EXHIBIT A

SCOPE OF WORK

☒ Contract ☐ Grant

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

PI Name: Qi Zhang

Project Title: Accelerated Evaluation of Ambient $PM_{2.5}$ in Regions Affected by the 2024 National Ambient Air Quality Standards (NAAQS) Update

Project Summary/Abstract

To address the regulatory challenges introduced by the United States Environmental Protection Agency's (U.S. EPA) revised annual $PM_{2.5}$ standard, lowered from 12 microgram per cubic meter (μg/m³) to 9 μg/m³, the California Air Resources Board (CARB) is significantly expanding its monitoring capability through the High-resolution Advanced Monitoring Program (CHAMP). This program involves deploying a statewide instrument network of eight Aerosol Chemical Speciation Monitors (ACSM) to generate continuous, high-time-resolution measurements of $PM_{2.5}$ chemical composition, including concentrations of organic aerosols (OA), nitrate (NO_3), sulfate (SO_4), ammonium (NH_4), and chloride (Chl). These data will provide unprecedented insights into $PM_{2.5}$ pollution dynamics, spatial variations, and source contributions in nonattainment regions, offering critical support for data-driven regulatory strategies.

This project will operationalize the CHAMP $PM_{2.5}$ capture vaporizers (CV)-ACSM network by establishing a comprehensive framework for reliable instrument deployment, long-term operation, and high-quality data generation. Over the three-year period of this contract, the network will operate continuously, supporting high-resolution, sustained aerosol monitoring across California, with a focus on nonattainment areas. Standardized protocols will be developed for instrument setup, calibration, maintenance, quality assurance/quality control (QA/QC), and data processing to ensure consistency and reliability. In parallel, targeted technical training will be provided to CARB personnel, covering instrument operation, troubleshooting, and data analysis.

This project will also advance scientific understanding of $PM_{2.5}$ sources across California's nonattainment areas through source apportionment analyses using ACSM datasets collected from both the CHAMP and Atmospheric Science and Chemistry mEasurement NeTwork (ASCENT) platforms. In addition, the project will assess the reliability of NO_3 measurements in California by comparing ACSM and filter-based methods in conjunction with thermodynamic modeling.

All results from this project will be compiled into a publicly accessible final report, accompanied by analytical tools, data products, and technical documentation to support transparency and stakeholder engagement. These deliverables will strengthen CARB's capabilities for high-resolution $PM_{2.5}$ characterization and source attribution, supporting science-based, equitable air quality management across California.

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.

Statement of Significance

Background and Identification of Problems

The U.S. EPA recently revised the annual average $PM_{2.5}$ NAAQS from 12 µg/m³ to 9 µg/m³. This stricter standard is expected to push many areas in California that were previously in compliance into exceedance, posing new challenges for air quality management. In many of these areas, air quality data is currently limited, highlighting an urgent need to expand monitoring and modeling efforts to identify and quantify the sources of $PM_{2.5}$ pollution accurately.

CARB is significantly expanding its non-regulatory ACSM network to address the growing demand for comprehensive air quality data, increasing coverage from two units currently operating in the San Joaquin Valley (SJV) to eight units deployed statewide. ACSM provides highly time-resolved, continuous measurements of key aerosol chemical components, including OA, NH_4, NO_3, SO_4, and Chl [Frohlich et al., 2013; Jayne et al., 2000; Ng et al., 2011]. These data offer valuable insights into the chemical composition, dynamic behavior, and PM pollution sources. Additionally, source apportionment analysis of the ACSM mass spectral matrix using the Positive Matrix Factorization (PMF) model [Paatero and Tapper, 1994] enables the identification of major pollution sources, key atmospheric processes, and their respective contributions to ambient PM concentrations [Q Zhang et al., 2011].

As part of an ongoing CARB research contract (#22RD038) (Long-Term Chemical Characterization and Source Apportionment of $PM_{2.5}$ in the San Joaquin Valley), a Time-of-Flight ACSM (ToF-ACSM) has been operating in Fresno since October 2018, while a Quadrupole ACSM (Q-ACSM) started operation in Bakersfield in August 2023. So far, these efforts have yielded over six years of continuous aerosol chemistry data from Fresno and nearly two years of data from Bakersfield, with 10- and 20-minute time resolution, respectively. These long-term, high-resolution datasets have yielded critical insights into $PM_{2.5}$ characteristics, temporal trends, and major source contributions in the SJV, demonstrating the remarkable potential of ACSM technology when fully leveraged and its data rigorously analyzed. CARB is currently in the process of deploying six additional Q-ACSM units throughout the State of California to support an expanded network of $PM_{2.5}$ chemical measurements. These deployments will be complemented by co-located real-time aerosol instruments such as Scanning Mobility Particle Sizers (SMPS) and Aethalometer black carbon (BC) analyzers (AE33 or AE36).

This expanded network, named CHAMP, will feature ACSM equipped with $PM_{2.5}$ aerodynamic lenses capable of transmitting particles up to 2.5 micrometers (μm) in aerodynamic diameters [*Peck et al.*, 2016] and CV, which minimize particle bounce and achieve near-unity collection efficiency (CE) [*W Xu et al.*, 2017]. The combination of the $PM_{2.5}$ lens and CV transforms the ACSM into a reliable and quantitative instrument for measuring $PM_{2.5}$ chemical composition [*Hu et al.*, 2017; *Sun et al.*, 2022; *Y Zhang et al.*, 2017; *Zheng et al.*, 2020].

Sun et al. [2022] conducted the first comprehensive analyses of long-term, high-time-resolution $PM_{2.5}$ composition in the SJV, using ToF-ACSM data collected in Fresno from 2018 to 2020. The study demonstrated the powerful utility of continuous, sub-hourly aerosol speciation to reveal pollution dynamics in a region chronically impacted by $PM_{2.5}$. The findings highlighted ACSM's strength in identifying emission sources and atmospheric formation processes of major $PM_{2.5}$ components under the SJV's complex geographical, meteorological, and chemical conditions. Notably, the study revealed marked seasonal variations in $PM_{2.5}$ sources and atmospheric processes. In winter, residential wood burning and nitrogen oxides oxidation were major contributors to elevated $PM_{2.5}$ levels, resulting in haze episodes dominated by biomass burning organic aerosols (BBOA) and NO_3. In autumn, agricultural activities and wildfires were the predominant sources of pollution. By spring (March to May), $PM_{2.5}$ concentrations declined substantially and were largely composed of oxygenated organic aerosols (OOA), reflecting shifts in atmospheric processing.

Beyond uncovering temporal and seasonal trends in $PM_{2.5}$ pollution, the study by Sun et al. [2022] also conducted a thorough evaluation of instrument performance. This was achieved through comparisons of the ACSM data with those from a suite of co-located reference and research-grade monitors deployed during the winter 2018-2019 intensive measurement campaign. Instruments include Beta Attenuation Monitors (BAM), high-resolution Soot Particle Aerosol Mass spectrometer (SP-AMS), SMPS, Multi-Angle Absorption Photometer (MAAP), and Interagency Monitoring of Protected Visual Environments (IMPROVE) $PM_{2.5}$ Sampler. Strong agreements were observed across instruments for both speciated aerosol concentrations and source apportionment results. Specifically, the summed concentrations of non-refractory (NR) $PM_{2.5}$ species (NR-$PM_{2.5}$ = organics + sulfate + nitrate + ammonium + chloride) measured by ACSM, combined with (BC, showed high correlations with $PM_{2.5}$ mass concentrations from BAM and IMPROVE, yielding Pearson's r^2 values between 0.92 to 0.94 for temporal variability and orthogonal regression slopes near unity (Sun et al., 2022). Given that BAM and IMPROVE sampler are designated as Federal Equivalent Method (FEM) and Federal Reference Method (FRM) instruments, respectively, these results validate the potential of ACSM equipped with CV and $PM_{2.5}$ lens ($PM_{2.5}$-CV-ACSM) to serve as reliable tools for regulatory $PM_{2.5}$ monitoring and source evaluation.

The successful implementation of the CHAMP program depends on the reliable operation of the associated $PM_{2.5}$-CV-ACSM instruments and the timely processing of the $PM_{2.5}$-CV-ACSM data. Achieving this requires careful strategic planning and effective technical capacity building. Key priorities include the development of standardized operation procedures (SOPs) to ensure consistent performance across the network, the application of rigorous QA/QC protocols to evaluate and maintain data integrity, and the provision of comprehensive training to CARB personnel to support long-term sustainable instrument operation and maintenance. In parallel, the establishment of streamlined workflows for data management and analysis will facilitate advanced applications such as temporal trend evaluation, pollution source apportionment, and regional transport analysis. Together, these efforts will ensure that CHAMP produces high-quality data capable of directly supporting regulatory air quality modeling and informing science-based decision-making across California.

The high-resolution data generated by the CHAMP network can also serve as a critical resource for advancing scientific understanding of $PM_{2.5}$ sources and improving measurement accuracy statewide. To support this goal, this project will analyze CHAMP datasets alongside measurements from three ToF-ACSM instruments deployed in the Southern California Air Basin (SoCAB) as part of the ASCENT. A key focus is to characterize $PM_{2.5}$ source contributions across diverse nonattainment regions and to gain deeper insights into emission patterns and atmospheric processes that drive $PM_{2.5}$ pollution in California.

In parallel, this project will address known limitations of filter-based NO_3 measurements under varying atmospheric conditions – an essential step toward improving regulatory assessments and air quality modeling. Ammonium NO_3, a major component of $PM_{2.5}$ in California during late fall and winter months [*Ge et al.*, 2012; *C L Parworth et al.*, 2017; *Sun et al.*, 2022; *Young et al.*, 2016], is semi-volatile and prone to sampling artifacts, such as evaporation losses or adsorption on filters, when measured using conventional filter-based methods [*Chiu and Carlton*, 2024]. To assess and quantify these potential biases, NO_3 data from CHAMP's ACSM will be compared with co-located regulatory $PM_{2.5}$ NO_3 measurements. Observed discrepancies will be analyzed to reduce measurement biases and improve the reliability of data used in air quality assessment and regulatory compliance tracking.

Objectives

This project will operationalize the CHAMP $PM_{2.5}$-CV-ACSM network by establishing a robust framework for reliable instrument deployment, sustained long-term operation, and high-quality data generation. It will also advance scientific understanding of $PM_{2.5}$ sources across California's nonattainment areas through source apportionment analyses using ACSM datasets from both the CHAMP and ASCENT platforms. In addition, this project will assess the reliability of NO_3 measurements in California by conducting comparisons between ACSM and filter-based methods and thermodynamic modeling.

Objective 1: Ensure long-term operability and data quality of the CHAMP network through standard operational protocols, and technical training.

To ensure robust, long-term operation of the CHAMP ACSMs, this project will establish standardized protocols for instrument operation, maintenance, QA/QC, and data processing. During the three-year period of this contract, the CHAMP network will operate continuously, with the objective of building a strong foundation for sustained, high-resolution aerosol monitoring. Targeted technical training will be provided to CARB personnel, covering instrument operation, troubleshooting, and data processing workflows. Collectively, these efforts will promote consistent instrument performance and data integrity across all monitoring sites, while also developing in-house capacity to support long-term sustainability of the CHAMP network.

Objective 2: Identify major $PM_{2.5}$ sources and atmospheric processes across California's nonattainment areas through source apportionment of ACSM data.

To identify major emission sources and atmospheric transformation processes contributing to $PM_{2.5}$ pollution, this objective will perform advanced source apportionment analyses on one year of ACSM data collected from each CHAMP network site, along with data from three ToF-ACSM instruments operating in the SoCAB under ASCENT. By integrating these datasets, the project will allow for spatially resolved source attribution and reveal key atmospheric processes affecting $PM_{2.5}$ levels in nonattainment areas across California, supporting enhanced air quality modeling capabilities and informed development of region-specific mitigation strategies.

Objective 3: Improve NO_3 *measurement accuracy through ACSM – filter comparisons and thermodynamic modeling.*

To better understand potential measurement biases associated with filter-based methods, ACSM NO_3 data from CHAMP sites will be systematically compared to co-located regulatory $PM_{2.5}$ NO_3 measurements. Special attention will be given to evaluating the accuracy of filter-based NO_3 measurements, which are known to suffer from artifacts such as volatilization and adsorption due to the semi-volatile nature of ammonium NO_3. Discrepancies between methods will be analyzed in conjunction with thermodynamic modeling across varying atmospheric conditions to quantify biases and improve the reliability of NO_3 data for regulatory assessments and air quality modeling.

Project Tasks

The overarching goal of this project is to operationalize the CHAMP $PM_{2.5}$-CV-ACSM network for long-term, sustainable monitoring of ambient $PM_{2.5}$ and to operate it continuously over a three-year period, supported by comprehensive data analysis, to advance scientific understanding of $PM_{2.5}$ sources, chemical composition, and atmospheric processes in California's nonattainment areas. The following section detail the key project tasks, outlining the activities, methodologies, and deliverables that collectively support the network's successful implementation and sustained operation.

Task 1: Operationalize ACSM Across the CHAMP Network to Ensure Continuous, High-Quality Data Collection Over a Three-Year Period

The University of California, Davis (UCD) will establish a standardized, reliable framework to support the immediate functionality and long-term success of the CHAMP PM2.5-CV-ACSM network. The final outcome will be a fully operational CHAMP network managed under a comprehensive framework that ensures data reliability, supports regulatory needs, and enables CARB staff to independently maintain and operate the system. UCD, in collaboration with Georgia Institute of Technology (GIT), will work closely with CARB to ensure smooth network performance, consistent data quality, and effective knowledge transfer to support long-term sustainability.

UCD will lead the technical and logistical efforts, in partnership with CARB's Research Division and Monitoring and Laboratory Division, to deploy and operate eight ACSM instruments (seven Q-ACSMs and one ToF-ACSM) at monitoring sites across California over three consecutive years. The project team, comprised of UCD and GIT personnel, will oversee all aspects of instrument deployment, calibration, maintenance, and troubleshooting in alignment with CARB standards to ensure consistent network performance and high-quality data collection. To support data integrity, standardized operating protocols and data analysis workflows will be developed and implemented to ensure robust and comparable results across all sites. In parallel, the project will prioritize knowledge transfer and capacity building to support the long-term, sustainable operation of the network.

Task 1a. Maintain Continuous Data Collection from CHAMP ACSMs Over a Three-Year Period

UCD, in collaboration with CARB personnel, will install, operate, and maintain eight $PM_{2.5}$-CV-ACSMs continuously for a period of three years. A key component of this effort is regular performance monitoring, which will be conducted either on-site or remotely via remote-access software (e.g., TeamViewer), to ensure timely issue detection and maximize data collection efficiency.

Another essential aspect involves periodic on-site calibrations for each instrument to determine the ionization efficiency (IE) and the relative ionization efficiencies (RIE) for NH_4 and SO_4. Calibrations for IE and NH_4 RIE will be performed using monodispersed NH_4NO_3 particles of known sizes [*Canagaratna et al.*, 2007; *Ng et al.*, 2011], while the SO_4 RIE will be calibrated using pure $(NH_4)_2$ SO_4 particles [*Setyan et al.*, 2012]. These procedures will also include verification and adjustment of the sampling line and ACSM inlet flow rates. To assess instrument background level and estimate detection limits for individual $PM_{2.5}$ species, additional sampling of particle-free ambient air sampling will be conducted.

The CHAMP ACSMs will operate at a 20-minute time resolution to capture short-term variations in $PM_{2.5}$ concentration and composition, thereby facilitating more refined source apportionment analysis. To ensure data integrity and redundancy, regular backups will be conducted both on-site and remotely. The CHAMP ACSM data will be batch-processed using Aerodyne's ACSM data analysis software packages within Igor Pro.

Pro environment (Wave-Metrics, Inc., Oregon, United States of America), with proper application of IE and RIE values. The resulting NR $PM_{2.5}$ (NR-$PM_{2.5}$) data will undergo comprehensive QA/QC, including 1) evaluation of detection limits for individual species, 2) diagnostic examination of mass spectral signals, and 3) quantification of uncertainties stemming from instrument noise, sampling efficiency, and background levels. To assess data accuracy and precision, NR-$PM_{2.5}$ mass concentrations derived from ACSMs will be compared with co-located $PM_{2.5}$ measurements from co-located FEM and FRM instruments. Measurements of BC, a key refractory PM component, will also be used to support these comparisons.

During the first year, UCD will lead all aspects of CHAMP ACSM operations, including calibrations, major maintenance, and significant repairs (e.g., pump replacements, filament or detector replacements). A CARB research staff member will accompany UCD personnel during site visits to facilitate site access and receive hands-on training. Routine tasks, such as cleaning critical orifice and sampling line, will be carried out with assistance from on-site CARB staff. UCD will remain available to offer remote technical guidance as needed.

During the second and third years, UCD would transition into a supervisory role overseeing operations, assisting with complex maintenance and troubleshooting, and continuing to train CARB staff through training on ACSM operation and data analysis (See Task 1e).

Deliverable:

- *Submit 20-minute time-resolved NR-$PM_{2.5}$ speciation data collected from eight CHAMP-deployed ACSM instruments over a three-year period.*

Task 1b. Develop SOPs for ACSM Deployment, Calibration, and Maintenance.

The project team will develop and implement a detailed SOP to ensure consistent and reliable operation of all ACSM instruments across the CHAMP network. The SOP will provide clear, step-by-step guidance on instrument installation, operation, calibration routines, startup and shutdown procedures, regular performance checks, diagnostics, and troubleshooting. By standardizing procedures for installation, calibration, maintenance, and data acquisition, the SOP will promote operational uniformity, minimize instrument downtime, and support the collection of high-quality, comparable data at all monitoring sites. The SOP will be provided by the end of the first contract year and will include both written documentation and instructional videos.

The CHAMP SOP will build on those already established for the ASCENT network. All ASCENT ACSM share a uniform setup for inlets, sampling systems, and calibration protocols, facilitating the continuous collection of high-quality data across that network. Although the ASCENT uses ToF-ACSM equipped with $PM_{2.5}$ lenses and standard vaporizers (SV) (i.e., $PM_{2.5}$-SV-ACSM), many of the existing SOP are directly transferable to the CHAMP $PM_{2.5}$-CV-ACSMs, given the same fundamental operating principles of the instruments.

Each CHAMP ACSM will be paired with a standardized sampling design that includes a URG cyclone configured to sample PM with diameters smaller than three ~ five micrometer (μm), a Nafion dryer to maintain relative humidity below 40 percent, and a stainless steel or copper sampling line to minimize particle losses. Accurate mass concentration measurements require precise control of flow rate and pressure at the ACSM critical orifice; therefore, flow calibrations will be conducted during each new installation as well as repeated periodically throughout the deployment. To minimize particle losses, the sampling system will be optimized by shortening the length of the sampling tubing, avoiding sharp bends or kinks, and using appropriate materials. Particle loss will be estimated and documented for each ACSM deployment site to support data QA.

IE calibration will be carried out periodically (e.g., semiannually). These calibrations will require an SMPS to be available on site. During IE calibration, 300 nanometer (nm) NH_4NO_3 and $(NH_4)_2SO_4$ particles will be generated using an atomizer and introduced simultaneously to both the ACSM and SMPS. IE will be determined by comparing particle mass concentrations measured by the ACSM with those measured by the SMPS. If an SMPS is available on site for continuous ambient sampling, the SMPS will be connected to the ACSM in a way that allows seamless switching between ambient sampling and IE calibration. This setup will eliminate the need to disconnect and reconnect tubing for each calibration, improving efficiency and reducing the risk of setup errors. If an SMPS is not available at a site, UCD will bring its own unit for calibration purposes. To validate accuracy and ensure consistency across the network, UCD's SMPS will be used for initial calibrations at all sites. When CARB's SMPS units are available, results from the collocated instrument will be compared to confirm agreement.

An instrument maintenance plan will be developed to outline key tasks, recommended frequencies, performance criteria, and corrective actions. Routine maintenance activities will include monitoring inlet flow rates, performing power cycles, conducting blank and leak checks, and cleaning components such as the critical orifice, cyclone, and sampling line. The project team will also dust the mass spectrometer parts, such as the Tofwerk Power Supply and panel fans. The project team will inspect and replace parts as needed to ensure reliable instrument performance.

A troubleshooting guide will also be created, drawing on operational experience acquired throughout the project. This guide will cover general issues related to instrument setup, routine maintenance, and calibration procedures, offering practical solutions for field technicians and CARB staff. The project guide will serve as a user-friendly reference to support consistent operation, reduce downtime, and promote long-term sustainability of the CHAMP network.

Deliverables:

- *Submit a comprehensive instrument maintenance and operation manual that includes a detailed maintenance plan (key tasks, recommended frequencies, performance checks, and corrective actions). The manual will also feature a troubleshooting section addressing general issues related to ACSM installation, routine maintenance, and calibration, with practical guidance tailored for field technicians and CARB staff.*

- *Submit the SOP covering instrument setup, calibration, and operation.*

Task 1c. Implement QA/QC Protocol to Ensure Consistent and Accurate Data Collection.

To maintain data integrity and consistency across the CHAMP network, the project team will develop and implement a comprehensive QA/QC protocol. This framework will incorporate best practices for ACSM operation, including procedures for identifying and flagging anomalous data, conducting routine performance checks, and performing inter-instrument comparisons to detect discrepancies.

During routine operation, key instrument parameters will be regularly checked (weekly) to verify stable performance and the continuous collection of high-quality data. These parameters include airbeam signal intensity, inlet flow rate, vaporizer temperature, filament emission current, detector voltage, and heater bias voltage. For each parameter, target values or acceptable operating ranges will be established. To support consistent monitoring and recordkeeping, an instrument checklist will be developed, building on the version used in the ASCENT network and adapted to meet the specific needs for the CHAMP $PM_{2.5}$-CV-ACSMs.

Data quality will also be assessed by verifying the correct application of airbeam corrections and IE and RIE calibration factors. Fragmentation diagnostics will be evaluated by examining the linearity and intercepts of correlations among characteristic fragment ions for NO_3, SO_4, and NH_4. In addition, ion balance (based on the comparison between measured and predicted ammonium concentrations) will also be reviewed to ensure internal consistency. To standardize QA/QC practices across the network, the project team will produce detailed guidelines and procedures for interpreting diagnostic plots and assessing ion balance.

Deliverables:

- *Submit a comprehensive QA/QC protocol for ACSM operation, including best practices for identifying and flagging anomalous data, routine performance checks, inter-instrument comparisons to detect discrepancies, and interpretation of diagnostic plots and ion balance assessments..*

- *Submit the instrument checklist based on the version used in the ASCENT network and adapted to meet the specific needs for the CHAMP PM2.5-CV-ACSMs.*

Task 1d. Establish Streamlined Workflows for Data Acquisition, Data Processing, and Storage to Support Long-Term Usability and Accessibility.

To support efficient data management and ensure the long-term utility of the CHAMP network, the project team will develop and implement streamlined workflows for data acquisition, validation, processing, and archiving. These workflows will support centralized integration of both raw and processed ACSM data into easily accessible databases. This infrastructure will also enable timely access to high-quality data and facilitate advanced downstream applications such as time trend analyses to assess changes in $PM_{2.5}$ composition over time, regional transport assessments to examine pollutant movement across air basins, and source apportionment modeling to quantify contributions from key emission sources.

A data SOP will be developed to ensure consistent analysis of data across all sites. Step-by-step guidelines will be provided for data processing tasks such as mass-to-charge-ratio calibrations, baseline refinement, and adjustments to peak shape, peak width, etc. A standardized data format (including metadata, time base, and applied corrections) will be defined to facilitate easy access, cross-site comparisons, and integration with other co-located measurements.

Deliverable:

- *Submit the data SOP with step-by-step guidelines for data processing and consistent analysis of CHAMP ACMS data, including procedures for mass-to-charge-ratio calibrations, baseline refinement, adjustments to peak shape and peak width, signal-to-noise evaluation, and diagnostic checks.*

Task 1e. Train CARB Personnel on ACSM Operation, Maintenance, and Troubleshooting.

UCD will support CARB staff in building the internal capability to independently manage, operate, and sustain the CHAMP network over the longer term. To facilitate, the project team will implement a comprehensive knowledge transfer strategy that includes, but is not limited to detailed documentation, technical support, and structured feedback mechanisms.

As part of Tasks 1b-1d, the project team will develop a full suite of user-oriented documentation to support CARB personnel in the operation, maintenance, and troubleshoot of the CHAMP $PM_{2.5}$-CV-ACSM systems. These resources will serve as clear, accessible references covering all key aspects of operating the CHAMP $PM_{2.5}$-CV-ACSM systems and will form the foundation for training CARB staff to ensure consistent and reliable performance across deployments.

Comprehensive training will be provided to CARB staff through a combination of in-person and virtual sessions, addressing topics such as instrument setup, operation, and configuration, routine maintenance, calibration, diagnostic checks, data acquisition, data analysis, validation, and troubleshooting. Initial hands-on training will be provided either at CARB’s Sacramento facility or during calibration visits at individual monitoring sites. If necessary, these sessions will be supplemented by virtual guidance to support continuous staff development.

To further reinforce operational knowledge, the project team will produce instructional materials and video tutorials demonstrating routine maintenance tasks, such as cleaning and replacing the critical orifice. These materials will serve as quick-reference tools for CARB's field staff, helping to ensure consistency and confidence in performing key procedures. Additionally, the UCD team will remain available to provide remote, on-demand technical guidance as needed.

Deliverables:

- *Provide comprehensive training for CARB staff on instrument operation, delivered through a combination of in-person and virtual sessions. Topics will include instrument setup, routine maintenance, calibration, diagnostic checks, data acquisition and analysis, validation, and troubleshooting.*

- *Submit the instructional materials, including video tutorials and a site operator checklist, covering routine maintenance tasks (e.g., cleaning and replacing the critical orifice), essential tasks for regular site visits, and post-event inspections following incidents such as power outages, wildfires, or severe weather.*

Task 2: Compare ACSM Measurements Against Co-Located Measurements

The project team will evaluate total NR-$PM_{2.5}$ mass concentrations and chemical speciation data from the CHAMP ACSM network by comparing with co-located filter-based PM measurements from selected sites. To support this evaluation, co-located measurements of refractory species such as trace metals and BC will also be included. In the first phase of the analysis, the sum of ACSM-measured NR-$PM_{2.5}$ and BC will be compared with $PM_{2.5}$ values from regulatory monitors (e.g., BAM) to identify site-specific trends, discrepancies, and potential biases.

In the second phase, the project team will identify and correct biases in filter-based measurements of particulate NO_3, focusing on volatilization losses of NH_4NO_3 from polytetrafluoroethylene filters used in FRM samplers. To address the artifacts, a temperature-based parameterization from Hering and Cass (1999) will be applied, using real-time ACSM NO_3 data as a constraint (Ward, 2025). The analysis will consider three potential mechanisms contributing to NO_3 losses: 1) depletion of ammonia and nitric acid upstream of the filter, 2) elevated filter temperatures relative to ambient air, and 3) pressure drops across the filter during sampling.

While the ACSM design minimizes evaporative losses and positive artifacts, it measures total NO_3, which includes both inorganic and organic forms. As a result, ACSM data may exhibit a positive bias when compared to filter-based methods, which quantify only inorganic NO_3. However, given the high ambient concentration of NO_x and NH_3 in California, NO_3 at CHAMP sites is expected to be largely inorganic. To assess the potential interference of organic NO_3, the project team will analyze seasonal variations in the ACSM ion signals at mass to charge ratio (m/z) 30 and 46. Ratios of m/z 30/46 obtained from IE calibrations using pure NH_4NO_3, along with wintertime measurements, when inorganic NO_3 is expected to dominate [L Xu et al., 2015], will be used to establish a reference baseline. The NO_3 intercomparison analysis will be performed on at least one year of data from a selected site where filter-based data is available. The project team will collaborate closely with CARB researchers to compile relevant co-located datasets and will provide regular updates on key findings from the analysis.

Deliverable:

- *Submit the ACSM and filter-based nitrate intercomparison results, along with the thermodynamic modeling results, in the final report.*

Task 3: Conduct Data Analysis and $PM_{2.5}$ Source Apportionment for the CHAMP Dataset

UCD will perform advanced analyses on at least one year of data collected from all eight ACSM instruments in the CHAMP network, along with co-located measurements, to characterize ambient $PM_{2.5}$ composition and identify key emission sources of $PM_{2.5}$ across California. After applying rigorous quality control procedures, source apportionment will be conducted using PMF, which incorporates data uncertainties and solves a constrained, weighted least-squares problem [*Paatero and Tapper*, 1994]. PMF minimizes the Q value based on a user-defined number of factors, down-weighting data affected by sampling errors, detection limits, missing values, or outliers. This normalization ensures that the solution reflects the most physically meaningful relationship between the observations and their sources. The resulting nonnegative factors represent distinct pollution sources and their contributions to the measured aerosol mixture.

Specifically, UCD will apply the Multilinear Engine (ME-2) approach to the ACSM data to identify major $PM_{2.5}$ sources and examine diurnal and seasonal variations in $PM_{2.5}$ concentration and composition. ME-2 is an extension of PMF that enables the incorporation of *a priori* information in the form of factor profiles or time series to guide the model. ME-2 can be viewed as a hybrid of the unconstrained PMF and the chemical mass balance approach, where all factor profiles are predetermined. One advantage of ME-2 is that it allows for the quantification of additional factors that would otherwise be unresolvable through the unconstrained PMF analysis [*Paatero et al.*, 2002; *Paatero and Tapper*, 1993].

UCD will use a rolling-window ME-2 analysis to assess NR-$PM_{2.5}$ mass spectral data from CHAMP ACMS. The goal is to identify the sources of OA and determine their contributions to $PM_{2.5}$ in nonattainment regions over a span of one year. The rolling-window approach is essential for long-term datasets, as OA source profiles can evolve over time due to changes in emissions, meteorology, and atmospheric chemistry. Compared to traditional seasonal PMF, rolling-window ME-2 improves model performance by capturing temporal variability, reducing rotational ambiguity, and enhancing correlations with external tracers [*Chazeau et al.*, 2022; *C Parworth et al.*, 2015; *Via et al.*, 2022].

Deliverable:

- *Submit PMF source apportionment analysis results of one year of CHAMP network ACSM data.*

3a. Train CARB personnel on ACSM data analysis and address questions.

UCD will provide training to CARB personnel on ACSM data analysis, focusing on data processing workflows, output interpretation, and QA procedures. Training will cover key steps required for accurate quantification of non-refractory PM components, including use of the ACSM analysis toolkit in IGOR Pro for baseline correction and signal integration; adjustment of fragmentation tables for proper allocation of ion signals to species such as nitrate, sulfate, and organics; and application of IE and RIEs.

The training will also address generation of time-resolved mass concentrations, averaging methods for trend analysis, and calculation of species ratios. QC procedures, such as identifying invalid data and comparing results with co-located measurements (e.g., BAM and SMPS), will be emphasized. For PMF-based source apportionment, participants will be guided through a workflow adapted from Zhang et al. (2011), tailored to ACSM datasets. Final data products will include time series plots, summary statistics, and uncertainty estimates suitable for interpretation and reporting.

In addition to formal training sessions held at the start of the project's second year, UCD will offer virtual office hours via Zoom or Microsoft Teams to support CARB personnel and address technical questions as needed.

Deliverable

- *Train CARB Personnel on ACSM data analysis, focusing on data processing workflows, output interpretation, and QA procedures.*

3b. Data Analysis SOP

UCD will develop an analysis protocol for generating QA/QC-processed data, ensuring consistency, transparency, and reproducibility across the CHAMP network. This protocol will include procedures for screening and flagging invalid data, applying calibration constants (e.g., IE and RIEs), and validating species mass concentrations through comparison with co-located reference instruments. Processed data will be converted into Comma-Separated Values (CSV) format to facilitate accessibility, data sharing, and integration with web-based visualization or archiving tools. In addition, a framework will be designed to support future automated uploading of raw ACSM data from the CHAMP network to a cloud-based platform, where automated QA/QC will be applied.

Deliverables:

- *Submit an ACSM data processing and analysis SOP.*

Task 4: Conduct Data Analysis and $PM_{2.5}$ Source Apportionment for the ASCENT Dataset

The ASCENT is a comprehensive, high-time-resolution, long-term aerosol speciation measurement network in the U.S. ASCENT currently operates three ToF-ACSMs accompanied by Xact (for trace metals), Aethalometer (for black/brown carbon), and SMPS (for aerosol number size distribution and concentration) in three SoCAB sites, namely Pico Rivera, Rubidoux, and Joshua Tree. During this contract, the project team is expected to continue ToF-ACSM monitoring at three ASCENT sites in SoCAB and perform at least one year of detailed analyses of the collected datasets, including advanced source apportionment analyses using the PMF model. Results from the three sites will be compared systematically to investigate how atmospheric aging impacts $PM_{2.5}$ composition and properties. Ideally, the analysis periods for both CHAMP and ASCENT datasets should coincide to allow for a more direct comparison of $PM_{2.5}$ emission sources throughout the state. If not, the ASCENT will provide CARB with one year of analyzed ACSM data from the preceding year.

Deliverable(s):

- *Submit the PMF source apportionment analysis results of one year of ACSM data from three ASCENT sites in the South Coast Air Basin.*

Task 5: Progress Meetings, Reporting, and Final Seminar

At the beginning of the project, UCD will hold a kick-off meeting with CARB. The research team will meet with CARB staff quarterly and submit quarterly progress reports using the CARB-designated template. Each progress report will accompany an invoice for the same period.

Six months prior to the end of the study, UCD will submit the DFR, which will detail the research findings and recommendations. The DFR will also include a thorough analysis of the methods and data collected, along with actionable suggestions for future applications and studies.

The DFR shall be copy-edited before being sent to CARB for review and the Principal Investigator shall attest that the Final Report has been reviewed and approved. The DFR will be submitted in accordance with the Final Report format and will be reviewed by CARB staff. CARB's comments will be sent to UCD and after receiving the reviewer's comments, UCD shall modify and resubmit the modified DFR to the CARB Project Manager. The modified DFR will be subject to formal review by the Research Screening Committee (RSC). Once accepted by the RSC, the research team will revise the modified DFR addressing the RSC comments and any remaining concerns from CARB staff and will submit the revised final report to CARB. If CARB has additional comments on the report, the research team will be notified so appropriate changes can be made; otherwise, CARB will accept the revised final report as the final.

UCD will submit the final report in an Americans with Disabilities (ADA) compliant format. A notation in the Final Report task should denote that the University will incorporate a one-page Public Outreach Document into the Final Report, that will be widely used to communicate, in clear and direct terms, the key research findings from the study to the public. The format for the Public Outreach Document is outlined in Exhibit A1, Section 2. CARB's standard for ADA compliance requires that the submitted document adhere to the Web Content Accessibility Guidelines (WCAG) 2.1 AA (https://www.w3.org/TR/WCAG21/) and Federal Section 508 (https://www.section508.gov/).

UCD will also include an Equity Implications Section into the Final Report, that will summarize how the research results inform disparate impacts of policies, regulations, or programs on priority communities. The Final Report shall be copy-edited before being sent to CARB for review and the Principal Investigator shall attest that the Final Report has been reviewed and approved.

The Principal Investigator (PI) will present a seminar in plain language to the CARB staff and the public. Additionally, the PI will provide an electronic copy of all data generated by this study to CARB.

CARB will publish publicly available detailed project reports outlining the findings, methodologies, and their impacts on racial equity, ensuring accessibility for diverse audiences. In addition, interactive tools, webinars, and presentations can be conducted to share the findings of this project while demonstrating equity-centered metrics and highlighting the outcomes of this research.

Deliverables.

- *A kick-off meeting will be held with CARB staff in the first month. Quarterly progress reports and an invoice for the same period will accompany each progress report.*
- *A DFR will be submitted six months prior to contract expiration, and a final report in the last project month.*
- *A virtual or in-person final seminar.*
- *Work with CARB to create plain-language outreach deliverables for the public, summarizing the project's results and impact.*

Data Management Plan

This project will collect high-time-resolution mass spectral data from eight CHAMP PM2.5-CV-ACSMs over a three-year period, with measurements recorded at 20-minute intervals. The datasets will include NR $PM_{2.5}$ species concentrations (e.g., NO_3, SO_4, NH_4, organics, and Chl), calibration metrics (IE and relative ionization efficiencies (RIE)), QA/QC records, and co-located reference measurements (e.g., BAM-$PM_{2.5}$ and BC).

Data will be batch processed using Aerodyne's ACSM analysis software within the Igor Pro. Environment. QA/QC procedures will include regular calibration checks, detection limit assessments, data validation against co-located instruments, and quantification of measurement uncertainties. Testing procedures to ensure instrument accuracy (e.g., IE and RIE calibrations and flow validations) are described in the "Project Tasks" section under Task 1.

Instrument data will be stored in real time on the internal computers and backup hard drives. On a weekly basis, data will be copied into organized directories on secure UCD servers, with additional backups to cloud storage and off-site locations. Final datasets will be shared in standardized formats (e.g., comma-separated values) and archived in a public repository upon project completion to ensure long-term accessibility and transparency.

Project results and analyses will also be disseminated through peer-reviewed publications and scientific presentations.

Project Schedule

The project duration is 36 months. Some tasks will be completed sequentially, while others will be performed simultaneously to ensure that the project goals and deliverables are met and submitted on time.

PROJECT PLAN		YEAR 1												YEAR 2												YEAR 3											
Task	Mo.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	Operationalize ACSM Across the CHAMP Network to Ensure Continuous, High-Quality Data Collection Over a Three-Year Period																																				
1a	Maintain Continuous Data Collection from CHAMP ACSMs Over a Three-Year Period																																				
1b	Develop SOPs for ACSM Deployment, Calibration, and Maintenance.																																				
1c	Implement QA/QC Protocol to Ensure Consistent and Accurate Data Collection.																																				
1d	Establish Streamlined Workflows for Data Acquisition, Data Processing, and Storage to Support Long-Term Usability and Accessibility.																																				
1e	Train CARB Personnel on ACSM Operation, Maintenance, and Troubleshooting.																																				
2	Compare ACSM Measurements Against Co-Located Measurements																																				
3	Conduct Data Analysis and PM2.5 Source Apportionment for the CHAMP Dataset																																				
3a	Provide training to CARB personnel on data analysis and address questions																																				
3b	Data processing and analysis SOP																																				
4	Conduct Data Analysis and PM2.5 Source Apportionment for the ASCENT Dataset																																				
5	Progress Meetings, Reporting, and Final Seminar																																				
		m		pm			pm			pm			pm			pm			pm			pm			pm			pm			dm			pm			fm

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

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 Riverside.

Project Management Plan

UCD

PI: Dr. Qi Zhang
Responsibilities:

- Provide overall leadership and coordination of the project, including supervision of research personnel and oversight of subcontracted work with the GIT team to ensure alignment with project goals,
- Lead the development and implementation of the CARB staff training program to support long-term CHAMP network sustainability, and
- Contribute directly to scientific analyses, data interpretation, and preparation of technical reports and deliverables.

Postdoctoral Researcher (TBD)
Responsibilities:

- Serve as the primary technical liaison with CARB staff and manage day-to-day operations and maintenance of CHAMP ACSM instruments,
- Lead the development and implementation of SOPs, QA/QC procedures, and data analysis workflows,
- Conduct ACSM data processing, ensure data quality, and prepare documentation and training materials, and
- Contribute to technical reporting and preparation of scientific manuscripts.

Graduate Student Researcher (GSR, TBD)
Responsibilities:

- Lead source apportionment analysis of CHAMP ACSM datasets and support QA/QC and result interpretation,
- Assist with data analysis and instrument operation as needed, and
- Contribute to technical reporting and preparation of scientific manuscripts.

Subcontractor: GIT

Co-PI: Dr. Nga Lee Ng
Responsibilities:

- Oversee the subcontracted work at GT, including supervision of a graduate student and oversight of data analysis to ensure proper progress,
- Collaborate with the UC Davis team on developing SOPs, QA/QC protocols, and data analysis workflows; support joint method refinement, and
- Contribute to technical reporting and manuscript preparation related to assigned work.

Graduate Research Assistant (GRA, TBD)
Responsibilities:

- Conduct source apportionment of ToF-ACSM data from three SoCAB ASCENT sites and contribute to statewide data interpretation,
- Lead nitrate reliability analysis through ACSM–filter comparisons and thermodynamic modeling, and
- Contribute to technical reporting and preparation of scientific manuscripts.

Coordination and Oversight

Dr. Zhang will organize biweekly internal meetings and monthly cross-institutional calls with the GIT team. A shared platform will be used for SOP drafts, workflow documentation, and progress monitoring. Project milestones and deliverables will be reviewed quarterly to ensure alignment with objectives. Dr. Zhang will engage in frequent (e.g., monthly) consultation conference calls with key stakeholders.

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EXHIBIT A1

SCHEDULE OF DELIVERABLES

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.
Initial 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
Task 1a. Deliverable	Submit 20-minute time-resolved NR-PM2.5 speciation data collected from eight CHAMP-deployed ACSM instruments over a three-year period.	Month 36
Task 1b. Deliverables	Submit a comprehensive instrument maintenance and operation manual that includes a detailed maintenance plan (key tasks, recommended frequencies, performance checks, and corrective actions). The manual will also feature a troubleshooting section addressing general issues related to ACSM installation, routine maintenance, and calibration, with practical guidance tailored for field technicians and CARB staff. Submit the SOP covering instrument setup, calibration, and operation.	Month 12 Month 12
Task 1c. Deliverables	Submit a comprehensive QA/QC protocol for ACSM operation, including best practices for identifying and flagging anomalous data, routine performance checks, inter-instrument comparisons to detect discrepancies, and interpretation of diagnostic plots and ion balance assessments. Submit the instrument checklist based on the version used in the ASCENT network and adapted to meet the specific needs for the CHAMP PM2.5-CV-ACSMs.	Month 12 Month 12

Task 1d. Deliverable	Submit the data SOP with step-by-step guidelines for consistent analysis of CHAMP ACMS data, including procedures for mass-to-charge-ratio calibrations, baseline refinement, adjustments to peak shape and peak width, signal-to-noise evaluation, and diagnostic checks.	Month 18
Task 1e. Deliverables	Provide comprehensive training for CARB staff on instrument operation, delivered through a combination of in-person and virtual sessions. Topics will include instrument setup, routine maintenance, calibration, diagnostic checks, data acquisition and analysis, validation, and troubleshooting. Submit the instructional materials, including video tutorials and a site operator checklist, covering routine maintenance tasks (e.g., cleaning and replacing the critical orifice), essential tasks for regular site visits, and post-event inspections following incidents such as power outages, wildfires, or severe weather.	Month 32 Month 12
Task 2. Deliverable	Submit the ACSM and filter-based nitrate intercomparison results, along with the thermodynamic modeling results, in the final report.	Month 30
Task 3 Deliverable	Submit PMF source apportionment analysis results of one year of CHAMP network ACSM data.	Month 30
Task 3a. Deliverable	Train CARB Personnel on ACSM data analysis, focusing on data processing workflows, output interpretation, and QA procedures.	Month 33
Task 3b. Deliverable	Submit an ACSM data Processing and analysis SOP.	Month 18
Task 4. Deliverable	Submit the PMF source apportionment analysis results of one-year ACSM data from three ASCENT sites in the South Coast Air Basin	Month 30
Progress Reports & Meetings	Quarterly progress reports and meetings throughout the agreement term, to coincide with work completed in quarterly invoices.	Quarterly
Draft Final Report	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 copy-edited before being sent to CARB for review, and the Principal Investigator shall attest that the Final Report has been reviewed and approved. The Draft Final Report shall be submitted in in accordance with the requirements outlined in Exhibit A1, Section 2 – Research Final Report Format.	Six (6) months prior to the agreement end date.
Data	Data compilations are 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.
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. The Technical Seminar slides shall be submitted in an ADA	On or before agreement end date.

	compliant format. CARB's standard for ADA compliance requires that the submitted document adhere to WCAG 2.1 AA (https://www.w3.org/TR/WCAG21/) and Federal Section 508 (https://www.section508.gov/).	
The following Deliverables are subject to paragraph 19. Copyrights, paragraph B of Exhibit C		
Final Report	Written record of the project and its results. The Final Report must be submitted in accordance with the requirements outlined in Exhibit A1, Section 2 – Research Final Report Format.	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 <u>and</u> 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. Contractor must ensure that the Final Report complies with Web Content Accessibility Guidelines 2.0, levels A and AA, and otherwise meets the accessibility requirements set forth in California Government Code Sections 7405 and 11135, Section 202 of the federal Americans with Disabilities Act (42 U.S.C. § 12132), and Section 508 of the federal Rehabilitation Act (29 U.S.C. § 794d) and the regulations promulgated thereunder (36 C.F.R. Parts 1193 and 1194) (collectively, the "Accessibility Requirements"). For any report provided in PDF format, Contractor shall also provide an electronic version in the original electronic format (for example, Microsoft Word or Adobe InDesign). CARB may request documentation from the Contractor of compliance with the Accessibility Requirements and may perform testing to verify compliance. Contractor must bring into compliance, at no cost to CARB, any report by Contractor or its subcontractors not meeting the Accessibility Requirements. If Contractor fails to bring its or its subcontractors' report into compliance with the Accessibility Requirements within five (5) business days of written notice from CARB, or within the time frame specified by CARB in its notice, Contractor will be responsible for all costs incurred by CARB in bringing Contractor's or its subcontractors' report into compliance with the Accessibility Requirements. Contractor agrees to respond to and resolve any complaint brought to its attention regarding accessibility of deliverables provided under this Contract for a period of one year following delivery of the final deliverable under this Contract.

Deviations from the Accessibility Requirements are permitted only by written consent by CARB.

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.

Attestation. A page dedicated to this attestation statement must follow the Acknowledgement(s). The Principal Investigator (PI) must digitally sign below the following statement:

> The Final Report for CARB Agreement No. [contract number] titled "[Enter project title]" has been copy-edited for grammar, style, and format and is reviewed and approved by the Principal Investigator (PI), [title and name of PI] of [Contractor Name]. The signature below attests that the PI has completed a thorough review of this Final Report and approves it for submission to the California Air Resources Board.
>
> PI Signature
> Date

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.

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.

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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 Disadvantaged Communities ; California Climate Investments to Benefit Disadvantaged Communities | CalEPA; CalEnviroScreen 4.0 | OEHHA

[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.

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 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. Contractor must ensure that all products and services submitted, uploaded, or otherwise provided by the Contractor and/or its subcontractors under this Agreement, including but not limited to data, software, plans, drawings, specifications, reports, operating manuals, notes, and other written or graphic work prepared in the course of performance of this Contract (collectively, the “Work”), comply with Web Content Accessibility Guidelines 2.0, levels A and AA, and otherwise meet the accessibility requirements set forth in California Government Code Sections 7405 and 11135, Section 202 of the federal Americans with Disabilities Act (42 U.S.C. § 12132), and Section 508 of the federal Rehabilitation Act (29 U.S.C. § 794d) and the regulations promulgated thereunder (36 C.F.R. Parts 1193 and 1194) (collectively, the “Accessibility Requirements”). For any Work provided in PDF format, Contractor shall also provide an electronic version in the original electronic format (for example, Microsoft Word or Adobe InDesign). CARB may request documentation from the Contractor of compliance with the Accessibility Requirements and may perform testing to verify compliance. Contractor must bring into compliance, at no cost to CARB, any Work by Contractor or its subcontractors not meeting the Accessibility Requirements. If Contractor fails to bring its or its subcontractors’ Work into compliance with the Accessibility Requirements within five (5) business days of written notice from CARB, or within the time frame specified by CARB in its notice, Contractor will be responsible for all costs incurred by CARB in bringing Contractor’s or its subcontractors’ Work into compliance with the Accessibility Requirements. Contractor agrees to respond to and resolve any complaint brought to its attention regarding accessibility of deliverables provided under this Contract for a period of one year following delivery of the final deliverable under this Contract.

Deviations from the Accessibility Requirements are permitted only by written consent by CARB.

EXHIBIT A2

KEY PERSONNEL

Last Name, First Name	Institutional Affiliation	Role on Project
Principal Investigator (PI):		
Qi Zhang	University of California, Davis	Dr. Zhang will serve as Principal Investigator for this project and will be closely involved in all aspects of the work including, but not limited to supervising the Assistant Specialist and Graduate Student Researcher.
Co-PI(s):		
Sally Ng	Georgia Institute of Technology	Dr. Ng will serve as the subcontractor on the project and contribute to developing SOP, analyzing ASCENT data, and comparing ACSM with filter-based measurements of NO_3.

EXHIBIT A3

AUTHORIZED REPRESENTATIVES & NOTICES

The following individuals are the authorized representatives for the State and the University under this Agreement. Any official Notices issued under the terms of this Agreement shall be addressed to the Authorized Official identified below, unless otherwise identified in the Agreement.

State Agency Contacts Agency Name: **CARB**	**University Contacts** University Name: University of California, Davis
Contract Project Manager (Technical) Name: Chinmoy Sarkar Address: Research Division 1001 I Street, 7th Floor Sacramento, CA 95814 Telephone: (279) 208-7544 Email: chinmoy.sarkar@arb.ca.gov	***Principal Investigator (PI)*** Name: Qi Zhang Address: 4251A Meyer Hall Department of Environmental Toxicology University of California Davis, CA 95616 Telephone: (530) 752-5779 Email: dkwzhang@ucdavis.edu
Authorized Official (contract officer) Name: Alice Kindarara, Branch Chief Address: Acquisitions Branch Fiscal Services Division 1001 I Street, 20th Floor Sacramento, CA 95814 Telephone: (279) 216-0406 Email: alice.kindarara@arb.ca.gov ***Send notices to (if different):*** Name: Renee Carnes Address: Research Division 1001 I Street, 7th Floor Sacramento, CA 95814 Telephone: (279)-208-7754 Email: renee.carnes@arb.ca.gov	***Authorized Official*** Name: Denise Ehlen Address: Research Administration Sponsored Research Office 1850 Research Park Davis, CA 95616 Email: awards@ucdavis.edu

<table>
<tr>
<td>Administrative Contact

Name: Renee Carnes
Address: Research Division
1001 I Street, 5th Floor
Sacramento, CA 95814

Telephone: (279)-208-7754
Email: renee.carnes@arb.ca.gov</td>
<td>Administrative Contact

Name: Mia Bartholomew
Address: One Shields Avenue
455 Crocker Lane
089 Academic Surge
Davis, CA 95616

Telephone: 530-752-4513
Email: dgbart@ucdavis.edu</td>
</tr>
<tr>
<td>Financial Contact/Accounting

Name: Accounts Payable
Address: P.O. Box 1436
Sacramento, CA 95814

Email: AccountsPayable@arb.ca.gov

Send courtesy copy to: rd.invoices@arb.ca.gov</td>
<td>Authorized Financial Contact/Invoicing

Name: Mario Reina-Guerra, Associate Director
Address: 1441 Research Park Drive
Davis, CA 95618

Email: mreinaguerra@ucdavis.edu

Designees for invoice certification in accordance with Exhibit C – University Terms and Conditions, Section 14 on behalf of the Financial Contact:
1. mreinaguerra@ucdavis.edu
2. jmscales@ucdavis.edu
3. tacastelli@ucdavis.edu</td>
</tr>
</table>

EXHIBIT A4

USE OF PREEXISTING INTELLECTUAL PROPERTY & DATA

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:

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

☒ None or ☐ List:

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:

EXHIBIT A5

RÉSUMÉ / BIOSKETCH

Qi Zhang

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date	FIELD OF STUDY
Nanjing University, China	BS	06/1994	Chemical Engineering
Nanjing University, China	MS	06/1997	Bioinorganic Chemistry
University of California, Davis	Ph.D.	07/2002	Atmospheric Chemistry
University of Colorado, Boulder	Postdoctoral	09/2004	Aerosol mass spectrometry

Positions, Scientific Appointments, and Honors

Positions and Employment

2024- Donald G. Crosby Endowed Chair in Environmental Chemistry, University of California at Davis, CA
2016- Professor, Dept. of Environmental Toxicology, University of California at Davis, CA
2012-2016 Associate professor, Dept. of Environmental Toxicology, University of California at Davis, CA
2009-2012 Assistant professor, Dept. of Environmental Toxicology, University of California at Davis, CA
2005-2009 Assistant Professor / Research Associate, Atmospheric Sciences Research Center and Dept. of Environmental Health, State University of New York at Albany, NY
2004-2005 Research Associated Step II, CIRES, University of Colorado, Boulder.

Other Experience and Professional Activities

1. Chair, Agricultural and Environmental Chemistry Graduate Group, University of California, Davis (since 2022)
2. Chair, Telluride Science Research Center (TSRC) Workshop on Organic Aerosol (2018 – 2022)
3. Editor, Aerosol and Air Quality Research (AAQR) (since 2015)
4. Editorial Advisory Board, ACS Environmental Au (since 2024)
5. Editorial Advisory Board, Atmospheric Environment (since 2013)
6. Board of Directors, American Association of Aerosol Research (AAAR) (since 2020)

Honor

2020 Leadership for the 21st century (LEAD21, Class 15)
2020 Highly Cited Researcher in the field of Cross-Field
2019 Highly Cited Researcher in the field of Cross-Field
2018 Highly Cited Researcher in the field of Geosciences
2017 Highly Cited Researcher in the field of Geosciences
2016 Highly Cited Researcher in the field of Geosciences
2015 Highly Cited Researcher in the field of Geosciences
2015 Chancellor's Fellow, University of California, Davis
2014 Highly Cited Researcher in the field of Geosciences
2014 *Zhang et al. 2007* "Ubiquity and dominance of oxygenated species in organic aerosols in anthropogenically-influenced Northern Hemisphere midlatitudes" article was selected in the Geophysical Research Letter (GRL) 40th Anniversary Special Collection. The only publication selected in the Atmospheric Science field.
2003 Atmospheric Chemistry Colloquium for Emerging Senior Scientists (ACCESS)

Contributions to Science

Selected Peer-reviewed Publications (Selected from 200+ peer-reviewed publications, trainees from Zhang's lab are underscored, * denotes corresponding author)

Most relevant to the current application

1. Sun, P., Farley, R. N., Li, L. J., Srivastava, D., Niedek, C. R., Li, J. J., Wang, N. X., Cappa, C. D., Pusede, S. E., Yu, Z., Croteau, P., and **Zhang, Q.*** (2022) $PM_{2.5}$ composition and sources in the San Joaquin Valley of California: A long-term study using ToF-ACSM with the capture vaporizer, *Environmental Pollution*, 292, 118254, https://doi.org/10.1016/j.envpol.2021.118254.
2. Farley, R., N. Bernays, D. A. Jaffe, D. Ketcherside, L. Hu, S. Zhou, S. Collier and **Zhang, Q.*** (2022) Persistent Influence of Wildfire Emissions in the Western United States and Characteristics of Aged Biomass Burning Organic Aerosols under Clean Air Conditions. *Environmental Science & Technology* **56**(6): 3645-3657
3. Pande, P., Shrivastava, M., Shilling, J. E., Zelenyuk, A., **Zhang**, **Q.**, Chen, Q., Ng, N. L., Zhang, Y., Takeuchi, M., Nah, T., Rasool, Q. Z., Zhang, Y., Zhao, B., and Liu, Y. (2022) Novel Application of Machine Learning Techniques for Rapid Source Apportionment of Aerosol Mass Spectrometer Datasets. *ACS Earth and Space Chemistry, 6(4): 932-942.*
4. Wang, J., Ye, J., **Zhang, Q.**, Zhao, J., Wu, Y., Li, J., Liu, D., Li, W., Zhang, Y., Wu, C., Xie, C., Qin, Y., Lei, Y., Huang, X., Guo, J., Liu, P., Fu, P., Li, Y., Lee, H. C., Hwang, S., Zhang, J., Chen, H. L. M., Sun, Y., Ge, X., Martin, S. T., and Jacob, D. J. (2021) Aqueous production of secondary organic aerosol from fossil fuel emissions in winter Beijing haze, *Proceedings of the National Academy of Sciences (PNAS),* 118, e2022179118, 10.1073/pnas.2022179118
5. Huang, D. D., Zhu, S., An, J., Wang, Q., Qiao, L., Zhou, M., He, X., Ma, Y.-g., Sun, Y., Huang, C., Yu, J. Z., and **Zhang, Q.*** (2021) Comparative assessment of cooking emission contributions to urban organic aerosol using online molecular tracers and aerosol mass spectrometer measurements, *Environmental Science & Technology*, 55, 14526-14535, 10.1021/acs.est.1c03280, 2021. https://pubs.acs.org/doi/pdf/10.1021/acs.est.1c03280
6. Li, H., **Zhang, Q.***, Jiang, W., Collier, S., Sun, Y., Zhang, Q., and He, K. (2021) Characteristics and sources of water-soluble organic aerosol in a heavily polluted environment in Northern China, *Science of The Total Environment*, 758, 143970
7. Zhao, Q. B., Huo, J. T., Yang, X., Fu, Q. Y., Duan, Y. S., Liu, Y. X., Lin, Y. F., **Zhang, Q.*** (2020) Chemical characterization and source identification of submicron aerosols from a year-long real-time observation at a rural site of Shanghai using an Aerosol Chemical Speciation Monitor, *Atmospheric Research*, 256, 105154, https://doi.org/10.1016/j.atmosres.2020.105154.
8. Parworth, C. L., Young, D. E., Kim, H., Zhang, X., Cappa, C. D., Collier, S., and **Zhang, Q*** (2017) Wintertime water-soluble aerosol composition and particle water content in Fresno, California: Results from DISCOVER-AQ 2013, *Journal of Geophysical Research - Atmospheres*, 122(5), 3155-3170, 10.1002/2016JD026173
9. Young, D., Kim, H. J., Parworth, C., Zhou, S., Zhang, X. L., Cappa, C., Seco, R., Kim, S., and **Zhang, Q.*** (2016) Influences of emission sources and meteorology on aerosol chemistry in a polluted urban environment: Results from DISCOVER-AQ California, *Atmospheric Chemistry & Physics,* 16, 5427-5451, 10.5194/acp-16-5427-2016.
10. **Zhang, Q.***, J. L. Jimenez, M. Canagaratna, I. Ulbrich, N. L. Ng, D. Worsnop, and Y. L. Sun (2011) Understanding atmospheric organic aerosols via factor analysis of aerosol mass spectrometry: a review, *Analytical and Bioanalytical Chemistry*, 401, 3045-3067, doi 10.1007/s00216-011-5355-y

Additional recent publications of importance to the field (in chronological order)

11. Zheng, Y., Miao, R., **Zhang, Q.**, Li, Y., Cheng, X., Liao, K., Koenig, T. K., Ge, Y., Tang, L., Shang, D., Hu, M., Chen, S., and Chen, Q. (2023) Secondary Formation of Submicron and Supermicron Organic and Inorganic Aerosols in a Highly Polluted Urban Area, *Journal of Geophysical Research: Atmospheres*, 128, e2022JD037865, https://doi.org/10.1029/2022JD037865.

12. Collier, S., Zhou, S., Onasch, T. B., Jaffe, D., Kleinman, L., Sedlacek, A. J., Briggs, N., Hee, J., Fortner, E., Shilling, J. E., Worsnop, D. R., Yokelson, R. J., Parworth, C. L., Ge, X. L., Xu, J. Z., Butterfield, Z., Chand, D., Dubey, M.K., Pekour, M., Springston, S., and **Zhang, Q*.** (2016) Regional Influence of Aerosol Emissions from Wildfires Driven by Combustion Efficiency: Insights from the BBOP Campaign. *Environ. Sci. and Technol.* 50, 8613–8622, 10.1021/acs.est.6b01617, 2016.

13. Zhou, S., Collier, S., Jaffe, D. A., Briggs, N. L., Hee, J., Sedlacek III, A. J., Kleinman, L., Onasch, T. B., and **Zhang, Q***. (2017) Regional influence of wildfires on aerosol chemistry in the Western US and insights into atmospheric aging of biomass burning organic aerosol, *Atmos. Chem. Phys.*, 2017, 2477-2493, 10.5194/acp-17-2477-2017.

14. Kim, H., **Zhang, Q**. *, Bae, G. N., Kim, J. Y., and Lee, S. B. (2017) Sources and atmospheric processing of wintertime aerosols in Seoul, Korea: Insights from real-time measurements using a high-resolution aerosol mass spectrometer, *Atmos. Chem. Phys.*, 17, 2009-2033, 10.5194/acp-17-2009-2017.

15. Li, H., **Zhang, Q.** *, Zhang, Q., Chen, C., Wang, L., Wei, Z., Zhou, S., Parworth, C., Zheng, B., Canonaco, F., Prévôt, A. S. H., Chen, P., Zhang, H., and He, K. (2017) Wintertime aerosol chemistry and haze evolution in an extremely polluted city of north China plain: Significant contribution from coal and biomass combustions, *Atmos. Chem. Phys.* 17, 4751-4768, 10.5194/acp-17-4751-2017

16. Collier, S., Williams, L. R., Onasch, T. B., Cappa, C. D., Zhang, X., Russell, L. M., Chen, C.-L., Sanchez, K. J., Worsnop, D. R., and **Zhang, Q.*** (2018) Influence of emissions and aqueous processing on particles containing black carbon in a polluted urban environment: Insights from a Soot Particle – Aerosol Mass Spectrometer, *Journal of Geophysical Research: Atmospheres*, 123, 6648-6666, 10.1002/2017JD027851.

17. Kim, H.; Collier, S.; Ge, X.; Xu, J.; Sun, Y.; Jiang, W.; Wang, Y.; Herckes, P.; **Zhang, Q.*** (2019) Chemical Processing of Water-Soluble Species and Formation of Secondary Aerosol in Fogs. *Atmospheric Environment*, 200, 158-166

18. Zhou, S., S. Collier, D. A. Jaffe, and **Zhang, Q.*** (2019) Free Tropospheric Aerosols at the Mt. Bachelor Observatory: More Oxidized and Higher Sulfate Content Compared to Boundary Layer Aerosols, *Atmospheric Chemistry and Physics*. **19**, 1571–1585, 10.5194/acp-19-1571-2019

19. Ge, X. L., **Zhang, Q.***, Y. L. Sun, C. R. Ruehl, A. Setyan (2012) Effect of Aqueous Phase Processing on Aerosol Chemistry and Size Distributions in Fresno, California, during Wintertime, *Environmental Chemistry*, 9(3), 221-235, 10.1071/EN11168

20. Ge, X. L., A. Setyan, Y. L. Sun, **Zhang, Q.*** (2012) Primary and Secondary Organic Aerosols in Fresno California during Wintertime: Results from High Resolution Aerosol Mass Spectrometry, *Journal of Geophysical Research – Atmospheres*, 117, D19, doi:10.1029/2012JD018026

Complete List of Published Work Available at:
https://sites.google.com/site/qizhanggroup/publications?authuser=0

Published Work and Citation Metrics in Publons:
https://publons.com/researcher/2824772/qi-zhang/

Nga Lee Ng
Love Family Professor
School of Chemical and Biomolecular Engineering
School of Earth and Atmospheric Sciences
Georgia Institute of Technology
ng@chbe.gatech.edu
http://ng.chbe.gatech.edu/

Education and Training

2007 Ph. D. Chemical Engineering, California Institute of Technology
2004 M.S. Chemical Engineering, California Institute of Technology
2002 B. Eng. Chemical and Environmental Engineering, Hong Kong University of Science and Technology, Hong Kong

Research and Professional Experience

2022-present Love Family Professor (Endowed Professorship), School of Chemical and Biomolecular Engineering, School of Earth and Atmospheric Sciences, Georgia Institute of Technology
2021-2022 Professor and Tanner Faculty Fellow, School of Chemical and Biomolecular Engineering, School of Earth and Atmospheric Sciences, Georgia Institute of Technology
2017-2021 Associate Professor and Tanner Faculty Fellow, School of Chemical and Biomolecular Engineering, School of Earth and Atmospheric Sciences, Georgia Institute of Technology
2011-2017 Assistant Professor and Baldwin Faculty Fellow, School of Chemical and Biomolecular Engineering, School of Earth and Atmospheric Sciences, Georgia Institute of Technology
2010-2011 Senior Scientist, Center for Aerosol and Cloud Chemistry, Aerodyne Research
2008-2010 Postdoctoral Scientist, Center for Aerosol and Cloud Chemistry, Aerodyne Research
2007-2008 Postdoctoral Scholar, Chemical Engineering, California Institute of Technology

Selected Honors and Awards

2023 Ascent Award, American Geophysical Union
2021 Robert W. Vaughan Lectureship, Chemical Engineering, California Institute of Technology
2017 Dreyfus Foundation Fellowship in Environmental Chemistry
2016 Kenneth T. Whitby Award, American Association for Aerosol Research
2015 CAREER Award, National Science Foundation
2014 Top Five Most-Cited Papers in 2011-2013, Aerosol Science and Technology
2013 Walter A. Rosenblith New Investigator Award, Health Effects Institute
2013 Early Career Award, Environmental Protection Agency
2010 Sheldon K. Friedlander Award (Outstanding Dissertation), American Association for Aerosol Research
2007 Atmospheric Chemistry Colloquium for Emerging Senior Scientists (ACCESS) Award

Five Closely Related Publications

Takeuchi, M., Wang, Y., Nault, B. A., Chen, Y., Canagaratna, M. R., and Ng, N. L.: Evaluating the response of the Aerodyne aerosol mass spectrometer to monoterpene- and isoprene-derived organic nitrate standards, Aerosol Sci. Technol., 1-18, 10.1080/02786826.2024.2389183, 2024.

Joo, T., Chen, Y., Xu, W., Croteau, P., Canagaratna, M. R., Gao, D., Guo, H., Saavedra, G., Kim, S. S., Sun, Y., Weber, R., Jayne, J., and Ng, N. L.: Evaluation of a New Aerosol Chemical Speciation Monitor (ACSM) System at an Urban Site in Atlanta, GA: The Use of Capture Vaporizer and PM2.5 Inlet, ACS Earth and Space Chemistry, 5, 2565-2576, 10.1021/acsearthspacechem.1c00173, 2021.

Wang, Y., Piletic, I. R., Takeuchi, M., Xu, T., France, S., and Ng, N. L.: Synthesis and Hydrolysis of Atmospherically Relevant Monoterpene-Derived Organic Nitrates, Environ. Sci. Technol., 10.1021/acs.est.1c05310, 2021.

Xu, L., Suresh, S., Guo, H., Weber, R. J., and Ng, N. L.: Aerosol characterization over the southeastern United States using high-resolution aerosol mass spectrometry: spatial and seasonal variation of aerosol composition and sources with a focus on organic nitrates, *Atmos. Chem. Phys*., 15, 7307-7336, 10.5194/acp-15-7307-2015, 2015.

Ng, N. L., Herndon, S. C., Trimborn, A., Canagaratna, M. R., Croteau, P. L., Onasch, T. B., Sueper, D., Worsnop, D. R., Zhang, Q., Sun, Y. L., and Jayne, J. T.: An Aerosol Chemical Speciation Monitor (ACSM) for Routine Monitoring of the Composition and Mass Concentrations of Ambient Aerosol, *Aerosol Sci. Technol.*, 45, 770-784, 2011.

Synergistic Activities:

- Editor-in-Chief, ACS ES&T Air
- Editorial Board Member, Nature Scientific Reports, ACS Earth and Space Chemistry
- Conference Chair, 37th American Association for Aerosol Research (AAAR) annual conference
- Instrument development: Aerosol Chemical Speciation Monitor (ACSM)
- Chair, Environmental Division, American Institute of Chemical Engineers (AIChE), 2020

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: Qi Zhang					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
Pending	25RD002	CARB	Accelerated Evaluation of Ambient PM2.5 in Regions Affected by the 2024 National Ambient Air Quality Standards (NAAQS) Update	TBD	TBD
Active	24RD013	CARB	Assessing Health Impacts of Brake and Tire Wear Emissions in Overburdened Communities of the San Joaquin Valley	5/01/2025	4/30/2027
Active	22RD038	CARB	Long-term chemical characterization and source apportionment of $PM_{2.5}$ in the San Joaquin Valley	7/1/2023	6/30/2026
Active	DE-SC0022140	DOE	Investigating the Impacts of Aqueous-Phase Processing on Organic Aerosol Chemical Climatology Using ARM and ASR Observations	8/15/2021	8/14/2025
Active	DE-SC0021242	DOE	Characterization of carbonaceous aerosols during TRACER-CAT	8/15/2020	8/14/2025
Active	AGS-2220307	NSF	Formation of photo-oxidants and processing of organic species in aerosol liquid water	7/15/2022	6/30/2026
Active	AGS-2308645	NSF	Aqueous aerosol chemistry: elucidating the mechanisms causing mismatch between field and laboratory chemical composition of biomass burning organic aerosol	7/1/2023	6/30/2026

Co-PI: Sally Ng					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
Pending	25RD002	CARB	Accelerated Evaluation of Ambient PM2.5 in Regions Affected by the 2024 National Ambient Air Quality Standards (NAAQS) Update	TBD	TBD
Active	460000333	EPRI	Measurement of Particles and Gases Emitted from a Jet Engine Combustor Operating with Different Fuels	Jun-25	May-27
Active	AWD-004704	FDA	In Vitro Assessment of Chemical Mixture-induced Airway Inflammation in Healthy and Diseased Lungs	Oct-22	Sep-25
Active	2131458	NSF	Collaborative Research: A Nitrate Radical Oxidation Flow Reactor: Development and Use in Laboratory and Field Studies	Nov-21	Jan-26
Active	2131914	NSF	Mid-scale RI-1 (M1:IP): ASCENT: Atmospheric Science and Chemistry mEasurement NeTwork	Oct-21	Sep-25
Active	NA21OAR4310221-T1-01	NOAA	Changes in Aerosol Loading and Composition in Atlanta Driven by Changes in Anthropogenic Emissions during the COVID-19 Pandemic	Sep-21	Aug-25
Active	2108916	NSF	Laboratory Chamber Studies on Gas-Phase Photooxidation and Aqueous Chemistry of Phenols and Methoxyphenols in Biomass Burning Organic Aerosol Formation	Aug-21	Jul-26
Active	NA21OAR4310131-T1-01	NOAA	Molecular-level Source Apportionment of Ambient Particulate Matter to Resolve Impacts of Anthropogenic and Biogenic Emissions in a Coastal Mega-City Environment	May-21	Apr-26
Pending		HEI	Atlanta PM2.5 signal amplification and effect accumulation leads to thromboinflammation	Jul-25	Jun-28

Pending		NSF	RAPID: Quantifying the Impacts of Canadian Wildfires on Ambient Aerosols in Atlanta	Jul-25	Jun-26
Pending		NOAA	Elucidating the influence of sources, atmospheric processes, and mitigation policies on U.S. urban air quality in the warming 21st century	Jun-25	May-28
Pending		NSF	Atmospheric Science and Chemistry mEasurement NeTwork (ASCENT): Operation, Management, and Scientific Studies	Apr-25	Mar-30
Pending		DOE	Ecosystem Stress, Volatile Organic Compounds, and Secondary Organic Aerosol Properties in Southeastern United States	Apr-25	Mar-28
Pending		DOE	Understanding Degradation Mechanisms of Aminopolymers Used in Direct Air Capture	Apr-25	Mar-28
Pending		NASA	Chemically-resolved particulate matter concentration maps to enable environmental epidemiology and exposure science	Feb-25	Jan-28
Pending		CARB	Accelerated evaluation of ambient PM2.5 in regions affected by the 2024 NAAQS update	Jan-26	Dec-28

EXHIBIT A7

THIRD PARTY CONFIDENTIAL INFORMATION REQUIREMENT

CONFIDENTIAL NONDISCLOSURE AGREEMENT

Exhibit A7 is not applicable for this Agreement.

EXHIBIT B2

BUDGET PERTAINING TO SUBAWARDEE(S)

The budgets will be incorporated prior to submitting to the CARB contracts office for review/approval.

EXHIBIT B3

INVOICE AND DETAILED TRANSACTION LEDGER 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

Detailed transaction ledger and/or payroll ledger for the invoice period [2]

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

[2] 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

Exhibit D is not applicable for this Agreement.

EXHIBIT E

SPECIAL CONDITIONS FOR SECURITY OF CONFIDENTIAL INFORMATION

Exhibit E is not applicable for this Agreement.

EXHIBIT F

ACCESS TO STATE FACILITIES OR COMPUTING RESOURCES

Access to CARB-operated and affiliated monitoring sites will be required to support instrument installation, maintenance, and data collection activities outlined in the Scope of Work. Specifically, we will need access to six Monitoring and Laboratory Division (MLD) sites, as well as additional sites maintained by CARB and local air quality districts. We will coordinate closely with the Research Division’s (RD) project manager to ensure that all necessary access agreements are completed in accordance with Exhibit F requirements.

EXHIBIT G

NEGOTIATED ALTERNATE UTC TERMS

I. Exhibit C, UTC – 220 Section 14 – Payment & Invoicing is hereby amended to incorporate the following:

Add Item 6 to Section 14. A. to read as follows:

6) CARB shall withhold payment equal to 10 percent after the Contractor has been compensated for 90 percent of the total agreement amount. 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.

Amend Section 14. C.2 – Invoicing to read as follows:

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: to Section 14, to read as follows:

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.

Amend Section 14.B –Budget Flexibility to read as follows:

B. Budget revisions between identified budget categories in cost reimbursement agreements that are within the total Agreement amount, comply with the Prior Approval Requirements, above and do not change the Scope of Work or substitute Key Personnel, as defined in this Agreement, are allowed as described below:

1) Up to 10% ~~of each annual budget amount or $10,000, whichever is less,~~ is allowed with approval of the State's Contract Project Manager, or as otherwise agreed to by the Parties and documented on Exhibit B.

2) Exceeding 10% ~~or $10,000, whichever is less,~~ of the last approved budget require the State's Contract Project Manager's prior approval and may require a formal amendment to this Agreement. The University will submit a revised budget to the State for approval. Budget transfers that would cause any portion of the funds to be used for purposes other than those consistent with the original intent of this Agreement are not allowed.

II. Add the following sections to the UTC-220 to incorporate additional required provisions:

Add Section 31 to read as follows:

31. GenAI Disclosure Obligations:

A. The following terms are in addition to the defined terms and shall apply to the Contract:

1) "Generative AI (GenAI)" means an artificial intelligence system that can generate derived synthetic content, including text, images, video, and audio that emulates the structure and characteristics of the system's training data. (Gov. Code § 11549.64.)

B. Contractor shall immediately notify the State in writing if it: (1) intends to provide GenAI as a deliverable to the State; or (2), intends to utilize GenAI, including GenAI from third parties, to complete all or a portion of any deliverable that materially impacts: (i) functionality of a State system, (ii) risk to the State, or (iii) Contract performance. For avoidance of doubt, the term "materially impacts" shall have the meaning set forth in State Administrative Manual (SAM) § 4986.2 Definitions for GenAI.

C. Notification shall be provided to the State designee identified in this Contract.

D. At the direction of the State, Contractor shall discontinue the provision to the State of any previously unreported GenAI that results in a material impact to the functionality of the System, risk to the State, or Contract performance, as determined by the State.

E. If the use of previously undisclosed GenAI is approved by the State, then Contractor will update the Deliverable description, and the Parties will amend the Contract accordingly, which may include incorporating the GenAI Special Provisions into the Contract, at no additional cost to the State.

F. The State, at its sole discretion, may consider Contractor's failure to disclose or discontinue the provision or use of GenAI as described above, to constitute a material breach of Contract when such failure results in a material impact to the functionality of the System, risk to the State, or Contract performance. The State is entitled to seek any and all remedies available to it under law as a result of such breach, including but not limited to termination of the contract.

Add Section 32 to read as follows:

32.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.

Add Section 33 to read as follows:

33. Executive Order N-6-22 – Russia Sanctions

On March 4, 2022, Governor Gavin Newsom issued Executive Order N-6-22 (the EO) regarding Economic Sanctions against Russia and Russian entities and individuals. "Economic Sanctions" refers to sanctions imposed by the U.S. government in response to Russia's actions in Ukraine, as well as any sanctions imposed under state law. The EO directs state agencies to terminate contracts with, and to refrain from entering any new contracts with, individuals or entities that are determined to be a target of Economic Sanctions. Accordingly, should the State determine Contractor is a target of Economic Sanctions or is conducting prohibited transactions with sanctioned individuals or entities, that shall be grounds for termination of this agreement. The State shall provide Contractor advance written notice of such termination, allowing Contractor at least 30 calendar days to provide a written response. Termination shall be at the sole discretion of the State.