both SF Bay PSR and CCAC possess the research experience and capability required for the fieldwork.

In Los Angeles County, given that the contractor is headquartered in Los Angeles, the community partner from the same region will exclusively contribute to home recruitment and the initial visit. They will also accompany the contractor during the second visit to assist in identifying the location of sampling. They will not be required to participate in conducting the technical work during the second visit or be present during the final visit. The contractor will be responsible for conducting the technical work, which is a more cost-effective approach.

Additionally, the second visit will involve the implementation of a survey designed to gather comprehensive information on demographic and household characteristics, including the demographic details (e.g., race/ethnicity, income levels, ages, and education levels), the amount of time participant family members spend indoors and outdoors, the building characteristics (e.g., the type of home, age of the structure, materials employed in above-ground construction, the fuels utilized in the household, ventilation systems, and the use of portable air purifiers), and the activities conducted within the residence (e.g., cooking, space and water heating, laundry, duration of portable air purifier usage, and frequency of filter replacement). The survey data will assist in determining the relevant parameters for assessing indoor and outdoor air quality and exposure in **Tasks 6.1, 6.2, and 6.3**.

Task 5.3.3 Final visit: instrument pick-up and closing survey implementation

Two weeks after the second visit, the contractor and/or community partners will have the final visit to collect the diffusion tubes and conduct a closing survey, which aims to recapitulate with homeowners the frequency and duration of appliance usage throughout the sampling period. The community partners in the Bay Area and San Joaquin County will store the diffusion tubes at room temperature and ship them to the contractor within a two-week timeframe for sample analysis.

Task 5.4 Sample and data analysis

Samples will be analyzed within 30 days of collection - the maximum hold time during which concentrations are considered stable[2]. The sample analysis will follow standard U.S. EPA methods as described in **Task 5.1**. Both the Summa canister and diffusion tube methods are capable of measuring target compounds in the low parts-per-billion (ppb) and parts-per-trillion (ppt) concentration range. Analysis priority will be given to analyzing BTEX, formaldehyde, hydrogen cyanide, and hexane. Additional TACs will be determined in consultation with CARB staff, based on their prevalence, concentrations, and health impacts.

In addition to the emission rates of TACs (μg min^{-1}), the contractor will also consider calculating other metrics to characterize emissions on various scales. These metrics may include leakage emissions in the percentage of fossil gas consumed, emissions per unit of fossil gas burned (see **Task 5.1.3**), and scale-up metrics such as emissions per year per appliance, emissions per year per community, and emissions per year per gas company territory. For instance, California has three main NG utilities: Pacific Gas and Electric (PG&E), Southern California Gas Company (SoCalGas), and San Diego Gas & Electric (SDG&E). Databases containing distribution pipeline emission maps from these utilities could be used to calculate the scale-up metric, as discussed in previous studies[1, 2, 38, 39].

Deliverables. A summary of emission rates and concentrations from tested appliances will be provided by month 22.

Task 5.5 Quality assurance and quality control (QA/QC)

Blanks, cleaning, and other quality checks of Summa canisters and diffusion tubes will be performed by the commercial testing laboratory. Throughout the field study, the contractor will conduct multiple quality control measurements. Firstly, in addition to cleaning the samplers, the contractor will also ensure that the sampled appliances, such as stoves, are thoroughly cleaned to prevent any cooking residues that could potentially result in emissions of TACs during combustion. For other appliances such as space and water heaters, the contractor will consult with the handyman to determine if cleaning is necessary and feasible. Secondly, for the Summa canister used for direct collection of NG through a Teflon tube, the contractor will obtain blank samples without turning on the gas flow knob. Thirdly, the contractor will collect duplicate samples consecutively or at separate time intervals to assess the level of variability. The contractor will collect blank and duplicate samples from randomly selected homes, instead of collecting them from every recruited home. Typically, the QA/QC process involves 10% of the total number of samples being blank samples, and another 10% being duplicate samples. For sample analysis, the contractor will adopt a conservative approach and assign a value of zero to data that falls below the laboratory's internal limit of detection[40].

Task 6 Air Quality and Health Impact Assessment

Task 6.1 Indoor air quality assessment

The contractor will use the Contaminant Transport Analysis Method (CONTAM) model developed by the National Institute of Standards and Technology (NIST) to simulate the contributions to indoor TAC concentrations caused by the emissions from these appliances. CONTAM is a simulation engine that enables users to model and predict contaminant concentrations in multizone, whole-building settings under various scenarios. It considers factors such as airflow rates, infiltration, wind pressures on the building envelope, and buoyancy effects[41,42]. The CONTAM model has been widely used to investigate the impact of building characteristics on the inter-unit transfer of pollutants such as $PM_{2.5}$ from indoor sources such as cooking and smoking. Less is reported on TACs or VOCs. Lebel et al. (2022)[2] used the CONTAM model to simulate the concentration of benzene in kitchen air. The study focused on two ventilation scenarios, specifically for unburned NG leaking from "steady-state-off" stoves.

In the proposed RESPECT study, the contractor will utilize emission rates of TACs from leakages and combustion in various appliances as input for the CONTAM model. Different building geometries, representing the size and types of recruited homes (e.g., single-family homes, multi-family homes, manufactured homes), will be selected from a pre-made building layouts database[43] for use in CONTAM. These geometries will be used to simulate TAC concentrations in different rooms. Additionally, parameters related to ventilation and activities will be established using survey data from **Tasks 5.3.2 and 5.3.3** and the literature review to optimize the modeling results.

Simulated values from the CONTAM model will be compared with the measured TAC concentrations from **Task 5.1.4** over a period of 2 weeks. This will allow us to evaluate the accuracy of the CONTAM model. During the pilot study, indoor TAC concentrations will be measured in multiple rooms such as the kitchen, dining room, living room, and bedroom. This will enable the contractor to validate the results from the CONTAM model simulation in the pilot study home and modify model inputs if needed. However, during the field study, indoor TAC concentrations will only be measured in the living room, thus only living room concentrations will be compared to the results from the CONTAM model. In addition, a correlation analysis will be conducted between the simulated and measured concentrations across different homes. This analysis will help us identify areas where the model requires refinement.

After validating the model, the contractor will apply the established CONTAM scenarios[2] across California representing the state's housing stock using data from the 2019 Residential Appliance Saturation Survey (RASS)[44] and building designs from the "Suite of Homes Representing the U.S. Housing Stock"[43, 45]. All simulations will be run under steady-state airflow conditions at normal temperature (298 K) and pressure (101.3 kPa). The contractor will first localize the modeling for seven regions[2]: the San Francisco Bay Area, Sacramento, Bakersfield, Fresno, San Diego, the Greater Los Angeles region, and the North San Fernando and Santa Clarita Valleys. The contractor will then use the median and 95th percentile values of TAC emission rates, combined with housing and ventilation types, to create a matrix of multiple simulations for each region.

Task 6.2 Outdoor air quality assessment

To estimate the contribution of emissions of TACs from indoor residential appliances to outdoor air quality, a simplified method will be used based on the assumption of a linear relationship between the emissions and concentrations.

First, the contractor will develop an inventory of TAC emissions from indoor appliances to outdoor environments. This will be accomplished by calculating the emissions of TACs from residential appliances exiting the buildings, using the indoor-outdoor air exchange rates. These rates will be modeled based on building geometries, ventilation, and activities, using the CONTAM model. The TAC emission inventory from indoor appliances to outdoor environments for individual homes tested will be scaled up to seven regions across California, including the San Francisco Bay Area, Sacramento, Bakersfield, Fresno, San Diego, the Greater Los Angeles region, and the North San Fernando and Santa Clarita Valleys, as described in **Task 6.1**. This will be achieved using CONTAM scenarios[2] based on data from the 2019 Residential Appliance Saturation Survey (RASS)[44] and building designs from the "Suite of Homes Representing the U.S. Housing Stock"[43, 45] as well.

Second, the contractor will retrieve TAC emission data from the U.S. EPA National Emission Inventory (NEI)[46] at the county level for both mobile and stationary sources. The most recent NEI data available are from 2017, which were released in 2020. The 2023 NEI data are currently being compiled and will not be published until March 2026. Additionally, the California Toxics Inventory (CTI)[47] developed by CARB also provides emissions estimates for various sources, including stationary sources (both individual and aggregated), areawide sources, on-road mobile sources (gasoline and diesel), off-road mobile sources (gasoline, diesel, and other), and natural sources. However, the most up-to-date CTI data available are from 2010, which were published in 2013.

Third, the contractor will estimate appliances' contribution to ambient TAC levels assuming:

1. There is a linear relationship between emission and ambient concentration of TACs.
2. The contributions of appliances and other TAC emission sources to the ambient TAC concentrations are in proportion to their emissions.

The ambient concentrations of TACs will be derived from the U.S. EPA's Ambient Monitoring Archive (AMA)[48] for hazardous air pollutants (HAPs). In California, relevant monitoring data for HAPs are available from 1990 to 2021, and the census tract ID is recorded for each monitoring site. Therefore, for the tracts with monitoring data, the estimation for each type of residential appliance will be calculated using the following equation:

$$C_k^{i,j} = \frac{E_k^{i,j}}{\sum_j E_k^{i,j} + E_k^{i,outdoor}} \times C_k^{i,ambient} \quad \text{(Eq. 2)}$$

where $C_k^{i,j}$ is the estimated contribution to the ambient concentration of TAC species *i* from appliance type *j* at the census tract *k* (μg/m^3). $E_k^{i,j}$ is the emission of air toxic species *i* from appliance type *j* at the census tract *k* (e.g., tons/year), calculated using the aforementioned emission inventory for the region in which census track *k* is located, specifically, scaled by the number of households in the census track *k* relative to the region. $E_k^{i,outdoor}$ is the emission of TAC species *i* from all outdoor sources (e.g., tons/year), calculated using the aforementioned emission inventory at county level, specifically, scaled by the area of the census tract *k* relative to the county, $C_k^{i,ambient}$ is the monitored ambient concentration of TAC species I at the census tract *k* (μg/m^3). The scaled-up estimation to the county or statewide level will be calculated by averaging the estimated concentrations across all census tracts with AMA data within a county or the state. A correlation analysis will be conducted between the estimated concentration from the above calculation and the measured outdoor concentration over two weeks from nearby recruited homes in **Task 5.1.4** across different locations to ensure similar spatial variation. These data will also be used to evaluate disparities among communities.

It should be noted that this approach assumes a linear relationship between emissions and concentrations, without considering non-linear chemical reactions, which will introduce uncertainty to the results. Nevertheless, this approach provides a rough estimate of the impact of indoor residential appliances on outdoor air quality that enables impact analysis in a relative scale. Additionally, the estimates of TAC emission inventory from residential appliances from this study also lay the foundation for future studies that might employ more sophisticated modeling techniques to quantify the contribution of TAC emissions from residential appliances to outdoor air quality.

Task 6.3 Exposure and health impact assessment

Exposure to TACs occurs through three principal pathways: inhalation, ingestion, and dermal penetration, with inhalation being the main route[49]. Therefore, the contractor will focus on inhalation exposure to TACs in the RESPECT study. The assessment of inhalation exposure, as well as the carcinogenic and non-carcinogenic risks attributable to TAC emissions from these appliances, will be conducted based on U.S.

EPA methods[50, 51], which has been deployed in some previous studies[52-55] assessing health risks attributable to gas combustions in residential settings.

Exposure and health risk assessments will be conducted separately for indoor and outdoor TAC emissions, while using the same methods. According to U.S. EPA, the inhalational exposure concentration (EC) (μg/m^3) is calculated using the following equation:

$$EC_i = C_i \times \frac{ET \times EF \times ED}{AT} \quad \text{(Eq. 3)}$$

where *i* is a specific TAC species, EC_i is the inhalation exposure concentration (μg/m^3) of a specific TAC species. C_i is the indoor or outdoor concentration (μg/m^3) from either **Tasks 6.1 or 6.2** respectively. *ET* is the exposure time (hours/day), which is the time participants spend indoors or outdoors. This information will be obtained from the survey conducted in **Task 5.3.2** and the literature review. *EF* is the exposure frequency (days/year), which is 365 days/year. *ED* is the exposure duration (years), which is 77.5 years, the life expectancy in the U.S.[56] *AT* is the averaging time. For non-carcinogens, *AT* is calculated as *ED* in years × 365 days/year × 24 hours/day. For chronic assessment of carcinogenic risk, *AT* is the potential lifetime average daily dose (LADD) with lifetime in hours substituted for *AT*. In this proposed project, since the exposure scenario involves residential settings rather than occupational facilities, it is assumed that everyone's exposure duration to emissions of both carcinogens and non-carcinogens from residential appliances will span their lifetime. Therefore, *AT* will be the same for both carcinogens and non-carcinogens.

The carcinogenic risk (CR) (unitless) will be calculated using the Equation:

$$CR_i = EC_i \times IUR_i \quad \text{(Eq. 4)}$$

where *i* is a specific TAC species, *IUR* is inhalation unit risk for the specific TAC species (μg/m^3)$^{-1}$, which is defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 μg/m^3 in air[57]. For instance, the *IUR* for formaldehyde is 1.30 × 10^{-5} (μg/m^3)$^{-1}$ [58]. The total *CR* for each home will be calculated as $\sum_{i=1}^{n} CR_i$. According to the U.S. EPA policy, a *CR* of less than 10^{-6} is considered a low or inconsequential risk. Risks that fall between 10^{-6} and 10^{-4} are uncertain, while risks greater than 10^{-4} (1:10,000) are considered actionable risks[47].

The non-carcinogenic risk will be represented by Hazard Quotient (HQ) (unitless) and calculated using the Equation:

$$HQ_i = \frac{EC_i}{RfC_i} \quad \text{(Eq. 5)}$$

where *RfC* is the chronic reference concentration (μg/m^3) for the specific TAC species, which is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime[57, 59]. For instance, the *RfC* for formaldehyde is 9.83 μg/m^3 [60, 61]. The total *HQ* for each home will be calculated as $\sum_{i=1}^{n} HQ_i$. An *HQ* value exceeding 1 indicates a significant non-carcinogenic risk, while an *HQ* value below 1 implies an acceptable level of non-carcinogenic risk[61].

Additionally, OEHHA's Proposition 65 List[62] provides relative risk factors for various health outcomes, including acute non-lymphocytic leukemia, myelodysplastic syndrome, and non-Hodgkin's lymphoma, derived from epidemiological studies. The contractor will cross-reference the analyzed TAC species in this project with the Proposition 65 List and adjust the relative risks by multiplying them by the emission rates of TACs.

Task 6.4 Community disparity analysis

Based on data collected from this study, the community disparity analysis will compare various metrics including TAC emissions, indoor and outdoor concentration attributable to these TAC emissions, and health impacts between DACs and non-DACs. This analysis will be conducted at multiple geographic levels, including the statewide, air basin, and county levels, to help understand trends at both broader and localized levels. At each geographic level, results from DACs and non-DACs will be grouped and presented using descriptive statistics including mean, standard deviation, minimum, 25th percentile, median, 75th percentile, and maximum. By examining the differences in the distribution, the contraction can identify if there are significant disparities between DACs and non-DACs at different geographic levels.

The results will be presented using both percentage differences and absolute differences to highlight the proportion and magnitude of the disparities. For example, the relative disparity in *CR* between DACs and non-DACs will be calculated using the following equation:

$$Relative\ disparity = \frac{CR_{mean,DACs} - CR_{mean,non-DACs}}{CR_{mean,non-DACs}} \times 100\% \qquad \text{(Eq. 6)}$$

where $CR_{mean,DACs}$ and $CR_{mean,non-DACs}$ are mean values of total CR for DAC homes and non-DAC homes, respectively.

Additionally, at each geographic level, the results will be presented by subgroups of demographic characteristics (e.g., race/ethnicity, income levels, ages, and education levels), household characteristics (e.g., the type of home, age of the structure, materials used in above-ground construction, fuels used in the household, ventilation systems, and the use of portable air purifiers), and activities (e.g., cooking, space and water heating, laundry, duration of portable air purifier usage, and frequency of filter replacement). These subgroups are derived from the survey conducted in **Task 5.3.2**. For example, results from different types of homes (single-family homes, multi-family homes, and manufactured homes) will be grouped together and summarized in the aforementioned statistics. This will allow people to understand the variations in emissions of TACs and their impact on air quality and health among different types of homes. For instance, the contractor can examine the difference in carcinogenic risks caused by appliance-emitted TACs for individuals residing in single-family homes compared to those living in multi-family homes in California. Similarly, the contractor will explore variation of TAC emissions and their impacts by other demographic, household, and activity factors. A comprehensive statewide analysis for various subgroups will be conducted if specific data on subgroup characteristics, along with linkable information on residential appliance prevalence and usage from literature review, is available.

Deliverables. A summary of air quality assessment and health impact results caused by the emissions from these appliances will be provided by month 24.

Task 7 Kick-off Meeting, Progress Update, Final Report and Presentation

At the beginning of the project, the contractor will hold a kick-off meeting with CARB staff to discuss the details and timeline of the project. The contractor will prepare and deliver quarterly progress reports to CARB with each invoice, containing brief narrative summaries of achievements, the state of progress relative to the plans, and any major problems encountered along with a brief description of the solutions. The contractor will hold quarterly progress update meetings with CARB staff to discuss progress, problems, and potential solutions.

The contractor will submit a copy-edited draft report to CARB for review six months before the end date of the project. The contractor will prepare and submit the revised Americans with Disabilities Act (ADA) compliant final report that addresses all comments from the TAG, CARB staff, and the public to CARB before the end date of the project. The principal investigator of the contractor team will present a seminar in plain language to the CARB staff and the public. Additionally, the contractor will provide an electronic copy of all data generated by this study to CARB.

Deliverables. A kick-off meeting will be held with CARB staff in month 1. Quarterly progress reports will be submitted to CARB staff, and quarterly progress meetings will be held throughout the project. A PI-reviewed and approved copy-edited draft final report will be provided by month 30. A revised ADA compliant final report will be provided before the contract closes. Additionally, a virtual or in-person lay-friendly seminar will be presented by the PI prior to contract close. Additional deliverables, such as fact sheets and outreach materials, are outlined in **Exhibit A1**.

Meetings

A. Initial meeting. Before work on the contract begins, the Principal Investigator and key personnel will meet with the CARB Contract Project Manager and other staff to discuss the overall plan, details of performing the tasks, the project schedule, items related to personnel or changes in personnel, and any issues that may need to be resolved before work can begin.

B. Progress review meetings. The Principal Investigator and appropriate members of his or her staff will meet with CARB's Contract Project Manager at quarterly intervals to discuss the progress of the project. This meeting may be conducted by phone.

C. Technical Seminar. The Contractor will present the results of the project to CARB staff and a possible webcast at a seminar at CARB facilities in Sacramento or El Monte.

Project Schedule

The table below shows the anticipated timeline for this project including tasks and subtasks.

ID	Task	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12
1	Literature Review												
2	Technical Advisory Group and Community Partners												
2.1	Technical Advisory Group (TAG)												
2.2	Community Partners												
3	Study Design												
4	Characterization of Representative Appliances for Testing												
5	Compositions and Emission Rates												
5.1	Methodology Development												
5.2	Home Recruitment												
5.3	Field Work												
5.4	Sample and Data Analysis												
5.5	Quality Assurance and Quality control (QA/QC)												
6	Air Quality and Health Impact Assessment												
6.1	Indoor Air Quality Assessment												
6.2	Outdoor Air Quality Assessment												
6.3	Exposure and Health Impact Assessment												
6.4	Community Disparity Analysis												
7	Kick-off Meeting, Progress Update, Final Report and Presentation												
		p m	p m	p m	p m	p m	p m	p m	p m	p m	p m d	p m	p m f

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

CONFIDENTIAL HEALTH DATA AND PERSONAL INFORMATION (OPTIONAL – For projects with Health Data and/or Personal Information)

CARB will not be provided access to and will not receive any confidential health data or other confidential personal information under this contract. Further, CARB will have no ownership of confidential health data or other confidential personal information used in connection with this contract. The entities conducting the research in this contract will follow all applicable rules and regulations regarding access to and the use of confidential health data and personal information, including the Health Insurance Portability and Accountability Act (HIPAA) and requirements related to the Institutional Review Board (IRB) process. CARB will not be a listed entity with authorized access to confidential information pursuant to the IRB process for this contract.

HEALTH AND SAFETY

Contractors are required to, at their own expense, comply with all applicable health and safety laws and regulations. Upon notice, Contractors are also required to comply with the state agency's specific health and safety requirements and policies. Contractors agree to include in any subcontract related to performance of this Agreement, a requirement that the subcontractor comply with all applicable health and safety laws and regulations, and upon notice, the state agency's specific health and safety requirements and policies.

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EXHIBIT A1 DELIVERABLES

List all items that will be delivered to the State under the proposed Scope of Work. Include all reports, including draft reports for State review, and any other Deliverables, if requested by the State and agreed to by the Parties.

If use of any Deliverable is restricted or is anticipated to contain preexisting Intellectual Property with any restricted use, it will be clearly identified in Exhibit A4, Use of Preexisting Intellectual Property & Data.

Unless otherwise directed by the State, the University Principal Investigator shall submit all deliverables to State Contract Project Manager, identified in Exhibit A3, Authorized Representatives.

Deliverable	Description	Due Date
Racial equity/implicit bias training	The Principal Investigator and key personnel must demonstrate that they have taken, or will take, cultural competency training, implicit bias training, or racial equity training, whichever is administered at their institution. Training certificates or certificates of completion completed within one (1) year prior to the agreement start date will be accepted. If the training has not been completed within one (1) year prior to the agreement start date, then the Principal Investigator and key personnel must demonstrate that they have scheduled the training within 30 days of the agreement start date and shall complete the training within 90 days of the agreement start date.	Within 90 days of the agreement start date.
Kick-off meeting	Principal Investigator and key personnel will meet with CARB Contract Project Manager and other staff to discuss the overall plan, details of performing the tasks, project schedule, items related to personnel or changes in personnel, and any issues that may need to be resolved before work can begin.	Month 1
Consultation calls	Consultation calls with CARB and key stakeholders	Monthly
TAG	Draft list of TAG members	Month 1
	Final list of TAG members	Month 6
	TAG meetings	Semiannually
Community partners	Draft list of community partners	Month 1
	Final list of community partners	Month 3
Interim reports	A draft summary of the findings from the literature review	Month 6
	A draft report summarizing the findings from the pilot study, a draft SOP for sample collection, and a draft questionnaire for home occupants	Month 10
	A draft report of appliance characteristic analysis and recommendations of the representative appliances to be tested	Month 10

	A draft report summarizing emission rates and concentrations from tested appliances	Month 22
	A draft report summarizing air quality assessment and health impact results	Month 24
Progress Reports & Meetings	Quarterly progress reports and meetings throughout the agreement term, to coincide with work completed in quarterly invoices.	Quarterly
Draft Final Report	A draft version of the Final Report detailing the purpose and scope of the work undertaken, the work performed, the results obtained and conclusions, and a Public Outreach Document and an Equity Implications Section. The Draft Final Report shall be submitted in an Americans with Disabilities Act-compliant format.	Six (6) months prior to the agreement end date.
Data	Data compilations first produced in the performance of this Agreement by the Principal investigator or the University's project personnel.	Two (2) weeks prior to the agreement end date.
Fact sheets	Fact sheets in plain language including suggestions for preventative actions, in both English and Spanish	Two (2) weeks prior to the agreement end date.
Outreach deliverables	Plain language outreach deliverables available in multiple languages for the public summarizing results and impact of this project	Two (2) weeks prior to the agreement end date.
Peer reviewed publications	Publicly available peer-reviewed publications: Submission-ready publications shall be reviewed by CARB staff	Two (2) weeks prior to the agreement end date.
Technical Seminar	Presentation of the results of the project to CARB staff and a possible webcast at a seminar at CARB facilities in Sacramento or El Monte. The Technical Seminar slides shall be submitted in an Americans with Disabilities Act-compliant format.	On or before the agreement end date.
The following Deliverables are subject to paragraph 19. Copyrights, paragraph B of Exhibit C		
Final Report	A written record of the project and its results. The Final Report shall be submitted in an Americans with Disabilities Act-compliant format. The Public Outreach Document and Equity Implications Section, as described in Exhibit A1, Section 2, shall be incorporated into the Final Report.	Two (2) weeks prior to the agreement end date.

1. Reports and Data Compilations

A. With respect to each invoice period University shall submit, to the CARB Contract Project Manager, one (1) electronic copy of the progress report. When emailing the progress report, the "subject line" should state the contract number and the billing period. Each progress report must accompany a related invoice covering the same billing period. Each progress report will begin with the following disclaimer:

The statements and conclusions in this report are those of the University and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

B. Each progress report will also include:

1. A brief summary of the status of the project, including whether the project is on schedule. If the project is behind schedule, the progress report must contain an explanation of reasons and how the University plans to resume the schedule.

2. A brief narrative account of project tasks completed or partially completed since the last progress report.

3. A brief discussion of problems encountered during the reporting period and how they were or are proposed to be resolved.

4. A brief discussion of work planned, by project task, before the next progress report. and

5. A graph or table showing percent of work completion for each task.

C. Six (6) months prior to Agreement expiration date, University will deliver to CARB an electronic copy of the draft final report in both PDF and Microsoft Word formats. The draft final report will conform to Exhibit A1, Section 2 – Research Final Report Format.

D. Within forty-five (45) days of receipt of CARB's comments, University will deliver to CARB's Contract Project Manager an electronic copy of the final report incorporating all reasonable alterations and additions. Within two (2) weeks of receipt of the revised report, CARB will verify that all CARB comments have been addressed. Upon acceptance of the amended final report approved by CARB in accordance to Exhibit A1, Section 2 – Research Final Report Format, University will within two (2) weeks, deliver to CARB an electronic copy of the final report in both PDF and Microsoft Word formats.

E. As specified in Exhibit A1, Section 2, Final Report will be submitted in an Americans with Disabilities Act compliant Format.

F. Together with the final report, University will deliver a set of all data compilations as specified in Exhibit A1 – Schedule of Deliverables.

G. University's obligation under this Agreement shall be deemed discharged only upon submittal to CARB of an acceptable final report in accordance to Exhibit A1, Section 2 – Research Final Report Format, all required data compilations, and any other project deliverables.

2. Research Final Report Format

The research contract Final Report (Report) is as important to the contract as the research itself. The Report is a record of the project and its results and is used in several ways. Therefore, the

Report must be well organized and contain certain specific information. The CARB's Research Screening Committee (RSC) reviews all draft final reports, paying special attention to the Abstract and Executive Summary. If the RSC finds that the Report does not fulfill the requirements stated in this Exhibit, the RSC may not recommend release, and final payment for the work completed may be withheld. This Exhibit outlines the requirements that must be met when producing the Report.

Note: In partial fulfillment of the Final Report requirements, the Contractor shall submit a copy of the Report in PDF format and in a word-processing format, preferably in Word – Version 6.0 or later. The electronic copy file name shall contain the CARB contract number, the words "Final Report", and the date the report was submitted.

Accessibility. To maintain compliance with California Government Code Sections 7405 and 11135, and Web Content Accessibility Guidelines, Assembly Bill No. 434, the final Report must be submitted in an Americans with Disabilities Act compliant format. The Final Report will be posted on the CARB website and therefore must be in an accessible format so that all members of the public can access it.

Watermark. Each page of the draft Report must include a watermark stating "DRAFT." The revised report should not include any watermarks.

Title. The title of the Report should exactly duplicate the title of the contract. However, minor changes to the title may be approved provided the new title does not deviate from the old title. These minor changes must be approved in writing by the contract manager. Significant changes to the title would require a formal amendment.

Page size. All pages should be of standard size (8 ½" x 11") to allow for photo-reproduction.

Corporate identification. Do not include corporate identification on any page of the Final Report, except the title page.

Unit notation. Measurements in the Reports should be expressed in metric units. However, for the convenience of engineers and other scientists accustomed to using the British system, values may be given in British units as well in parentheses after the value in metric units. The expression of measurements in both systems is especially encouraged for engineering reports.

Section order. The Report should contain the following sections, in the order listed below:

Title page
Disclaimer
Acknowledgment (1)
Acknowledgment (2)
Table of Contents
List of Figures
List of Tables
Abstract
Public Outreach Document
Executive Summary
Equity Implications Section
Body of Report
References
List of inventions reported and copyrighted materials produced

Glossary of Terms, Abbreviations, and Symbols
Appendices

Page numbering. Beginning with the body of the Report, pages shall be numbered consecutively beginning with “1”, including all appendices and attachments. Pages preceding the body of the Report shall be numbered consecutively, in ascending order, with small Roman numerals.

Title page. The title page should include, at a minimum, the contract number, contract title, name of the principal investigator, contractor organization, date, and this statement:
"Prepared for the California Air Resources Board and the California Environmental Protection Agency"

Disclaimer. A page dedicated to this statement must follow the Title Page:

> The statements and conclusions in this Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

Acknowledgment (1). Only this section should contain acknowledgments of key personnel and organizations who were associated with the project. The last paragraph of the acknowledgments must read as follows:

> This Report was submitted in fulfillment of [CARB contract number and project title] by [contractor organization] under the [partial] sponsorship of the California Air Resources Board. Work was completed as of [date].

Acknowledgment (2). Health reports should include an acknowledgment to the late Dr. Friedman. Reports should include the following paragraph:

> This project is funded under the CARB’s Dr. William F. Friedman Health Research Program. During Dr. Friedman’s tenure on the Board, he played a major role in guiding CARB’s health research program. His commitment to the citizens of California was evident through his personal and professional interest in the Board’s health research, especially in studies related to children’s health. The Board is sincerely grateful for all of Dr. Friedman’s personal and professional contributions to the State of California.

Table of Contents. This should list all the sections, chapters, and appendices, together with their page numbers. Check for completeness and correct reference to pages in the Report.

List of Figures. This list is optional if there are fewer than five illustrations.

List of Tables. This list is optional if there are fewer than five tables.

Abstract. The abstract should tell the reader, in nontechnical terms, the purpose and scope of the work undertaken, describe the work performed, and present the results obtained and conclusions. The purpose of the abstract is to provide the reader with useful information and a means of determining whether the complete document should be obtained for study. The length of the abstract should be no more than about 200 words. Only those concepts that are addressed in the executive summary should be included in the abstract.

Example of an abstract:

A recently developed ground-based instrument, employing light detecting and ranging (lidar) technology, was evaluated, and found to accurately measure ozone concentrations at altitudes of up to 3,000 meters. The novel approach used in this study provides true vertical distributions of ozone concentrations aloft and better temporal coverage of these distributions than other, more common methods, such as those using aircraft and ozonesonde (balloon) techniques. The ozone and aerosol measurements from this study, in conjunction with temperature and wind measurements, will provide a better characterization of atmospheric conditions aloft and the processes involved in the formation of unhealthful ozone concentrations than can be achieved with traditional ground-based monitors.

Public Outreach Document. The public outreach document is a one-page document that will be widely used to communicate, in clear and direct terms, the key research findings from the study to the public. CARB will be translating the document into other languages. This document must adhere to the following guidelines:

- Single space, limited to one-page or about 500 words.
- Use narrative form and active voice.
- Incorporate a graphic that it is easy to interpret and captures the results' central message.
- Avoid jargon and technical terms. Use a style and vocabulary level comparable to that of sixth grade reading level.
- The document should contain a title and the following five sections: Issue/s, Main Question, Key Research Findings, Conclusion/s, and More Information. Guidance on how to write these sections is described below.

  TITLE: Adopt a short, non-technical title to make the topic clear and concise. The title will likely differ from the original title of the contract.

  ISSUE/S: In one to two paragraphs, describe why the project was needed. In this section, identify the problem leading to this study and what the study was set to accomplish to help address the problem. Reference any history that is relevant such as a regulation, legislation, program, law, or other. Without going into detail and disclosing the research findings, mention the methods used in the study and how it informed the results.

  MAIN QUESTION: Present a concise central research question driving this project.

  KEY RESEARCH FINDING/S: This section covers the key research findings. List key points and or findings.

  CONCLUSION/S: In one to two paragraphs, discuss how the results could be used. Mention its relevance to policies, rules, regulations, legislations, or CARB programs. Include suggestions for next steps, additional research, or other actions.

  MORE INFORMATION: In two to three short sentences provide specifics about the study. This section should include the full title of the study, sponsor, authors, and where the full report can be found (the final report will be posted on the CARB website). In addition to a direct contact to gain more information (author and CARB contract manager).

Executive Summary. The function of the executive summary is to inform the reader about the important aspects of the work that was done, permitting the reader to understand the research without reading the entire Report. It should state the objectives of the research and briefly describe the experimental methodology[ies] used, results, conclusions, and recommendations for further study. All of the concepts brought out in the abstract should be expanded upon in the Executive Summary. Conversely, the Executive Summary should not contain concepts that are not expanded upon in the body of the Report.

The Executive Summary will be used in several applications as written; therefore, please observe the style considerations discussed below.

Limit the Executive Summary to two pages, single spaced.

Use narrative form. Use a style and vocabulary level accessible to the general audience. Assume the audience is being exposed the subject for the first time.

Do not list contract tasks in lieu of discussing the methodology. Discuss the results rather than listing them.

Avoid jargon.

Define technical terms.

Use passive voice if active voice is awkward.

Avoid the temptation to lump separate topics together in one sentence to cut down on length.

The Executive Summary should contain four sections: Background, Objectives and Methods, Results, and Conclusions, described below.

THE BACKGROUND SECTION. For the Background, provide a one-paragraph discussion of the reasons the research was needed. Relate the research to the Board's regulatory functions, such as establishing ambient air quality standards for the protection of human health, crops, and ecosystems; the improvement and updating of emissions inventories; and the development of air pollution control strategies.

THE OBJECTIVES AND METHODS SECTION. At the beginning of the Objectives and Methods section, state the research objectives as described in the contract. Include a short, one or two sentences, overview of what was done in general for this research.

The methodology should be described in general, nontechnical terms, unless the purpose of the research was to develop a new methodology or demonstrate a new apparatus or technique. Even in those cases, technical aspects of the methodology should be kept to the minimum necessary for understanding the project. Use terminology with which the reader is likely to be familiar. If it is necessary to use technical terms, define them. Details, such as names of manufacturers and statistical analysis techniques, should be omitted.

Specify when and where the study was performed if it is important in interpreting the results. The findings should not be mentioned in the Objectives and Methods section.

THE RESULTS SECTION. The Results section should be a single paragraph in which the main findings are cited, and their significance briefly discussed. The results should be presented as a narrative, not a list. This section must include a discussion of the implications of the work for the Board's relevant regulatory programs.

THE CONCLUSIONS SECTION. The Conclusions section should be a single short paragraph in which the results are related to the background, objectives, and methods. Again, this should be presented as a narrative rather than a list. Include a short discussion of recommendations for further study, adhering to the guidelines for the Recommendations section in the body of the Report.

Equity Implication Section. The equity implications section should summarize how the research results inform disparate impacts of policies, regulations, or programs on priority communities. [1] This section should summarize how sociodemographic factors were examined in this research. Given the data used or collected, which populations are excluded or overrepresented? How were relevant communities engaged in the research effort and/or how were existing data gaps identified and ground-truthed during the research project? If ground-truthed data were found to not accurately reflect the lived experiences of community members, what future research projects could address this disconnect. The research results should inform existing or future CARB programs and the equity implications section should discuss how the research results may inform programs to close disparities in health outcomes, pollutant exposure or climate adaptation, etc., for priority communities. This section should be limited to a maximum of two (2) pages, single spaced and shall include the following sections.

HISTORICAL ANALYSIS. Provide an overview of the inequities and disparities observed in the existing data or data gathered during the research and how it ties to historic policies. For example, what is the root-cause of the disparity being experienced by the community or population central to this research?

MATERIALS AND METHODS. Describe how this research project examines racial equity. Some methods can include but are not limited to: examining the potential for existing data to address racial inequalities, ground-truthing existing data, engaging priority communities, assessments for racial and ethnic subgroups in the development of data and approaches, identifying data gaps and filling those gaps.

RESULTS AND DISCUSSION. Describe how the results improve our understanding of the equity issues identified or interventions to address those inequalities .

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[1] Priority communities here encompasses various terms CARB uses such as priority populations[2], communities of concern[3], protected classes[4], or disadvantaged communities[5].

[2] Priority Populations — California Climate Investments

[3] Referenced from the California Public Utilities Commission Environmental and Social Justice Plan an effort resulting from California's Capitol Collaborative on Race & Equity.

[4] Protected Classes | California State Senate

[5] SB-535-Designation-Final.pdf (ca.gov) ; California Climate Investments to Benefit Disadvantaged Communities | CalEPA; CalEnviroScreen 4.0 | OEHHA

Body of Report. The body of the Report should contain the details of the research, divided into the following sections:[2]

INTRODUCTION. Clearly identify the scope and purpose of the project. Provide a general background of the project. Explicitly state the assumptions of the study.

Clearly describe the hypothesis or problem the research was designed to address. Discuss previous related work and provide a brief review of the relevant literature on the topic.

MATERIALS AND METHODS. Describe the various phases of the project, the theoretical approach to the solution of the problem being addressed, and limitations to the work. Describe the design and construction phases of the project, materials, equipment, instrumentation, and methodology.
Describe quality assurance and quality control procedures used. Describe the experimental or evaluation phase of the project.

RESULTS. Present the results in an orderly and coherent sequence. Describe statistical procedures used and their assumptions. Discuss information presented in tables, figures, and graphs. The titles and heading of tables, graphs, and figures, should be understandable without reference to the text. Include all necessary explanatory footnotes. Clearly indicate the measurement units used.

DISCUSSION. Interpret the data in the context of the original hypothesis or problem. Does the data support the hypothesis or provide solutions to the research problem? If appropriate, discuss how the results compare to data from similar or related studies. What are the implications of the findings?

Identify innovations or development of new techniques or processes. If appropriate, discuss cost projections and economic analyses.

SUMMARY AND CONCLUSIONS. This is the most important part of the Report because it is the section that will probably be read most frequently. This section should begin with a clear, concise statement of what, why, and how the project was done. Major results and conclusions of the study should then be presented, using clear, concise statements. Make sure the conclusions reached are fully supported by the results of the study. Do not overstate or overinterpret the results. It may be useful to itemize primary results and conclusions. A simple table or graph may be used to illustrate.

RECOMMENDATIONS. Use clear, concise statements to recommend (if appropriate) future research that is a reasonable progression of the study and can be supported by the results and discussion.

References. Use a consistent style to fully cite work referenced throughout the Report and references to closely related work, background material, and publications that offer additional information on aspects of the work. Please list these together in a separate section, following the body of the Report. If the Report is lengthy, you may list the references at the end of each chapter.

List of inventions reported and publications produced. If any inventions have been reported, or

[2] Note that if the research employs multiple distinct methods, analyses, etc., the final report can include separate materials/methods, results, and discussion sections to allow for coherent discussion of each set of analyses and findings. However, the executive summary and conclusions sections should synthesize the collective findings of the entire study.

publications or pending publications have been produced as a result of the project, the titles, authors, journals or magazines, and identifying numbers that will assist in locating such information should be included in this section.

Glossary of terms, abbreviations, and symbols. When more than five of these items are used in the text of the Report, prepare a complete listing with explanations and definitions. It is expected that every abbreviation and symbol will be written out at its first appearance in the Report, with the abbreviation or symbol following in parentheses [i.e., carbon dioxide (CO2)]. Symbols listed in table and figure legends need not be listed in the Glossary.

Appendices. Related or additional material that is too bulky or detailed to include within the discussion portion of the Report shall be placed in appendices. If a Report has only one appendix, it should be entitled "APPENDIX". If a Report has more than one appendix, each should be designated with a capital letter (APPENDIX A, APPENDIX B). If the appendices are too large for inclusion in the Report, they should be collated, following the binding requirements for the Report, as a separate document.

The contract manager will determine whether appendices are to be included in the Report or treated separately. Page numbers of appendices included in the Report should continue the page numbering of the Report body. Pages of separated appendices should be numbered consecutively, beginning at “1”.

3. Other Deliverables

A. Any other deliverables shall be provided in a mutually agreed upon format unless the deliverable format is already specified in Exhibit A.

EXHIBIT A2

KEY PERSONNEL

List Key Personnel as defined in the Agreement starting with the PI, by last name, first name followed by Co-PIs. Then list all other Key Personnel in alphabetical order by last name. For each individual listed include his/her name, institutional affiliation, and role on the proposed project. Use additional consecutively numbered pages as necessary.

Last Name, First Name	**Institutional Affiliation**	**Role on Project**
Principal Investigator (PI):		
Li, Jing	University of California, Los Angeles	PI
Co-PI(s) – if applicable:		
Zhu, Yifang	University of California, Los Angeles	Co-PI
Other Key Personnel:		
Plumb, Marj	San Francisco Bay Physicians for Social Responsibility (SF Bay PSR)	Site-PI
Tyner, Tim	Central California Asthma Collaborative (CCAC)	Site-PI

EXHIBIT A4 **USE OF INTELLECTUAL PROPERTY & DATA**

If either Party will be using any third-party or pre-existing intellectual property (including, but not limited to copyrighted works, known patents, trademarks, service marks and trade secrets) "IP" and/or Data with restrictions on use, then list all such IP/Data and the nature of the restriction below. If no third-party or pre-existing IP/Data will be used, check "none" in this section.

A. State: Preexisting Intellectual Property (IP)/Data to be provided to the University from the State or a third party for use in the performance in the Scope of Work.

☒ None or ☐ List:

Owner (State Agency or 3rd Party)	Description	Nature of restriction:

B. University: Restrictions in Preexisting IP/Data included in Deliverables identified in Exhibit A1, Deliverables.

☒ None or ☐ List:

Owner (University or 3rd Party)	Description	Nature of restriction:

C. Anticipated restrictions on use of Project Data.

If the University PI anticipates that any of the Project Data generated during the performance of the Scope of Work will have a restriction on use (such as subject identifying information in a data set), then list all such anticipated restrictions below. If there are no restrictions anticipated in the Project Data, then check "none" in this section.

☒ None or ☐ List:

Owner (State Agency or 3rd Party)	Description	Nature of restriction:

EXHIBIT A5

RÉSUMÉ / BIOSKETCH

Attach 2-3 page Résumé/Biosketch for Key Personnel listed in Exhibit A2

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Li, Jing

POSITION TITLE: Associate Project Scientist

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of Science & Technology, Beijing, Beijing, China	B.S.	06/2013	Environmental Engineering
Peking University, Beijing, China	Ph.D.	07/2018	Environmental Science

Personal Statement

I am currently an Associate Project Scientist in the Department of Environmental Health Sciences at the University of California, Los Angeles (UCLA) Fielding School of Public Health. Previously, I worked as a postdoctoral researcher here. Before joining UCLA, I worked as a postdoctoral researcher in the Department of Environmental Science and Engineering at the California Institute of Technology (Caltech). I earned my Ph.D. in Environmental Science from the Peking University, China. My current focus revolves around the exposure, health effects, and mitigation of indoor air pollution, along with investigating how climate change impacts public health. More broadly, my research interests also include bioaerosols, particularly exploring airborne transmission and mitigation strategies for pathogens. I have published 24 peer-reviewed papers in top journals in the field, including *Environmental Science and Technology*, *Clinical Infectious Diseases*, and *Atmospheric Environment*, to name a few. I am the first/co-first/co-corresponding author on 10 papers and a co-author on another 14 papers. In 2019, I was honored with the prestigious Sheldon K. Friedlander Award from the American Association for Aerosol Research (AAAR) for my outstanding doctoral dissertation in aerosol science and technology.

Some of the projects I would like to highlight are as follows:

<u>Ongoing</u>

California Air Resources Board (CARB), 22RD026
Li, J. (Postdoctoral Researcher, Key Personnel)
2023.06-2025.05
Indoor Air Quality in California: New Evidence and Environmental Justice

<u>Completed</u>

Bill & Melinda Gates Foundation, INV-030223
Li, J. (Postdoctoral Researcher, Key Personnel)
2021.04-2021.09
COVID-19: mgLAMP for SARS-CoV-2 Phase 2 - Transition and Field-Testing

Bill & Melinda Gates Foundation, INV-018569
Li, J. (Postdoctoral Researcher, Key Personnel)
2020.06-2020.10
To develop an assay that could be used to enable rapid quantification of SARS-CoV-2 pathogens in

wastewater

Citations

The following publications are related to this proposal and supply relevant exposure assessment and health effects assessment:

# denotes equal contribution, * denotes corresponding author.

1. Tiancong Ma, Haoxuan Chen, Yu-Pei Liao, Jiulong Li, Xiang Wang, Liqiao Li, **Jing Li**, Yifang Zhu*, Tian Xia* (2023), Differential toxicity of electronic cigarette aerosols generated from different generations of devices in vitro and in vivo, *Environment & Health*, 1 (5): 315-323.
2. **Jing Li**, Haoxuan Chen, Xinyue Li, Minfei Wang, Xiangyu Zhang, Junji Cao*, Fangxia Shen, Yan Wu, Siyu Xu, Hanqing Fan, Guillaume Da, Rujin Huang, Jing Wang, Chak K. Chan, Alma Lorelei de Jesus, Lidia Morawska, Maosheng Yao* (**2019**), Differing toxicity of ambient particulate matter (PM) in global cities, *Atmospheric Environment*, 212, 305-315.
3. Haoxuan Chen, **Jing Li**, Xiangyu Zhang, Xinyue Li, Maosheng Yao*, Gengfeng Zheng* (**2018**), Automated *in vivo* nano-sensing of breath-borne protein biomarkers, *Nano Letters*, 18: 4716-4726.
4. **Jing Li**, Liantong Zhou, Xiangyu Zhang, Caijia Xu, Liming Dong*, Maosheng Yao* (**2016**), Bioaerosol emissions and detection of airborne antibiotic resistance genes from a wastewater treatment plant, *Atmospheric Environment*, 124, 404-412.
5. Kai Wei#, Yunhao Zheng#, **Jing Li#**, Fangxia Shen, Zhuanglei Zou, Hanqing Fan, Xinyue Li, Chang-yu Wu, Maosheng Yao* (**2015**), Microbial aerosol characteristics in highly polluted and near pristine environments featuring different climatic conditions, *Science Bulletin*, 60 (16):1439-1447.

B. Positions, Scientific Appointments, and Honors

Positions and Scientific Appointments

2023.09-	Associate Project Scientist, Department of Environmental Health Science, Fielding School of Public Health, University of California, Los Angeles
2022.09-2023.09	Postdoctoral Researcher, Department of Environmental Health Science, Fielding School of Public Health, University of California, Los Angeles
2018.09-2022.09	Postdoctoral Researcher, Department of Environmental Science and Engineering, Division of Engineering and Applied Science, California Institute of Technology

Honors

2019	Sheldon K. Friedlander Award, American Association for Aerosol Research
2019	CEMI Training and Travel Grants, California Institute of Technology
2016	Exceptional Award for Academic Innovation, Peking University
2016	Gao Tingyao Scholarship for National Outstanding PhD student Award, Tongji University
2016	Presidential Scholarship, Peking University
2015	Special Scholarship for PhD Students, Peking University
2015	Outstanding Student Award, Peking University
2015	Tang Xiaoyan Environmental Science and Innovation Scholarships, Peking University
2014	Special Scholarship for PhD Students, Peking University
2014	Outstanding Student Award, Peking University
2014	National Scholarship for PhD Students, the Chinese Ministries of Education and Finance

C. Contributions to Science

1. **Revealed significant differences in particulate matter (PM)-contained microbial contents and PM toxicity**. Air quality is often assessed using PM mass concentration without considering PM toxicity, which can lead to improper control policies and inadequate health protection. I uncovered the geographical heterogeneity of PM toxicity and found that PM toxicity was influenced by microbial fractions such as endotoxin and fungi, highlighting the importance of optimizing current air quality control measures by considering the toxicity factor and its microbial constituents.
   a. **Jing Li**, Haoxuan Chen, Xinyue Li, Minfei Wang, Xiangyu Zhang, Junji Cao*, Fangxia Shen, Yan Wu, Siyu Xu, Hanqing Fan, Guillaume Da, Rujin Huang, Jing Wang, Chak K. Chan, Alma Lorelei de Jesus, Lidia Morawska, Maosheng Yao* (**2019**), Differing toxicity of ambient particulate matter (PM) in global cities, *Atmospheric Environment*, 212, 305-315.
   b. Haoxuan Chen, **Jing Li**, Xiangyu Zhang, Xinyue Li, Maosheng Yao*, Gengfeng Zheng* (**2018**), Automated *in vivo* nano-sensing of breath-borne protein biomarkers, *Nano Letters*, 18: 4716-4726.
   c. Kai Wei#, Yunhao Zheng#, **Jing Li#**, Fangxia Shen, Zhuanglei Zou, Hanqing Fan, Xinyue Li, Chang-yu Wu, Maosheng Yao* (**2015**), Microbial aerosol characteristics in highly polluted and near pristine environments featuring different climatic conditions, *Science Bulletin*, 60 (16):1439-1447.
2. **Uncovered, for the first time, that global urban air is contaminated with antibiotic resistance genes (ARGs)**. I used a self-established auto air conditioning filter method to collect PM samples from 19 cities worldwide. This study revealed, for the first time, that ARGs are widely spread via the airborne route in urban atmosphere. The global geographical disparity in PM-borne ARG loadings was found to be up to two orders of magnitude. This work was featured on the cover of *Environmental Science & Technology* (*ES&T*), selected as an American Chemical Society (ACS) Editors' Choice, and awarded one of the 11 best *ES&T* papers of 2018. Additionally, it was featured by ACS as an "Embargoed Press Release" and by the American Association for the Advancement of Science (AAAS).
   a. **Jing Li**, Junji Cao, Yongguan Zhu, Qinglin Chen, Fangxia Shen, Yan Wu, Siyu Xu, Hanqing Fan, Guillaume Da, Rujin Huang, Jing Wang, Alma Lorelei de Jesus, Lidia Morawska, Chak K. Chan, Jordan Peccia, Maosheng Yao* (**2018**), Global survey of antibiotic resistance genes in air, *Environmental Science & Technology*, 52: 10975-10984.
   b. **Jing Li**, Liantong Zhou, Xiangyu Zhang, Caijia Xu, Liming Dong*, Maosheng Yao* (**2016**), Bioaerosol emissions and detection of airborne antibiotic resistance genes from a wastewater treatment plant, *Atmospheric Environment*, 124, 404-412.
3. **Developed a rapid, portable, and *in situ* detection method for in-field absolute quantification of environmental SARS-CoV-2 and bacterial pathogens in wastewater**. In my role as a Postdoc at Caltech, I led a sub-group dedicated to developing and implementing portable and rapid microbial detection methods for regions with limited resources. I successfully developed the novel membrane-based in-gel loop-mediated isothermal amplification (mgLAMP) system (US Patent Number US20220162686A1), addressing the shortcomings of current gold standard methods that require advanced equipment and highly skilled laboratory personnel. The mgLAMP technology was awarded as the Non-PCR Winner in the Rapid Wastewater SARS-CoV-2 Testing Challenge hosted by the Water Environmental Foundation (WEF). Additionally, the mgLAMP technology has been licensed by Z-Field Technology LLC.
   a. Yanzhe Zhu, Xunyi Wu, Alan Gu, Leopold Dobelle, Clément A. Cid, **Jing Li***, Michael R. Hoffmann* (**2022**), Membrane-based in-gel loop-mediated isothermal amplification (mgLAMP) system for SARS-CoV-2 quantification in environmental waters, *Environmental Science & Technology*, 56 (2): 862–873.
   b. **Jing Li**, Yanzhe Zhu, Xunyi Wu, Michael R Hoffmann* (**2020**), Rapid detection methods for bacterial pathogens in ambient waters at the point of sample collection: A brief review, *Clinical Infectious Diseases*, 71 (Supplement_2): S84-S90.

Complete list of my published work on Google Scholar:

https://scholar.google.com/citations?hl=en&user=C3ykF0AAAAAJ

RESUME

Yifang Zhu, Ph.D.
Professor, Department of Environmental Health Sciences
University of California, Los Angeles, CA 90095-9565

Professional Preparation

University of California, Los Angeles	Environmental Health Sciences	Ph.D.	2003
Kwangju Institute of Science & Technology, South Korea	Environmental Science & Engineering	M.S.	1999
Tsinghua University, China	Environmental Engineering	B. Eng.	1997

Major Research Interests

Air pollution, exposure and health effects, indoor air quality, mobile source emissions, climate change co-benefits, aerosol characterization

Professional Appointments

2016 – present Professor, Environmental Health Sciences, UCLA
2018 – 2023 Academic Dean, Fielding School of Public Health, UCLA
2012 – 2016 *Associate Professor,* Environmental Health Sciences, UCLA
2010 – 2012 *Assistant Professor,* Environmental Health Sciences, UCLA
2006 – 2010 *Assistant Professor,* Environmental Engineering, Texas A&M University, Kingsville
2005 – 2006 *Assistant Professor in Residence,* Environmental Health Sciences, UCLA
2003 – 2005 *Post-doctoral Researcher,* Environmental Health Sciences, UCLA

Representative Publications from 150+ Peer-reviewed Journal Articles

1. Qiao Yu, Yueshuai He, Jiaqi Ma, and Yifang Zhu, "California's zero-emission vehicle adoption brings air quality benefits yet equity gaps persist" (2023), Nature Communications, in press.
2. Julia C. Fussella, Meredith Franklin, David C. Green, Mats Gustafsson, Roy M. Harrisond,, William Hicks, Frank J. Kelly, Franceska Kishta, Mark R. Miller, Ian S. Mudway, Farzan Oroumiyeh, Liza Selley, Meng Wang, and Yifang Zhu, "A review of road traffic-derived non-exhaust particles: emissions, physicochemical characteristics, health risks and mitigation measures" (2022), Environ Sci. Technol., 7;56(11):6813-6835. doi: 10.1021/acs.est.2c01072.
3. Jonathan Liu, Jonah Lipsitt, Michael Jerrett, and Yifang Zhu "Decreases in near-road NO and NO_2 concentrations during the COVID-19 pandemic in California" (2021), Environ. Sci. Technol. Lett., 8, 2, 161–167 https://doi.org/10.1021/acs.estlett.0c00815.
4. Rachel Connolly, Gregory Pierce, Julien Gattaciecca, and Yifang Zhu "Estimating Mortality Impacts from Vehicle Emission Reduction Efforts: The Tune In and Tune Up Program in the San Joaquin Valley", (2020), Transportation Research Part D: Transport and Environment, 78: 102190.
5. Tianyang Wang, Zhe Jiang, Bin Zhao, Yu Gu, Kuo-Nan Liou, Nesamani Kalandiyur, Da Zhang, and Yifang Zhu, "Health Co-benefits of Roadmap towards Sustainable Net-zero

Greenhouse Gas Emissions in California", (2020), Nature Sustainability, https://doi.org/10.1038/s41893-020-0520-y.
6. Bin Zhao, Tianyang Wang, Zhe Jiang, Yu Gu, Kuo-Nan Liou, Nesamani Kalandiyur, Yang Gao, and Yifang Zhu, "Air quality and health co-benefits of different deep decarbonization pathways in California", (2019), Environmental Science and Technology, Volume 53, 12, Pages 7163-7171.
7. Eon S Lee.; Dilhara R Ranasinghe; Faraz Enayati Ahangar; Seyedmorteza Amini; Steven Mara; Wonsik Choi; Suzanne Paulson; Yifang Zhu, "Field evaluation of vegetation and noise barriers for mitigation of near-freeway air pollution under variable wind conditions", (2018), Atmospheric Environment, Volume 175, p. 92-99.
8. Shu, S., Batteate, C., Cole, B., Froines, J., and Yifang Zhu (2016). "Air quality impacts of a CicLAvia event in Downtown Los Angeles, CA", Environmental Pollution 208, Part A: 170– 176.
9. Shi Shu, Pu Yang, and Yifang Zhu "Correlation of noise levels and particulate matter concentrations near two major freeways in Los Angeles, California" (2014), Environmental Pollution, 193: 130 – 137.
10. Yifang Zhu, W. C. Hinds, et al. (2002). "Concentration and size distribution of ultrafine particles near a major highway." Journal of the Air & Waste Management Association 52(9): 1032-1042.
11. Yifang Zhu, W. C. Hinds, et al. (2002). "Study of ultrafine particles near a major highway with heavy-duty diesel traffic." Atmospheric Environment 36: 4323-4335.

Honors, Awards, Affiliations

- Outstanding Reviewer Award – Aerosol Science and Technology, 2021
- Faculty of the Year – UCLA Sustainability Green Gala Awards, 2021
- Haagen-Smit Prize – Atmospheric Environment, 2011
- National Science Foundation Faculty Early Career Development (CAREER) Award, 2009
- The Health Effects Institute Walter A. Rosenblith New Investigator Award, 2007
- Delta-Omega Honorary Society for Graduate Studies in Public Health, 2003
- UCLA Samuel J. Tibbitts Award, 2002
- UCLA Chancellor's Fellowship, 1999–2002

Synergistic Activities

1. Serving as technical advisor for an environmental advocacy organization, Coalition for a Safe Environment.
2. Outreach to communities and schools located in the environmental justice area to educate public about air pollution and related health effects.
3. Trained community members on how to use air quality sampling equipment including low- cost air sensors to assess their exposures and advocate for their communities.
4. Supervision of many women underrepresented undergraduate students, and high school students in research activities at UCLA.

BIOGRAPHICAL SKETCH

NAME Marjorie Jane Plumb	POSITION TITLE Owner and Principal
eRA COMMONS USER NAME marjplumb	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
University of San Francisco	BPA	1986	Public Administration
University of San Francisco	MNA	1989	Nonprofit Administration
University of California, Berkeley	DrPH	2006	Public Health (focus on Public Policy and Community-Based Participatory Research)

A. Personal Statement

I have over 45 years' experience working in diverse communities, specifically on public health issues. My professional and academic training blend together to make me a highly experienced consultant for projects seeking to bridge the community-researcher divide. I have developed and directed multiple training programs that bring researchers, community representatives, health care providers and others to form partnerships to forward health and social policy agendas. As a well-qualified consultant on designing, fostering, and evaluating Community-Based Participatory Research (CBPR) studies, I have worked with over fifty CBPR research teams to strengthen their partnerships and study plans. I have a curriculum development certification in Online Teaching and Learning (OTL) and am a certified practitioner of the Myers-Briggs Type Indicator (Step I and Step II). I am also a professional coach working with executive directors of nonprofit organizations having received my coaching training from the Coaches Training Institute and the Co-Active Leadership Program and advanced coaching training on teams and organizational development from The Center for Right Relationship. I have also been awarded the Professional Coach Certificate from the International Coach Federation.

B. Positions and Honors

Positions and Employment, 2000 - current

2013 Adjunct Professor, San Francisco State University, San Francisco, CA
2015 – 2019 Director, Coalition for a Strong Nebraska, Omaha, NE
2020 – 2021 Interim Executive Director, Breast Cancer Action, San Francisco, CA
1998 – present Owner and Principal, Plumbline Coaching and Consulting, Inc, Washington, DC
1999 – present Executive Director, San Francisco Bay Physicians for Social Responsibility, San Francisco, CA

Public Service, 2000 - current

2001 – 2002 Co-Coordinator, National LGBTI Health Conference
2006 – 2007 Vice Chair, Women's Health Council, California Department of Health Services
2007 Grant Peer Review, Academic Community Partnership Program, University of California San Francisco National Center of Excellence in Women's Health
2007 – 2008 Chair, Women's Health Council, California Departments of Health Care Services and Public Health
2008 – 2012 Reviewer, University Community Partnerships Program, University of California, San Francisco
2008 – 2012 Reviewer, University Community Partnerships Program, University of California, San Francisco
2007 – 2014 Advisory Council Member, Lesbian Health & Research Center, University of California, San Francisco
2011 – 2016 Reviewer, National Institute of Environmental Health Sciences, P30 Core Center Applications, NC
2011 – 2016 Chair, Board of Directors, Lyon-Martin Health Services, San Francisco, CA
2018 – 2019 Member, Equality Fund Review Committee, Omaha, NE
2004 – 2020 Member, Board of Directors, Woman Vision, San Francisco, CA
2017 – 2024 Member, Women's Preventive Services Initiative, the American College of Obstetricians and

	Gynecologists, Washington, DC
2017 – 2022	Member, Board of Directors, ACLU, Nebraska, Lincoln, NE
2019 – 2022	Chair, Board of Directors, ACLU, Nebraska, Lincoln, NE
2020 – 2022	Member, Board of Directors, Equal Play: Inspiring Confidence (EPIC)
2022 – present	Member, Board of Directors, New Left Accelerator

Honors and Awards, 2000 - current

2000	Proclamation of "Marj Plumb Day" from San Francisco Mayor Willie Brown
2002	Gay Men's Health Crisis, New York, NY, for leadership in the fight against AIDS
2008	California Department of Health Care Services, Certificate of Appreciation
2013	Cindy Marano Leadership Award, Women's Foundation of California
2014	Certificate of Recognition, California State Senate
2014	Commendation, California State Senate
2015	Roger Baldwin Civil Libertarian of the Year Award, ACLU of Nebraska

C. Contribution to Science

1. My work in Community-based Participatory Research (CBPR) documents the value to funders like the California Breast Cancer Research Program (CBCRP) in actively supporting academic/community researcher teams. Critical to success is fostering positive relationships and training both partners on the elements of a research study, the topics being studied, and team/partner dynamics. These publications and articles document how training and technical assistance are important elements in achieving successful research results.
   - **Plumb, M**., Price, W., & Kavanaugh-Lynch, M.H. (2004). Funding community-based participatory research: lessons learned. *Journal of Interprofessional Care*. 18(4): 428-439.
   - **Plumb, M.,** Collins, N., Cordeiro, J., & Kavanaugh-Lynch, M. (2008). Assessing Process and Outcomes: Evaluating Community-Based Participatory Research. Progress in Community Health Partnerships: Research, Education, and Action. 2(2), 85-86, 87-97.
   - **Plumb, M.**; Poole, S.F., Sarantis, H.; Braun, S., Cordeiro, J., Van Olphen, J.; & Kavanaugh-Lynch, M. (2019). "Development and Evaluation of a Training Program for Community-Based Participatory Research in Breast Cancer." *Int. J. Environ. Res. Public Health*. 6;16(22).
   - **Plumb, M**. (2001). Community Research Collaboration Awards: Report on the Evaluation and Capacity Expansion Project. California Breast Cancer Research Program, Oakland, CA.
   - **Plumb, M.,** Collins, N., Cordeiro, J. N., & Kavanaugh-Lynch, M. (2005). "Transforming Research: An Evaluation of the Community Researcher Collaboration Awards." California Breast Cancer Research Program, Oakland, CA.
   - **Plumb, M.,** Collins, N., Cordeiro, J. N., & Kavanaugh-Lynch, M. (2007). "Transforming Partnerships: The Relationship Between Collaboration and Outcomes in the Community Research Collaboration Awards." California Breast Cancer Research Program, Oakland, CA.

2. My work in developing a participant advisory panel for the California Health and Development Studies, a 50-year, three generation cohort study, has resulted in research studies that both focus on issues of concern for the cohort members and advance the science of environmental research. In particular, study results coming out in 2021 will show that providing individual level biomonitoring data directly back to participants increases their understanding of environmental exposures, their plans to engage in advocacy on the environment, without added undue stress.
   - Brody, J.G., Cirillo, P.M.; Boronow, K.E., Havas, L., **Plumb, M.**, Susman, H.P., Gajos, K.Z., & Cohn, B.A. (under review, publication expected 2021). "Outcomes from returning individual-level or only study-wide results from biomonitoring for environmental chemicals in a cohort study using the Digital Exposure Report-Back Interface (DERBI).
   - Cohn, B. A., Terry, M. B., **Plumb, M.** & Cirillo, P. M. (2012). Exposure to polychlorinated biphenyl (PCB) congeners measured shortly after giving birth and subsequent risk of maternal breast cancer before age 50. *Breast Cancer Res. Treat.* 136(1), 267-275.
   - Judd, S & **Plumb, M.** (2012). "Reporting Personal Exposures to Environmental Chemicals: Focus Group Feedback." Oakland, CA: Child Health and Development Studies, Public Health Institute.

3. My work in large group multi-stakeholder strategic planning processes has ensured that community voice is heard and incorporated into planning projects including setting research agendas for environmental causes of breast cancer and disparities in breast cancer, and addressing health workforce issues.
    - Sutton, P., Kavanaugh-Lynch, M.H.E., **Plumb, M**., Yen, I.H., Sarantis, H., Thomsen, C.L., Campleman, S., Galpern, E., Dickenson, C., & Woodruff, T.J. (2014). California Breast Cancer Prevention Initiatives: Setting a research agenda for prevention. *Reproductive Toxicology, http://dx.doi.org/10.1016/j.reprotox.2014.09.008*.
    - **Plumb, M** & Thomsen, C. (2012). "Special Research Initiatives (SRI): Initiative Summaries and Funded Projects." California Breast Cancer Research Program, Oakland, CA.
    - **Plumb, M**. & Tew, S. (2003). "Maximizing the Public Benefit of Research and Policy Efforts." The Center for Reproductive Research and Health Policy, University of California, San Francisco, San Francisco, CA.
    - **Plumb, M**. (2005). Evaluation of Central Valley Nursing Workforce Diversity Project. California Health Collaborative. Fresno, CA.
    - **Plumb, M.,** Weitz, T., Hernandez, M., Estes, C., & Goldberg, S. (2007). In The California Endowment (Eds), "Improving Care and Assistance Security for Vulnerable Older Women in California." In Women, Health and Aging: Building a Statewide Movement, 9-44.

D. Research and Other Support

Current

None

***Select* Completed Research Support**

California Breast Cancer Research Program 2015-2016
Prime Award from NIH (PI Kavanaugh-Lynch)
QuickStart: The goal of this project was to create an intensive training, technical assistance, and web-based training program that will result in the conduct of community/academic collaborative research on the environmental causes of and social disparities in breast cancer. I was a member of the team that created and implemented the outreach, training, and technical assistance program for 12 collaborative teams of scientists and community members.
Role: Collaborator

University of California, San Francisco 2011-2016
Prime Award from the California Breast Cancer Research Program (PI Woodruff)
California Breast Cancer Prevention Initiatives: The purpose of this project was to coordinate a multi-stakeholder planning process to plan approximately $24 million in dedicated, coordinated, and collaborative research to pursue the most compelling and promising approaches to researching the environmental causes of breast cancer, disparities in the burden of breast cancer, population-level interventions. I coordinated and facilitated the meetings and interactions of the multiple layer of stakeholders and staff participating in this project ensuring the achievement of benchmarks throughout the project.
Role: Collaborating Investigator

Public Health Institute, Oakland 2013-2016
Prime Award from California Breast Cancer Research Program (Co-PI's Cohn/Havas)
Impact of Reporting Personal Levels of Environmental Chemicals: The goal of this four-year research project was to determine the impact of personal-level report backs to individuals participating in an environmental health study. This was the first study to have selected members of a research cohort to become community-partners in a CBPR study. I attended and facilitated meetings of the project team and of the Co-PI's, ensured meaningful engagement between the project team and Participant Advisory Committee (PAC), and assisted in overall project management.
Role: Collaborator

Public Health Institute, Oakland 2010-2015
Prime Award from NIH/NIEHS (Co-PI's Cohn/Terry)

PEDIGREE: Prenatal Environmental Determinants of InterGenerational Risk: This research project examined both the role of the pregnancy and prenatal environment on both the mother's and daughter's lifetime risk of breast cancer. I was responsible for recruiting and training a diverse group of 10-12 Child Health and Development Study (CHDS) participants to create a Participant Advisory Committee (PAC). Additionally, I partnered with Dr. Cohn in the development, conduct, analysis, and results dissemination of this study.
Role: Collaborator

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: TIM R TYNER

eRA COMMONS USER NAME (credential, e.g., agency login): TIMTYNER

POSITION TITLE: EXECUTIVE DIRECTOR

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
California State University, Fresno	B.A.	1990	Biology
University of California, Santa Barbara	M.S.	1992	Molecular Biology

A. Personal Statement

I have been involved in collaborative environmental exposure and health studies in the Fresno area for 20 years. As Executive Director (ED) of the Central California Asthma Collaborative (CCAC), and former Director of the Clinical Research Center at UCSF Fresno, I have been involved with more than 50 sponsored research projects, including oversight of study staff and budgets, coordinating activities with collaborators and reporting to funders. As the ED at CCAC, I have lead development of a valley-wide community air monitoring network (SJVAir), including school-based FEMs, and built partnerships with CBOs to establish air pollution-focused community steering committees in over a half dozen underserved communities across the San Joaquin Valley. I also oversee all research at CCAC, including three federal and five state funded air pollution and health studies that are/were conducted in collaboration with researchers at UCSF, UC Berkeley, Lawrence Berkeley National Lab, Berkeley Air Monitoring Group and UC Merced. I co-founded CCAC in 2011 to provide asthma education, home environmental assessments and trigger remediation, including indoor and outdoor air pollution, for low-income families utilizing a community health worker (CHW) model. CCAC is currently contracted by five managed care plans and employs twenty (20) CHWs to provide asthma remediation services to thousands of Medi-Cal patients each year in seven counties of the San Joaquin Valley, including over 70 rural, underserved communities. I believe my experience as a PI and co-investigator on multiple collaborative, multidisciplinary, air pollution-related research projects and my work engaging and supporting underserved communities, especially in regard to air quality, will ensure the successful implementation of the proposed ESTUDIO project.

B. Positions, Scientific Appointments, and

Honors

<u>Positions and Employment</u>

Executive Director and Chairman — 2024 – present
Central California Asthma Collaborative

Co-Executive Director and Chairman — 2018 – 2024
Central California Asthma Collaborative

Director, Clinical Research Center — 2015 – 2018
UC San Francisco – Fresno MEP

Research Manager, Department of Medicine — 2008 – 2018
San Francisco – Fresno MEP

Research Director, Department of Surgery — 2002 – 2008
UC San Francisco – Fresno MEP

Adjunct Associate Professor, Department of Biology — 2002 – 2009
College of Science and Math, California State University, Fresno

Research Associate, Cardiology Division — 1996 – 1998
Department of Medicine, University of California, Los Angeles, Westwood CA

Research Associate, Department of Neurobiology — 1995 – 1996
University of Southern California, Los Angeles CA

Adjunct Associate Professor, Departments of Biology and Chemistry — 1992 – 1996
El Camino Community College, Torrance, CA
State Center Community College District, Fresno, CA

Other Experience and Professional Memberships

Chairman, Board of Directors, Central California Asthma Collaborative (CCAC) — 2011 – 2021
Co-Chair, California School Environmental Health and Asthma Collaborative — 2012 – 2014
Consultant, Fresno Unified School District Asthma Management Program — 2008 – 2012
Co-Chair, San Joaquin Valley Air District Health Advisory Board — 2007 – 2010

Honors

EPA National Environmental Leadership Award in Asthma Management (CCAC) — 2021
EPA National Environmental Leadership Award in Asthma Management* — 2006
(*CCAC in partnership with Blue Cross of California State)

C. Contributions to Science

1. My research has focused on the health effects of particulate air pollution in California's San Joaquin Valley. In a longitudinal cohort study of 500 children in Fresno, CA, we demonstrated a correlation between traffic-related pollutants and clinical indicators of obesity and pre-diabetes. In a cross-sectional study of residents in three Valley communities, we demonstrated strong associations between ambient fine particle concentrations and childhood asthma hospital encounters. In a pilot panel study, we demonstrated a relationship between ambient fine particles, upper respiratory virus infection and asthma exacerbation in adults. In collaboration with toxicologists at NYU, we demonstrated variable ROS and pro-inflammatory responses to ambient particulate matter dependent on particle size and location of collection. Earlier publications included spirometric correlations with lung volume abnormalities, mechanisms of LDL-induced atherosclerosis, surgical therapies for neuropathic pain, non-pharmacologic therapies for wound healing, and structural proteins in neuromuscular junctions.
   a. Neophytou AM, Lutzker L, Good KM, Mann JK, Noth EM, Holm SM, Costello S, **Tyner TR**, Nadeau KC, Eisen EA, Lurmann F, Hammond SK, Balmes JR. Associations between prenatal and early-life air pollution exposure and lung function in young children: Exploring influential windows of exposure on lung development. Environ Res. 2023 Apr 1;222:115415. doi: 10.1016/j.envres.2023.115415. PMID: 36738772
   b. Aguilera J, Han X, Cao S, Balmes J, Lurmann F, **Tyner TR**, Lutzker L, Noth E, Hammond SK, Sampath V, Burt T, Utz PJ, Khatri P, Aghaeepour N, Maecker H, Prunicki M, Nadeau K. Increases in ambient air pollutants during pregnancy are linked to increases in methylation of IL4, IL10, and IFNγ. Clin Epigenetics. 2022 Mar 14;14(1):40. doi: 10.1186/s13148-022-01254-2. PMID: 35287715

c. Zhang AL, Balmes JR, Lutzker L, Mann JK, Margolis HG, **Tyner TR**, Holland N, Noth EM, Lurmann F, Hammond SK, Holm SM. Traffic-related air pollution, biomarkers of metabolic dysfunction, oxidative stress, and CC16 in children. J Expo Sci Environ Epidemiol. 2022 Jul;32(4):530-537. doi: 10.1038/s41370-021-00378-6. PMID: 3441754
d. Mann JK, Lutzker L, Holm SM, Margolis HG, Neophytou AM, Eisen EA, Costello S, **Tyner TR**, Holland N, Tindula G, Prunicki M, Nadeau K, Noth EM, Lurmann F, Hammond SK, Balmes JR. Traffic-related air pollution is associated with glucose dysregulation, blood pressure, and oxidative stress in children. Environ Res. 2021 Apr;195:110870. doi: 10.1016/j.envres.2021.110870. PMID: 33587949

Additional publications can be viewed at https://www.ncbi.nlm.nih.gov/myncbi/tim.tyner.2/bibliography/public/

EXHIBIT A6

CURRENT & PENDING SUPPORT

University will provide current & pending support information for Key Personnel identified in Exhibit A2 at time of proposal and upon request from State agency. The "Proposed Project" is this application that is submitted to the State. Add pages as needed.

PI: Jing Li					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
Proposed project	Pending	CA-EPA-AIR RESOURCES BOARD	Residential Appliances in Diverse California Communities: Emission, Exposure, and Health Impacts of Toxic Air Contaminants (RESPECT)	03/01/25	02/29/28
Active	22RD026	CA-EPA-AIR RESOURCES BOARD	Indoor Air Quality in California: New Evidence and Environmental Justice Implications	06/01/23	05/31/25

PI: Yifang Zhu					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
Proposed project	Pending	CA-EPA-AIR RESOURCES BOARD	Residential Appliances in Diverse California Communities: Emission, Exposure, and Health Impacts of Toxic Air Contaminants (RESPECT)	03/01/25	02/29/28
Pending	N/A	EPA-ENVIRONMENTAL PROTECTION AGENCY	AirPIN: A Multi-modal Model for Integrating Harbor-related Air Pollution Measurement Data to Improve Community Health in City of Galena Park, Texas	02/01/25	03/31/29
Active	PH-005030	LAC-DEPARTMENT OF PUBLIC HEALTH	Aliso Canyon Community Exposure and Health Study (ACCOUNT)	12/01/22	10/31/27
Active	T42OH008412	DHHS-CDC Centers for	Southern California Education and Research Center	07/01/22	06/30/27

		Disease Control and Prevention			
Active	DE-AC02-05CH11231	CA-California Energy Commission	CEVICA: Cooking Electrification and Ventilation Improvements for Children's Asthma	01/30/23	03/31/26
Active	R02CP6948	UC/OFFICE OF THE PRESIDENT, SYSTEMWIDE	Climate Action - Community-Driven Electric Vehicle Charging Solution (CA-CLEAN)	08/01/23	07/31/25
Active	R02CP7333	UC/OFFICE OF THE PRESIDENT, SYSTEMWIDE	Respiratory Protection for Firefighters Responding to Wildland Fires	08/01/23	07/31/25
Active	T32IR4655	UC TOBACCO-RELATED DISEASE RESEARCH PROGRAM	Reducing Environmental Exposures to Electronic Cigarettes Aerosols and Associated Health Effects	07/01/22	06/30/25
Active	22RD026	CA-EPA-AIR RESOURCES BOARD	Indoor Air Quality in California: New Evidence and Environmental Justice Implications	06/01/23	05/31/25
Active	SGC22121	CA-Strategic Growth Council	Community Engagement S/Hero Supplement	09/01/23	03/31/25
Active	5002-RFA23-1/24-6	Health Effects Institute	Novel Exposures, Birth Outcomes and Environmental Justice in a Changing Transportation Landscape	04/01/24	03/31/27

PI: Marj Plumb					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
Proposed project	Pending	CA-EPA-AIR RESOURCES BOARD	Residential Appliances in Diverse California Communities: Emission, Exposure, and Health Impacts of Toxic Air Contaminants (RESPECT)	03/01/25	02/29/28
Active	N/A	N/A	N/A	N/A	

PI: Tim Tyner					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
Proposed project	Pending	CARB	Residential Appliances in Diverse California Communities: Emission, Exposure, and Health Impacts of Toxic Air Contaminants (RESPECT)	03/01/25	02/29/28
Pending	Pending (R01ES035504-01A1)	UCSF (NIEHS)	Driving Environmental Justice: Community Monitoring of Diesel Truck Emissions and Impacts on Asthma Morbidity in Immigrant Communities	09/1/24	08/31/27
Pending	Pending (GFO-23-501)	LBNL (CEC)	Cooking and Clean Air in Homes Study	01/01/25	12/31/26
Active	DE-AC02-05CH11231	LBNL (CEC)	Cooking Electrification and Ventilation Improvements for Children's Asthma	07/01/22	06/30/25
Active	98T58201	US EPA	School-based Air Monitors in Disadvantaged Communities of the San Joaquin Valley	04/1/23	03/31/25
Active	22RD005	UCB (CARB)	Children's Health and Air Pollution Study: Standardized assessments, Attention and Cognition in California Kids	04/15/23	04/14/25
Active	A23-0163-S001	UCM (UCOP)	Enhancing Central Valley Climate Resilience against Wildfire via AIoT-Enabled Augmented Air Quality Monitoring	06/01/23	06/30/25
Active	ES030888	UCB (NIEHS)	Children's Health and Air Pollution Study (CHAPS)	03/01/20	02/28/25
Active	G21-CAGP-05	CARB	Community Air Grant (cycle 4): SJVAir	06/20/24	03/31/26
Active	G22-SWCF-01	CHDC (CARB)	Statewide Clean Cars 4 All and Financing Assistance	03/01/24	05/31/25

EXHIBIT A7

THIRD PARTY CONFIDENTIAL INFORMATION

CONFIDENTIAL NONDISCLOSURE AGREEMENT

(Identified in Exhibit A, Scope of Work – will be incorporated, if applicable)

If the Scope of Work requires the provision of third party confidential information to either the State or the Universities, then any requirement of the third party in the use and disposition of the confidential information will be listed below. The third party may require a separate Confidential Nondisclosure Agreement (CNDA) as a requirement to use the confidential information. Any CNDA will be identified in this Exhibit A7.

Or

Exhibit A7 is not applicable for this Agreement.

Exhibit A7 is not applicable for this Agreement.

EXHIBIT B

BUDGET

Use Exhibit B Budget Template

EXHIBIT B3

INVOICE ELEMENTS

In accordance with Section 14 of Exhibit C – Payment and Invoicing, the invoice, summary report and/or transaction/payroll ledger shall be certified by the University's Financial Contact and the PI (or their respective designees).

Invoicing frequency

☒ Quarterly ☐ Monthly

Invoicing signature format

☐ Ink ☒ Facsimile/Electronic Approval

Summary Invoice – includes either on the invoice or in a separate summary document – by approved budget category (Exhibit B) – expenditures for the invoice period, approved budget, cumulative expenditures and budget balance available[1]

- Personnel
- Equipment
- Travel
- Subawardee – Consultants
- Subawardee – Subcontract/Subrecipients
- Materials & Supplies
- Other Direct Costs
    - TOTAL DIRECT COSTS (if available from system)
- Indirect Costs
    - TOTAL

[1] If this information is not on the invoice or summary attachment, it may be included in a detailed transaction ledger.

Detailed transaction ledger and/or payroll ledger for the invoice period [1]

- University Fund OR Agency Award # (to connect to invoice summary)
- Invoice/Report Period (matching invoice summary)
- GL Account/Object Code
- Doc Type (or subledger reference)
- Transaction Reference#
- Transaction Description, Vendor and/or Employee Name
- Transaction Posting Date
- Time Worked
- Transaction Amount

[1] For salaries and wages, these elements are anticipated to be included in the detailed transaction ledger. If all elements are not contained in the transaction ledger, then a separate payroll ledger may be provided with the required elements.

EXHIBIT D

ADDITIONAL REQUIREMENTS ASSOCIATED WITH FUNDING SOURCES

If the Agreement is subject to any additional requirements imposed on the funding State agency by applicable law (including, but not limited to, bond, proposition and federal funding), then these additional requirements will be set forth in Exhibit D. If the University is a subrecipient, as defined in 2 CFR 200 (Uniform Guidance on Administrative Requirements, Audit Requirements and Cost Principles for Federal Financial Assistance), and the external funding entity is the federal government, the below table must be completed by the State agency. (Please see sections 10.A and 10.B of the Exhibit C.)

State Agency to Complete (Required for Federal Funding Source):

Federal Agency	
Federal Award Identification Number	
Federal Award Date	
Catalog of Federal Domestic Assistance (CFDA) Number and Name	
Amount Awarded to State Agency	
Effective Dates for State Agency	
Federal Award to State Agency is Research & Development (Yes/No)	

University to Complete:

Research and Development (R&D) means all research activities, both basic and applied, and all development activities that are performed by non-Federal entities. The term research also includes activities involving the training of individuals in research techniques where such activities utilize the same facilities as other R&D activities and where such activities are not included in the instruction function.

This award ☑ does ☐ does not support Research & Development.

OR

Exhibit D is not applicable for this Agreement.

EXHIBIT E

SPECIAL CONDITIONS FOR SECURITY OF CONFIDENTIAL INFORMATION

If the Scope of Work or project results in additional legal and regulatory requirements regarding security of Confidential Information, those requirements regarding the use and disposition of the information, will be provided by the funding State agency in Exhibit E. (Please see section 8.E of Exhibit C.)

OR

Exhibit E is not applicable for this Agreement.

Exhibit E is not applicable for this Agreement.

EXHIBIT F

ACCESS TO STATE FACILITIES OR COMPUTING RESOURCES

If the Scope of Work or project requires that the Universities have access to State agency facilities or computing systems and a separate agreement between the individual accessing the facility or system and the State agency is necessary, then the requirement for the agreement and the agreement itself will be listed in Exhibit F. (Please see section 21 of Exhibit C.)

OR

Exhibit F is not applicable for this Agreement.

Exhibit F is not applicable for this Agreement.

EXHIBIT G

NEGOTIATED ALTERNATE UTC TERMS

Exhibit C, Section 14 – Payment & Invoicing is hereby amended to incorporate the following:

Add Item A – Section 6:

6) CARB shall withhold payment equal to 10 percent after the contractor has been compensated for 90 percent of the agreement per Exhibit B1, Budget Justification. The 10 percent shall be withheld until completion of all work and submission to CARB by the University of a final report approved by CARB in accordance with Exhibit A1, Schedule of Deliverables, Section 2. It is the University's responsibility to submit one (1) original and one (1) copy of the final invoice.

Modify Item C – Invoicing, 2 is hereby replaced in its entirety with the following:

2) Invoices shall be submitted in arrears not more frequently ~~than monthly and not less frequently~~ than quarterly to the State Financial Contact, identified in Exhibit A3. Invoices may be submitted electronically by email. If submitted electronically, invoice must include the following certification for State certification to the State Controller's Office, in compliance with SAM 8422.1

This bill has been checked against our records and found to be the original one presented for payment and has not been paid. We have recorded this payment so as to prevent later duplicate payment.

______________________________Signed:

State Agency Accounting Officer

Add Item E:

E. Advance Payment

1) Nothing herein contained shall preclude advance payments pursuant to Title 2, Division 3, Part 1, Chapter 3, Article 1 of the Government Code of the State of California.

2) Upon termination or completion of this Agreement, Contractor shall refund any excess funds to the CARB. Contractor will reconcile total Agreement costs to total payments received in advance and any remaining advance will be refunded to the CARB's Accounting Office. In the event the Agreement is terminated, total project costs incurred prior to the effective date of termination (including close-out costs) will be reconciled to total project payments received in advance and any remaining advance will be refunded to the CARB. In either event Contractor shall return any balance due to CARB within sixty (60) days, of expiration or earlier termination.