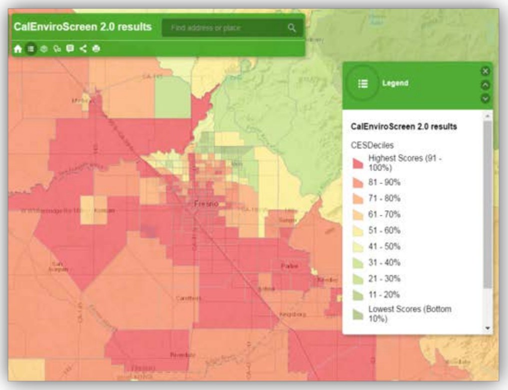
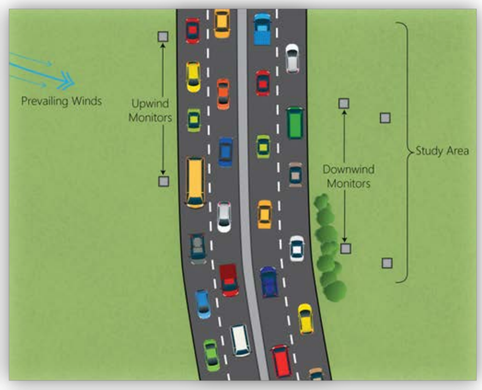
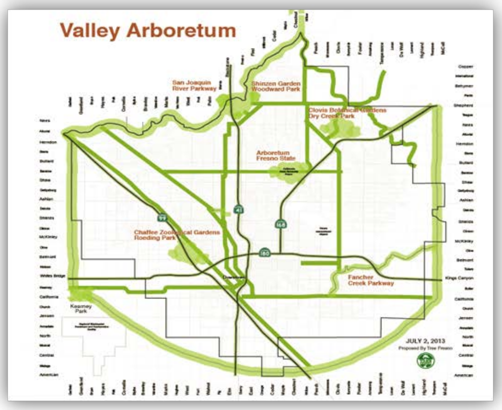
The Fresno TREES Project







Prepared for

Enforcement Division
California Air Resources Board
Sacramento, CA

October 2016

TREE FRESNO

STi
Sonoma Technology, Inc.
Innovative Environmental Solutions

The Fresno TREES Project

Tree planting along **R**oads to help **E**liminate pollution **E**xposure and **S**equester carbon

Prepared for

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The cover symbolizes Fresno EJ ratings, a planned Fresno greenway, and proposed monitoring and tree planting.

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Executive Summary

The Fresno TREES project (**T**ree planting along **R**oads to help **E**liminate pollution **E**xposure and **S**equester carbon) will address three high priority environmental issues in Fresno, one of the state's most important environmental justice (lower socio-economic) regions. Our proposed project will (1) assess the efficacy of using vegetative barriers to reduce near-road pollution exposure; (2) plant trees and shrubs in the near-road environment to improve the Fresno community while reducing exposure to traffic-related air pollutants; and (3) help sequester carbon through tree planting and contribute to the California goal of reducing climate change impacts. Each of these efforts is highlighted below.

First, we will evaluate how well vegetative barriers (using trees and shrubs) protect people from exposure to air pollution downwind of major roads. Near-road air pollution has emerged as one of the most important air quality issues, especially for roads with substantial truck traffic. Near-road pollution is a recognized contributor to health impacts such as asthma which, according to the American Lung Association, affects 24% of children in Fresno County. Studies also show that those living close to major roads include higher fractions of minority and lower income residents compared to surrounding areas. Through a series of field studies, we will measure air quality in areas with and without near-road vegetation, and help quantify the benefits of using a vegetative barrier to separate traffic-related air pollution from the public downwind of the road. Our work will help local, state, and federal agencies quantify vegetative barrier benefits and encourage use of trees and shrubs to reduce pollution exposure.

Our measurements will focus on various forms of traffic-related particulate pollution that are of key interest to the transportation, air quality, and public health communities. We will use traditional air quality measurement equipment to monitor concentrations of black carbon (BC), which serves as a marker for diesel vehicle particulate pollution; particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) and particulate matter less than 10 microns in diameter (PM_{10}), which are state and federally regulated air pollutants that contribute disproportionately to health impacts and are emitted by diesel-powered trucks; and ultra-fine particulate (UFP) matter, which has been shown to be elevated near major roads and, because of its small size, can penetrate deep into the lung. We will also use innovative low-cost air quality sensors to measure $PM_{2.5}$ and PM_{10}, to help assess how well emerging technology performs as an air quality management resource. Our focus on particulate pollution is a function of the potential benefits offered by vegetative barriers. Studies show that vegetative barriers can reduce particulate concentration levels downwind of major roads in two ways: (1) as air passes through the barrier, the vegetation can filter and remove airborne particles; and (2) a dense vegetative barrier can force traffic-related pollution to flow up and over the barrier, lofting the pollution plume higher into the air and giving it time to disperse and become less concentrated as it travels to downwind locations.[1]

Second, we will plant trees near roads to achieve four Fresno community objectives: (1) improve the community adjacent to Fresno area freeways by planting trees within the Caltrans Right of Way (ROW); (2) improve the quality of approximately a half-dozen public parks and/or schools located near freeways; (3) improve several rural and urban districts located near freeways and truck corridors in the Fresno area through the development of Community Landscapes Plans (CLPs) and associated tree planting; and (4) help implement the vision of a system of greenways known as the Valley Arboretum. The Valley Arboretum, developed by Tree Fresno, is part of the Parks and Open Space element of the City of Fresno General Plan adopted in 2014. Our work will complement community goals to "green" areas currently lacking trees and other vegetation. These efforts will improve community aesthetics and, as the vegetation matures, add shade and help reduce exposure to near-road air pollution.

Third, our tree planting will contribute to state goals to address climate change. Trees sequester carbon through their uptake of carbon dioxide (CO_2). Tree planting is recognized by the state as an important climate change mitigation action, and CARB has worked with CAL FIRE to encourage tree planting through the CAL FIRE urban forestry program. The work proposed here will plant over 3,700 trees and model vegetation use as an environmental mitigation measure.

In addition, our project includes tool development and outreach, education, and community engagement efforts. We propose to develop an easy-to-use tool to help agencies quantify air quality benefits of near-road vegetative barriers. Our proposed outreach, education, and community engagement efforts will inform high-school aged youth, other Fresno area residents and organizations, and regulatory agencies about air pollution problems and the use of trees to achieve environmental and community benefits.

Overall, findings from this project will support multiple state agencies, including CARB, CAL FIRE, Caltrans, Housing and Community Development (HCD), and the Governor's Office of Planning and Research (OPR). In addition, the U.S. Environmental Protection Agency (EPA), the U.S. Federal Highway Administration (FHWA), and the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) are interested in finding ways to support near-road pollution exposure reduction. The proposed project team includes a multi-agency advisory panel to involve these stakeholder organizations.

The proposed package of work consists of base and supplemental tasks spread across a five-year period. The base work efforts are needed to meet project objectives; the supplemental efforts are designed to expand knowledge and understanding of vegetative barriers and improve implementation. Together, base and supplemental tasks cover planning and project coordination, air

[1] Baldauf R., et al. (2013) Integrating vegetation and green infrastructure into sustainable transportation planning. *TR News*, (288), 14-18, September-October; and Steffens J.T., Wang Y.J., and Zhang K.M. (2012) Exploration of effects of a vegetation barrier on particle size distributions in a near-road environment. *Atmos. Environ.*, 50, 120-128.

quality measurement and data analysis, tree planting and care, outreach and education, and reporting. During the development of our proposal, we paid close attention to addressing the following study design questions; the approach taken to each of these issues is described in the Project Description discussion in the main body of our proposal:

- Tree Planting Considerations
  - What types of trees are reasonable to plant?
  - How can trees be cared for and maintained to ensure their long-term health?
  - How can tree planting complement public health and community improvement objectives?
- Pollutants of Interest
  - What near-road pollutant concentrations are of greatest interest?
  - What near-road pollutant measurements can be deferred to help reduce costs?
  - What is the recommended list of pollutants to measure?
- Air Quality Field Study Design
  - Can the study minimize field measurement costs while properly evaluating vegetative barrier concentration influences?
  - How can the work effort inform a variety of vegetative barrier situations?
  - How can the work effectively assess PM concentration changes given the importance of background concentrations?
  - Will low-cost sensors yield sufficiently reliable concentration data?
- Data Analysis
  - How can the study account for fleet turnover?
  - Will the study account for near-road pollution sources other than on-road vehicles?
  - How can the study findings be used to contribute to decision making?
  - Will the potential confounding effects of meteorology be addressed during data analysis?

Overall, the study proposed here aims to cost-effectively address important questions regarding near-road vegetation use, successfully plant trees to improve the Fresno area, and prepare and disseminate information and resources to assist stakeholders. It further aims to help policy makers develop a better understanding of options to (1) improve freeway design to mitigate near-road air pollution, (2) provide setbacks from freeways and truck corridors for parks and schools, and (3) select and design vegetative barriers to protect urban districts, rural communities, and greenways located near freeways and high air pollution producers.

Table ES-1 provides an overall funding estimate for this project, while **Figure ES-1** illustrates the timing of tasks. The work package is modular; the timing of work and the execution of individual base and supplemental efforts can be adjusted to accommodate available funding on a year-by-year basis.

Table ES-1. Summary of proposed base (in blue) and supplemental (italicized in red) estimated costs for the Fresno TREES project.

Task/Cost	2017	2018	2019	2020	2021
Planning and Project Coordination					
PPC-1. Initial/ongoing planning	41,889	18,843	19,364	20,231	20,752
PPC-2. Advisory team/meetings	34,712	27,950	28,728	30,024	30,801
Air Quality Measurement and Analysis					
AQ-1. "Before" tree planting (base)	604,389				
AQ-2. "After" tree planting (base)				454,632	463,751
AQ-3. Mature vegetation (base)		430,316			
AQ-4. Seasonality test (supp.)		*324,198*			
AQ-5 Different vegetation types (supp.)					
- dense vs. sparse			*332,227*		
- leaf vs. conifer				*347,854*	
- low vs. high height				*347,854*	
- with sound wall			*332,227*		
AQ-6. Different road grade (supp.)		*324,198*			
AQ-7. Parks/schools (supp.)			*332,227*		*355,670*
AQ-8. Neighborhoods (supp.)				*347,854*	*355,670*
AQ-9. Valley arboretum (base)			439,434		
AQ-10. Tool development/refinement (supp.)	*30,389*	*243,987*	*84,994*	*28,102*	
Tree Planting					
TP-1. Near-freeway plan (base)	125,000	96,700	99,481	102,345	105,296
TP-2. Near-freeway planting (base)	*240,000*	240,000	120,000	240,000	120,000
TP-3. Near-freeway tree care (base)		14,000	16,000	30,000	32,000
TP-4. CLP plans (base)	80,000	86,350	87,741	89,173	90,648
TP-5. CLP planting (supp.)		*48,000*	*96,000*	*144,000*	*192,000*
TP-6. CLP tree care (supp.)			*4,000*	*6,000*	*8,000*
TP-7. Valley Arboretum plans (base)	40,000	126,350	49,741	51,173	52,648
TP-7. Valley Arboretum planting (base)		48,000	48,000	48,000	48,000
TP-7. Valley Arboretum tree care (base)			2,000	4,000	6,000
Outreach, Education, Engagement					
OE-1. Stakeholders (base)	80,960	103,607	120,218	110,825	127,784
OE-2. Youth (supp.)	*25,055*	*102,992*	*105,764*	*110,384*	*113,152*
OE-3. Tree mapping (supp.)	7,040	7,251	7,469	7,693	7,924
Reporting	91,568	94,242	96,923	101,235	103,931
Base Funding Totals	1,065,558	1,293,609	1,135,098	1,289,331	1,209,534
Supp. Funding Totals	*295,444*	*1,043,375*	*1,287,440*	*1,332,048*	*1,024,492*
Overall Funding Totals	**1,401,002**	**2,336,984**	**2,422,538**	**2,621,379**	**2,234,026**

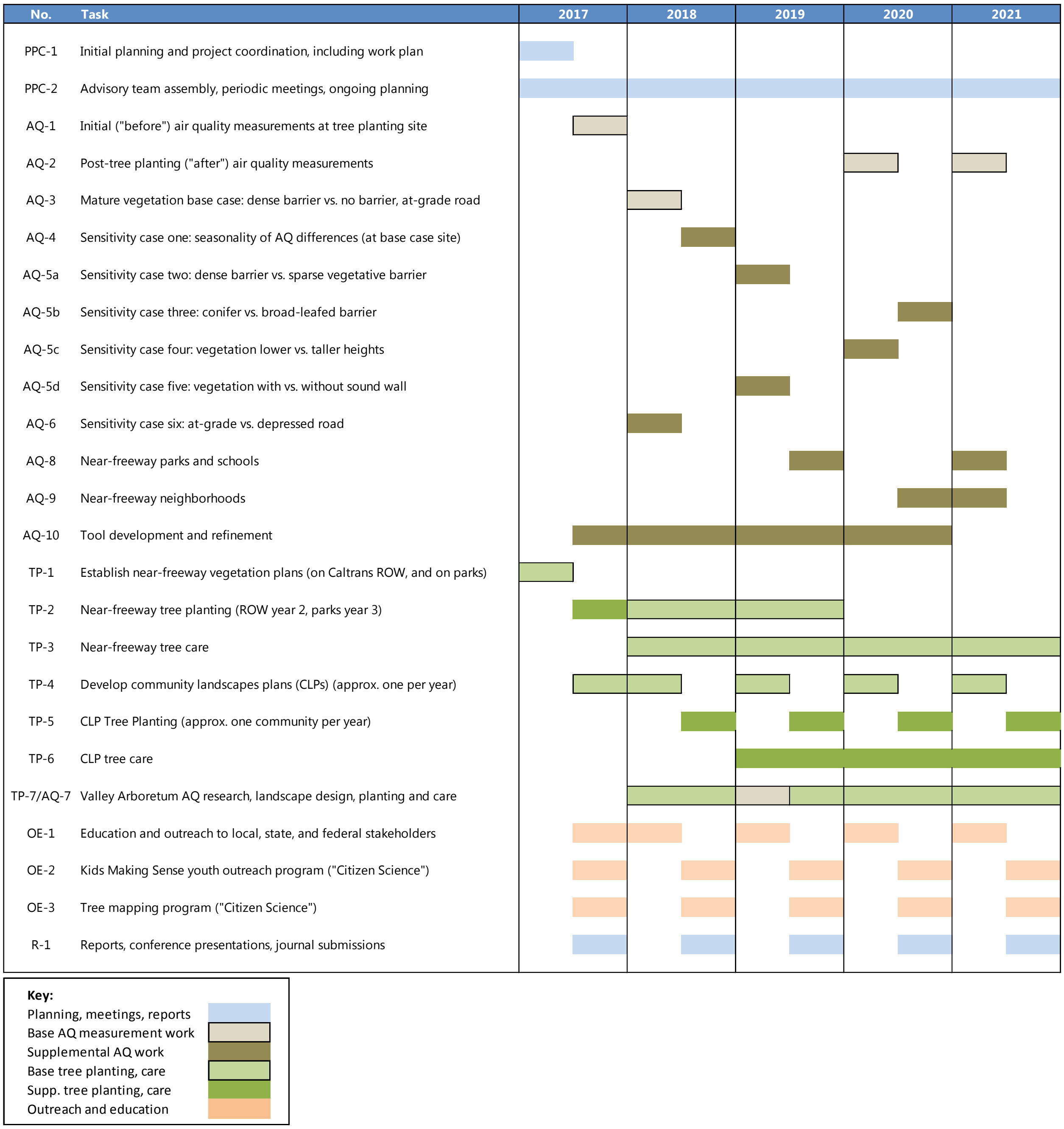


Figure ES-1. Anticipated tasks and approximate time periods for task completion.

1. Organization Description

1.1 Tree Fresno, a 501(c)(3) Organization

Mission, History, and Business Status: The mission of Tree Fresno (TF) is to transform the San Joaquin Valley with trees, trails, greenbelts, and beautiful landscapes. TF was established in 1985, when a group of concerned citizens met to discuss ways to celebrate the Fresno Centennial while helping the environment. Their efforts came to fruition in the form of a telethon, which raised $27,000 for planting trees in the downtown and Tower District areas. Today, more than three decades later, TF has been responsible for the planting of over 41,000 trees in the Fresno and Clovis areas, including over 4,000 trees on Fresno County school campuses. TF officially formed in 1987 as a **501(c)(3) nonprofit corporation** and ran purely on volunteers for the first six years before hiring a professional staff.

Vision: TF's purpose is to be a regional resource for trees, trails, and greenbelts. Educational and stewardship projects such as the Tree Fresno Tree Selection Guide, the Tree Portraits program, the Tree Fresno Demonstration Garden, and the Living Laboratories program at local schools, help teach local children the value of green spaces and caring for their environment. Programs such as Tribute Trees, Tribute Benches, and Veterans' Groves, offer individuals a unique way to commemorate their loved ones. TF has received national attention for projects such as the Great Rail Trail Planting, where 4,400 trees were planted in one day thanks to the commitment of 2,800 volunteers. Additional projects include the Blackstone Avenue planting of 939 trees, the McKinley Avenue Canal Bank planting of 500 trees, the award winning Reedley Community Landscapes Plan (CLP), the award winning El Dorado Park re-landscaping project, and the partnership with PG&E and the National Arbor Day Foundation to plant trees at parks and giveaway water-wise shade trees to residents.

Goals: TF has several big goals: (1) teach the art of living green to every citizen; (2) demonstrate how trees, trails, and greenways can reduce air pollution, increase ground water recharge, and reduce ground water contamination and energy use; (3) help the Fresno State campus become an inspiration for the region; (4) raise the Trust for Public Land's ParkScore for Fresno from last to the top 10 percent; (5) transform disadvantaged communities with trees and beautiful landscapes; (6) establish a Veterans' Grove and a Tribute Grove in each city in our region; and (7) develop the Valley Arboretum, a signature greenway amenity for the region.

1.2 Sonoma Technology, Inc., a Small Business

Mission, History, and Business Status: Sonoma Technology (STI) was established in 1982 to research and address air quality issues. As stated in our corporate charter, STI's objective is to provide high-quality, innovative, science-based solutions for air quality, meteorological, and other environmental needs worldwide in an ethical and objective manner, and to facilitate effective environmental management. STI was formed by a small group of scientists who wanted to do high quality, scientifically objective work to support organizations seeking to understand and address air pollution problems. A key component of STI's culture, history, and skills is the ability to complete field work—to measure real-world meteorological and air quality conditions, and to use those measurement findings to help clients understand and address air quality challenges. Today, STI's team includes approximately 60 scientists, engineers, and support staff. STI has a unique mix of field scientists, emissions and air quality computer modelers, exposure and health effects researchers, air quality forecasters, fire science experts, software developers, and transportation-related air quality experts. STI is a **certified small business in California (ID #21447)**. The U.S. Small Business Administration has also certified that STI meets the federal small business size standard requirement for Environmental Consulting Services, NAICS code 541620, and the U.S. General Services Administration catalogue identifies STI as a small business, contract No. GS-10F-0181K.

Vision: As stated in our charter, STI's vision is to (1) operate at the forefront of science and technology; (2) always perform sound science and engineering; (3) maintain a high level of technical respect and visibility through publications and technical meetings; (4) develop complementary, synergistic teams with the highest level of technical expertise; (5) maintain technical excellence and an outstanding reputation; (6) encourage contacts and joint projects with universities and other groups with complementary expertise; (7) take personal responsibility for quality; (8) ensure that our work is ethical, honest, objective, innovative, understandable, and practical; (9) ensure that our clients understand our work and its implications and that our work is used ethically and effectively; (10) be respectful of our clients and staff; (11) satisfy our clients, maintain strength through diversity, and provide an enjoyable and rewarding place to work; and (12) be financially sound.

Goals: STI strives to advance knowledge in critical environmental management areas. A sampling of recent accomplishments helps underscore this goal-oriented work. For over 16 years, STI has operated the U.S. Environmental Protection Agency (EPA) AirNow system, which provides real-time air quality throughout the United States. STI has participated in the Southern California Children's Health Study for over 20 years and has co-authored numerous landmark publications that established the connections between air pollution, public health, and the influence of near-road air pollution. STI manages and completes research for a federal-state multi-agency pooled fund, dedicated to understanding and addressing near-road air pollution. Together with colleagues at UC Davis, STI published a synthesis of worldwide data on near-road air quality that has become a benchmark publication used by researchers throughout the world. STI assists the U.S. State Department by making real-time air quality data from U.S. Embassies in China available on the web. These and many other projects demonstrate STI's goal-driven efforts to improve understanding about pollution problems.

2. Organization Experience

2.1 Tree Fresno

2.1.1 Ability and Capacity to Complete the Proposed Project

TF has over 30 years of directly related experience managing tree planting and outreach and education projects. TF has a well-respected network of professional resources, full-time and part-time staff, interns, and volunteers to accomplish tree planting and tree care. TF's organizational structure and project approach enables it to scale up to meet the demands of individual projects. For this effort, TF will focus study year one on developing vegetation plans, a community engagement program, a CLP, and staffing to support the tree planting scheduled to begin in study year two. In addition, TF will strengthen its outreach and education work in year one by hiring a Community Engagement Coordinator (CEC). The CEC will improve TF's social media presence and publications, and enable TF to create and implement comprehensive outreach, education, and community engagement work through the life of this project.

2.1.2 Tree Fresno Project Experience

TF's history, accomplishments, and current projects are described in detail on the organization's website: http://www.treefresno.org. Related past work includes development of a CLP for the City of Reedley, tree planting in El Dorado Park, creation of the Tree Fresno Demonstration Garden, and creation of the Valley Arboretum vision for incorporation in the Fresno General Plan. Current work includes over $50,000 in funding to support tree planting at 12 school campuses in the Fresno region. The projects highlighted on the following pages exemplify Tree Fresno's experience and commitment to community improvement.

Client/Partners:	City of Reedley
Title:	Reedley Community Landscape Plan
Description:	In partnership with the City of Reedley – and with four co-sponsors – TF crafted a Landscapes Plan for the City (5.1 square miles with 25,000 residents) that was composed of five elements: (1) landscape assessment (what trees and plants are working well or not; this led to a well-received "do not plant list"); (2) conceptual plan with tree and plant palate by District and major corridor; (3) water conservation plan; (4) community engagement plan; and an (5) action plan with the identification of strategic properties. TF retained two leading experts in the region; a landscape architect, Rich Vaillancour, and a certified arborist, John Pape. They collaborated with the TF network and a local advisory committee. Bi-lingual materials were prepared for

	the community engagement work with the assistance of Dr. Brissa Queros, STEM Coordinator at Reedley College. TF launched the "Tree Portrait" series with the preparation of a one page description of each tree recommended in the plan, drawing from authoritative reference books, experts, and documented in source notes. Part of the work's strategic objective was to plant trees on public property and inspire planting on private property, where 90% of the tree canopy opportunities exist. Further, TF put a spot light on the Kings River, a somewhat neglected resource. The project earned the "Astounding Urban Forestry Project Award" at the annual California Urban Forestry Council & California Releaf conference in August, 2016.

Client/Partners:	California State University - Fresno
Title:	Tree Fresno Demonstration Garden
Description:	TF obtained approval from Fresno State to construct an 8,000 sf "Demonstration Garden" and parking lot in front of the TF office at the Horticulture Center. Now under construction, it features an outdoor classroom with seating for 32, and will be shaded by a Valley Oak tree, 15 other trees, and 20+ species of understory plants.

Client/Partners:	City of Fresno, PG&E, Wesley United Methodist Church, Residents
Title:	El Dorado Park
Description:	TF transformed a badly vandalized, heavily used park serving a very low income neighborhood near Bull Dog Stadium. Work involved planting trees and establishing irrigation with a below grade in-line drip ring system. For TF's work on the park, the California Urban Forest Council presented TF with the "Outstanding Urban Forestry Project of the Year" award in 2012. The award recognized that TF's tree planting efforts transformed the local neighborhood. The project was a collaborative effort by the City of Fresno, PG&E, Wesley United Methodist Church, property owners, and residents. This project aligned with the *Vibrant Neighborhoods* strategic priority set forth in the Tree Fresno Vision statement.

Client/Partners:	Fresno and Washington Unified School Districts (Fresno)
Title:	Tree Planting at School Campuses
Description:	With funding by the California GHG Reduction Funds, administered by CAL FIRE and CaReLeaf, TF is completing tree planting at school sites. Trees are being chosen with shade and air quality benefits in mind. Each school will have hydra-loop irrigation dedicated to trees, with a below-grade in-line drip ring for each tree. A companion education component is enabling the school Districts to provide instruction to support the implementation of Next Generation Science Standards.

2.2 Sonoma Technology, Inc.

2.2.1 Ability and Capacity to Complete the Proposed Project

STI has over 30 years of experience performing air quality field studies similar to the work proposed for this project. STI has also completed numerous studies involving tool development and outreach and education. For this effort, STI will develop its overall work plans during the first half of study year one, and begin implementation of air quality measurement and outreach work during the second half. The six-month period between contract initiation and field work is sufficient to enable STI to plan for equipment acquisition, identify study sites, and schedule field staff for all project years. STI is also proposing to phase in delivery of its Kids Making Sense™ (KMS) outreach program[2] by providing the KMS program to one high school in year one, followed by four high schools in each subsequent year. This phase-in schedule will allow STI sufficient time to work with school officials and schedule program delivery. In addition, STI will use the second half of study year one to plan for tool development work that will use field study findings. Since the data analysis and software development work for the tool will occur primarily in study year two, there will be sufficient time in study year one to schedule the work with STI's software development team.

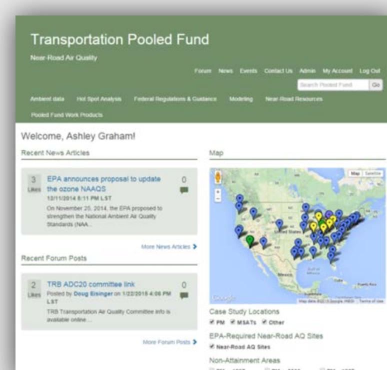
2.2.2 Sonoma Technology, Inc. Project Experience

Selected examples of projects performed by STI are listed on the following pages.

[2]See: kidsmakingsense.org.

Near-Road Air Quality Emissions and Air Quality Modeling Support Projects

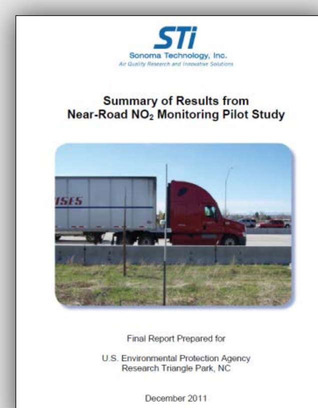
Client:	California Department of Transportation, Division of Environmental Analysis, Sacramento, CA
Title:	Near-Road Air Quality Analysis Support; Greenhouse Gas, Mobile Source Air Toxics, and Criteria Pollutant Emissions and Air Quality Support
Description:	STI supports the California Department of Transportation (Caltrans), Division of Environmental Analysis (DEA). Caltrans must deliver transportation projects while meeting applicable federal, state, and local air quality, climate change, and public health requirements. Caltrans contracted with STI to provide analysis methods, tools, training, and other support to help Caltrans meet mandates and speed project delivery (two consecutive contract vehicles). Example work completed includes analysis methods, tools, and training to complete EPA-mandated PM hot-spot assessments; development of an enhanced construction equipment emissions model; and development of GIS-based resources to assist with near-road analyses. 
Dates:	10/1/2009 through 6/30/2017
Funding Amount:	Contract work 2009 through 2016: $4.7 million

Client:	Near-Road Air Quality Transportation Pooled Fund, Washington State Department of Transportation (Lead Agency), Olympia, WA
Title:	Support for the Near-Road Air Quality Transportation Pooled Fund Research Project
Description:	STI is providing the Washington State Department of Transportation (WSDOT) with near-road support services through a Transportation Pooled Fund (TPF). STI is developing tools, analyses, and other materials to address near-road requirements. Work has so far included reviewing literature on near-road barriers (sound walls and vegetation) to assess their ability to improve near-road air quality; using emissions data to identify situations in which traffic will not create air quality problems; evaluating near-road monitoring data collected throughout the United States; and developing an information-exchange website for transportation and air quality planners. In addition 

	to WSDOT, TPF participants include state Departments of Transportation from Arizona, California, Colorado, Ohio, Texas, and Virginia; and the U.S. Federal Highway Administration.
Dates:	4/10/2014 through 6/30/2019
Funding Amount:	Contract work 2014 through 2016: $1 million

Near-Road Air Quality Monitoring and Monitoring Support Projects

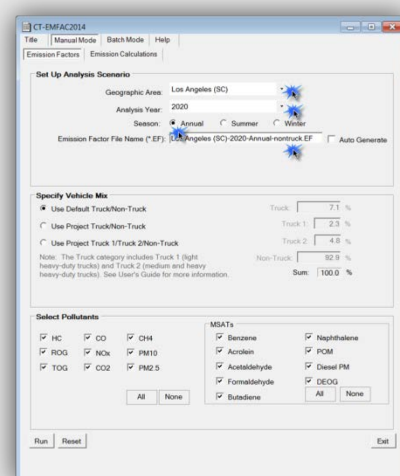
Client:	Nevada State Department of Transportation, Carson City, NV
Title:	U.S. 95 Near-Road Study and Follow-On Study
Description:	STI conducted a near-road study in 2007-2008 in Las Vegas, Nevada, to enhance information about sources and behaviors of mobile source air toxics (MSATs) near major roadways and to test the effectiveness of mitigation techniques to reduce concentrations of MSATs in neighboring school classrooms. Following completion of the original measurement and mitigation work, STI conducted follow-on tests at three near-road schools to determine how effectively filtration systems worked five years after the original study was performed. 
Dates:	5/17/2006 through 12/31/2014
Funding Amount:	Contract work (original and follow-on study) through 2014: $1.6 million

Client:	U.S. Environmental Protection Agency, Research Triangle Park, NC
Title:	Near-Road Monitoring Guidance Development
Description:	The U.S. Environmental Protection Agency (EPA) published monitoring regulations that require states to establish and operate nitrogen dioxide (NO_2) monitors near highly trafficked roads in major urban areas to measure peak concentrations. STI helped EPA develop near-road air pollutant monitoring guidance by identifying relevant literature that might support guidance development, supporting EPA staff with the creation of near-road guidance, identifying monitoring methods that may be suitable for evaluating near-road pollutant concentrations, and supporting the planning and implementation 

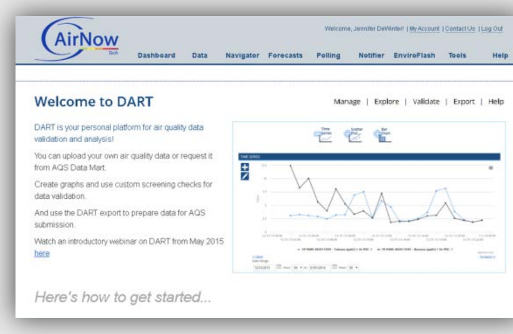
	process for the near-road pilot monitoring sites. STI also developed a quality assurance plan for near-road pilot study monitoring, coordinated the monitoring project conducted in several states, and analyzed and reported findings. The pilot study corroborated the conceptual model of near-road pollutant concentration gradients and gave state agencies experience in siting and operating a near-road site including working with land owners and state DOTs.
Dates:	7/21/2010 through 10/4/2012
Funding Amount:	Contract work through 2012: $240,000

Tool Development Projects

Client:	**California Department of Transportation, Division of Environmental Analysis, Sacramento, CA**
Title:	CT-EMFAC Rebuild
Description:	With support from CARB and Caltrans, STI developed updated versions of the CT-EMFAC tool. In California, on-road motor vehicle emissions are calculated using CARB's EMFAC model. CARB developed new versions of EMFAC, EMFAC2011 and EMFAC2014, which included changes in travel activities and emissions information. CT-EMFAC pairs EMFAC-based emission factors with user-supplied travel activity data to produce project-specific emissions estimates; CT-EMFAC also allows users to directly estimate project-level mobile source air toxics and enables numerous model runs in a batch mode. This work builds on our prior work developing earlier versions of CT-EMFAC with UC Davis.
Dates:	4/16/2012 through 6/30/2016
Funding Amount:	Contract work for CT-EMFAC versions 5 (based on EMFAC2011) and 6 (based on EMFAC2014) through 2016: $578,000



Client:	**U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (OAQPS), Research Triangle Park, NC**
Title:	Development and Updating of the Data Assessment and Reporting Tool (DART) and Supporting Materials
Description:	STI created a web-based validation and analysis platform to help local, state, and federal agencies evaluate air quality monitoring data. STI worked with U.S. EPA and

	key stakeholders to include desired features and to create documentation and training materials. The new tool, called the Data Assessment and Reporting Tool (DART), is accessed online through the EPA *AirNow-Tech* web portal. Following initial development, STI completed several rounds of tool updates and enhancements, such as including "one-click" auto-data-screening with interactive tables and plots to allow analysts to evaluate and flag Photochemical Assessment Monitoring Station (PAMS) data, improve status information for data uploads and AQS requests, and customize units on graphics. 
Dates:	10/5/2013 through 1/4/2017
Funding Amount:	Contract work for 2013 through 2016: $1 million

Low-Cost Sensor Use to Monitor Air Quality Projects

Client:	**Electric Power Research Institute**
Title:	Sensor Technology to Inform New Environmental Monitoring
Description:	STI will deploy a network of low-cost particulate matter (PM) sensors (Alphasense OPC-N2), reference instruments, and meteorological instruments at a coal-fired power plant for a period of six months. The study will determine how new, low-cost sensors can address air-quality issues associated with coal-fired power plant operations. Specifically, this study will investigate how well low-cost particulate matter sensors can detect lofted coal dust and thus be used for improving operational decisions to mitigate air quality impacts. 
Dates:	6/1/2016 through 7/31/2017
Funding Amount:	Contract work through 2017: $190,000

Client:	San Joaquin Valley Unified Air Pollution Control District
Title:	San Joaquin Valley Ozone Saturation Study
Description:	STI worked with the San Joaquin Valley Unified Air Pollution Control District to monitor ozone air quality, evaluate low-cost sensor technology, and assess the relocation of a regulatory monitor in Arvin, California. For this study, STI deployed 23 low-cost ozone sensor systems in and around Arvin during summer 2013. As part of this work, STI co-located low-cost sensors with a federal equivalent method (FEM) instrument for inter-comparison and calibration before and after the six-week field program. Results demonstrated the spatial variability of ozone, the representativeness of the planned ozone monitoring relocation site, and the usefulness of low-cost sensors. 
Dates:	5/31/2013 through 5/31/2014
Funding Amount:	Contract work through 2014: $180,000

Outreach, Education, and Planning to Support Citizen Science Projects

Client:	U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (OAQPS), Research Triangle Park, NC
Title:	AirNow International and Kids Making Sense
Description:	STI helped EPA support the AirNow-International (AirNow-I) program and website, and develop instructional materials and educational workshops for the Kids Making Sense™ (KMS) education program. KMS is a STEM education program that teaches students in grades 6-12 about monitoring and improving air quality in their communities. STI developed and designed a Student Workbook and a companion Teacher's Guide that align with Next Generation Science and Common Core standards. The program provides lessons and hands-on activities that teach students about air quality, the health effects of pollution, low-cost air sensors, and data interpretation. Using this curriculum, STI has conducted KMS workshops in California, New York, Taiwan, and Thailand schools. Also as part of this work, STI upgraded mapping software within AirNow, 

	provided enhancements to the AirNow-I community website, and helped EPA and the U.S. State Department get international data into the AirNow system.
Dates:	1/5/2015 through 1/6/2016
Funding Amount:	Contract work through 2016: $158,000

Client:	**U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (OAQPS), Research Triangle Park, NC**
Title:	Advanced Monitoring (Low-Cost Sensor) Scoping Study
Description:	 EPA asked STI to help plan for and respond to the rapid emergence of low-cost, advanced air quality monitoring technology. In contrast to traditional, often expensive, monitoring methods, emerging technologies are or have the potential to be cheaper, more mobile, quicker (often avoiding the need for long delays of sending samples to a laboratory), and more networked. EPA sought STI assistance to help agencies prepare for transformations in the monitoring arena, and to seize emerging opportunities to strengthen environmental protection. STI delivered its report, "Advanced Monitoring Technology: Critical Next Steps for EPA and States," to EPA and the E-Enterprise Leadership Council (EELC), a consortium of senior EPA and state officials dedicated to modernizing the business of environmental protection. STI's recommendations included: (1) Perform a detailed options and feasibility analysis on the creation of an independent third party evaluation/certification program for advanced monitoring technology. (2) Develop and start executing technology scanning and screening procedures within EPA and the states, and provide support to users. (3) Develop messaging and tools to support the interpretation of short-term monitoring results. (4) Develop data use tiers and data standards for advanced monitoring technologies. And (5) lean the current technology approval process.
Dates:	1/5/2016 through 1/4/2017
Funding Amount:	Contract work through 2016: $75,000

3. Project Description

3.1 Overview

The Fresno TREES project (**T**ree planting along **R**oads to help **E**liminate pollution **E**xposure and **S**equester carbon) is an ambitious project that will plant trees to create vegetative barriers and will (1) help reduce near-road air pollution exposure; (2) reduce greenhouse gas (GHG) impacts by sequestering CO_2; (3) give CARB and its partner agencies improved data and analysis methods to support near-road vegetation use statewide; (4) educate school-aged youth about air quality with hands-on "citizen science" pollution monitoring through the nationally recognized KMS outreach program; and (5) engage and educate local, state, and national stakeholders on the efficacy of vegetative barriers to reduce near-road pollution exposure.

The project will take place in Fresno County, which has the highest rankings (most heavily impacted) for environmental justice (EJ) concerns in California (**Figure 1**). Fresno County is home to some of the nation's worst air pollution, and regional highways experience high levels of automotive and truck traffic. This project addresses these issues by evaluating the efficacy of vegetative barriers to reduce near-road pollution impacts, especially from trucks. We will use traditional air quality measurement equipment to monitor concentrations of black carbon (BC), which serves as a marker for diesel vehicle particulate pollution; particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) and particulate matter less than 10 microns in diameter (PM_{10}), which are state and federally regulated air pollutants that contribute disproportionately to health impacts and are emitted by diesel-powered trucks; and ultra-fine particulate (UFP) matter, which has been shown to be elevated near major roads and, because of its small size, can penetrate deep into the lung. We will also use innovative low-cost air quality sensors to measure $PM_{2.5}$ and PM_{10}, to help assess how well emerging technology performs as an air quality management resource. Our focus on particulate pollution is a function of the potential benefits offered by vegetative barriers. Studies show that vegetative barriers can reduce particulate concentration levels downwind of major roads in two ways: (1) as air passes through the barrier, the vegetation can filter and remove airborne particles; and (2) a dense vegetative barrier can force traffic-related pollution to flow up and over the barrier, lofting the pollution plume higher into the air and giving it time to disperse and become less concentrated as it travels to downwind locations.

Findings will support multiple state agencies, including CARB, CAL FIRE, Caltrans, Housing and Community Development (HCD), and the Governor's Office of Planning and Research (OPR). In addition, EPA, the U.S. Federal Highway Administration (FHWA), and the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) are also interested in finding ways to support near-road pollution exposure reduction. The proposed project team includes a multi-agency advisory panel to involve stakeholders from each of these organizations in the study design, implementation, and findings.

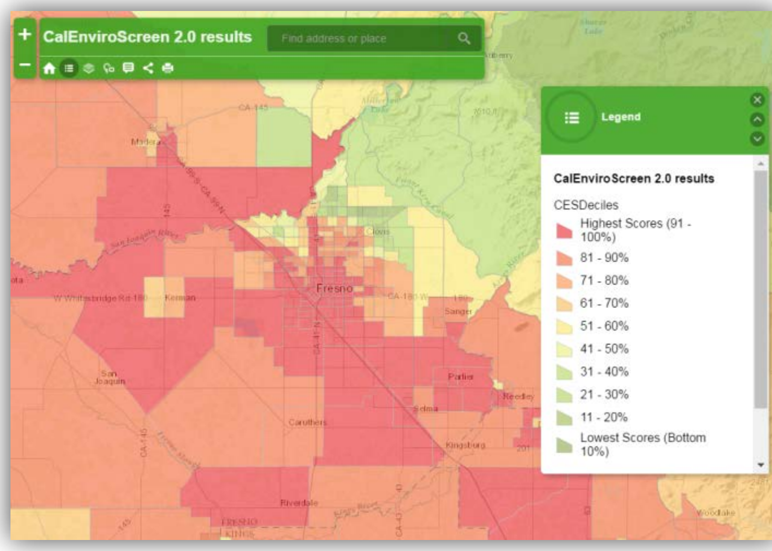


Figure 1. Fresno area CalEnviroScreen rankings.[3]

Limited studies indicate that a vegetative barrier of trees and shrubs, when positioned between a major road and downwind locations such as homes and schools, helps reduce roadway-related air pollution exposure.[4] However, the evaluation work proposed here is needed because there is a severe lack of quantitative data and evaluation tools to assess the air quality benefits of roadside tree planting. The need for additional studies in this area was confirmed at a recent national workshop on vegetation as a near-road pollution exposure mitigation strategy.[5]

Caltrans data indicate that in the Fresno area, between 5,000 to 18,000 heavy-duty trucks travel daily on each of State Highways 41, 99, 168, and 180, with Highway 99 having the highest daily truck count. Given the scientific understanding of near-road problems, we will measure pollution at several locations within 150 m of Fresno area freeways (particularly along Highway 99), and, depending on the supplemental tasks funded, adjacent to heavily traveled major arterials with higher levels of truck traffic. Measurement work will to assess how well vegetation reduces air pollution near roads and evaluate the benefits of mature and newly planted trees. Trees planted as part of this project will limit future exposure to air pollution and improve the quality of life for those Fresno area residents living and spending time near major roads.

Our work will also develop a new analysis tool to help others quantify the benefits of using near-road vegetative screens to reduce pollution exposure. Creation of this new tool will help the transportation-air quality community begin to quantitatively evaluate vegetative barriers and help

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[3] See: http://oehha.ca.gov/calenviroscreen/report/calenviroscreen-version-20.

[4] See: https://archive.epa.gov/nrmrl/archive-appcd/web/pdf/baldauf.pdf.

[5] See: http://www.sacbreathe.org/Air%20Quality%20Resources/vegetationconference.html (Day 2 discussion summary highlights the needed research).

agencies understand how certain near-road factors, such as wind speed and direction, affect downwind air quality.

In addition, our work includes outreach, education, and community engagement efforts. These work tasks are designed to educate youth about air pollution, assist regulators in understanding the benefits of vegetative barriers, and engage community members in working to improve the Fresno area through tree planting. Key findings from our work will be distributed through meetings and briefings for community members and local, state, and federal agency staff; and to the transportation-air quality community as a whole via publications and conference presentations.

We have proposed a multi-year, multi-task effort that combines air quality measurements and analysis, community design, tree planting and care, and outreach, education, and community engagement. Our study design is modular; the timing of work modules can be adjusted to accommodate available funding on a year-by-year basis. To assist in scheduling work, we have divided the overall study into base and supplemental efforts. Base work efforts are needed to meet project objectives, while supplemental efforts are designed to expand knowledge and understanding of vegetative barriers and to improve implementation of the project.

3.2 Project Management Team

Lee Ayres of TF and Douglas Eisinger of STI will be co-principal investigators. Mr. Ayres will be assisted by a team of TF professional staff members and by others hired as needed to support tree planting, such as outside certified arborists, landscape architects, ecologists, and other tree experts who serve on TF's governing and advisory boards. Dr. Eisinger will be assisted in managing STI's work by Clinton MacDonald, who will oversee the STI air quality measurement program, and by Paul Roberts, who will serve as a senior advisor and work-product quality assurance reviewer. Various other STI staff will assist with the field studies, data analysis, outreach and education, and tool development work, depending on the task. Key staff information is provided below.

Lee Ayres has served as TF's Executive Director since 2011. His previous leadership experience includes working as City Manager for Sunnyvale, California, owner of Sequoia investments, and Project Coordinator with Stewards, Inc. He enjoys transforming communities with beautiful landscapes and teaching the art of living green. He has served on the Board of Directors for the Fresno Business Council since 2006, currently Chairs the SJV Urban Forest Council, and has served on the California Urban Forest Council Board and the City of Fresno Downtown Neighborhoods Community Advisory Committee. He was the Project Coordinator for TreeTOPS, a regional urban forest, trails, and open space initiative, and has taught Social Entrepreneurship at CSU-Fresno.

Dr. Douglas Eisinger joined STI in 1995 and serves as Vice President and Chief Scientist for Transportation Policy and Planning. He has led near-road air quality studies worth over $4 million in recent years and is currently overseeing an eight-agency pooled fund to help federal and state transportation agencies address near-road air pollution. In 2013, with STI colleagues, he published, "Processes Influencing Ambient Concentrations Near Roadways." In 2010, with UC Davis colleagues, he published, "Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data;" the publication has become a definitive reference on the spatial scale of near-road pollution problems (see Figure 2). From 1997 to 2010, Dr. Eisinger served as Program Manager for the UC Davis-Caltrans Air Quality Project and oversaw development of hundreds of transportation-air quality analysis work products. From 1991 to 1995, he was Mobile Sources Section Chief for EPA Region 9, San Francisco. He has extensive experience collaborating with EPA, FHWA, Caltrans, and various local agencies on transportation and air quality projects. Beginning in 2017, he will chair the U.S. Transportation Research Board (TRB) Transportation Air Quality committee. TRB is part of the U.S. National Academy of Sciences.

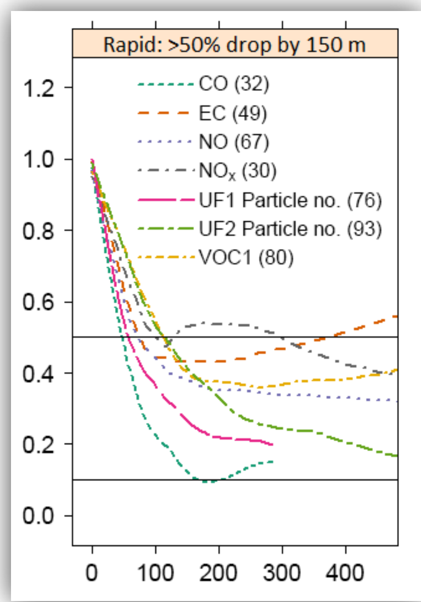

Figure 2. Excerpt from STI and UC Davis synthesis of worldwide data on near-road pollution concentrations. Y axis is normalized concentrations; X axis is distance from road in meters.[6]

Clinton MacDonald joined STI in 1996 and is manager of the Meteorology, Measurements, and Outreach Division. His areas of expertise include meteorological and air quality analysis; air quality forecasting; boundary-layer meteorological measurements; and designing and managing field studies. Mr. MacDonald has 20 years of experience in, and in-depth knowledge of, instrumentation, data validation, data analysis, and modeling. He is the Principal Investigator for several measurement projects that include a range of sophisticated instruments for characterizing air quality and meteorological processes. He is the Principal Investigator/Project Manager for the operation and maintenance of five upper-air meteorological sites for the South Coast Air Quality Management

[6]Karner A., Eisinger D.S., and Niemeier D. (2010) Near-roadway air quality: synthesizing the findings from real-world data. *Environ. Sci. Technol.*, 44, 5334-5344, doi: 10.1021/es100008x (STI-3923). Available at http://pubs.acs.org/doi/abs/10.1021/es100008x.

District (2006–present), and Project Manager for calibration and audits of the State of California's near-road meteorological monitors (2009–present). He has led several studies to test and apply new low-cost air quality sensor technology, including a 2013 ozone small sensor study for the San Joaquin Valley Air Pollution Control District. Mr. MacDonald leads several routine measurement programs to support air quality permitting, regulations, and operations. He has published several journal articles on meteorological and air quality processes, and coauthored the EPA's guidance on developing an air quality forecasting program. Mr. MacDonald has MS and BS degrees in Atmospheric Science from the University of California, Davis.

Dr. Paul Roberts joined STI in 1986 and serves as Executive Vice President and Chief Scientific Officer. He has worked on projects spanning the U.S., including near roadway, near-source, regional, and exposure studies. He has designed and managed many air quality field, data management, and data analysis projects focusing on a range of issues, including ozone, PM_{10} and $PM_{2.5}$, visibility, toxics, carbon monoxide, and meteorology. In recent years, Dr. Robert's work has included leading the Mountain View Corridor Near-Roadway Study in Salt Lake City, as well as the U.S. Route 95 air toxics near-roadway study sponsored by the Nevada Department of Transportation in Las Vegas. The Utah and Nevada near-roadway studies also included measurements of PM filtration efficiencies in school classrooms. He also oversaw air quality and meteorological measurements for an Arizona Department of Transportation study of near-roadway emissions and air quality impacts from construction equipment.

3.3 Advisory Panel and Local Partners

The work proposed here is of substantial interest to all major regulatory agencies involved with transportation-related air quality. Therefore, initial work will include development of a comprehensive project work plan, assembly and engagement with a multi-agency stakeholder advisory panel, and outreach to local partners who have indicated they will support the proposed work effort. TF and STI have already identified agencies and likely liaisons to serve on the advisory panel, and most of these individuals have already confirmed their willingness to participate. Key stakeholders that the study team has contacted or identified for project involvement include

Federal

- **EPA:** Dr. Richard Baldauf, Office of Transportation and Air Quality
- **FHWA:** Robert O'Loughlin, Air Quality Resource Center

State

- **CAL FIRE:** John Melvin, Resource Protection and Improvement
- **CARB:** Dr. Linda Smith (or Dr. Barbara Weller), Research Division
- **Caltrans:** Marilee Mortenson, Office of Regional and Interagency Planning
- **HCD:** Linda Wheaton, Local Government Affairs
- **OPR:** Dr. Elizabeth Baca, Senior Health Advisor

Local

- **City of Fresno:** Manual Molinedo, Parks, After School, Recreation, and Community Services Department; Sophia Palgaloutas, Long Range Planning Manager; and Scott Mozier, Director of Public Works
- **SJVUAPCD:** Tom Jordan, Senior Policy Advisor
- **Central California Environmental Justice Network:** Nayamin Martinez, Executive Director
- Building Health Communities: and Sandra Celedon-Castro, HUB Manager (funded by the California Endowment)
- **Caltrans:** Sheri Ehlert Bender, District Director; and Brad Cole, Landscape Architect
- **CSU Fresno:** Dr. Sam Lankford, Chair, Department of Recreation Administration

In addition, STI and UC Berkeley are working collaboratively on the Children's Health & Air Pollution Study – San Joaquin Valley (CHAPS – SJV). The CHAPS – SJV effort has a Community Advisory Board[7] with participants representing environmental, health/medical, academic, and general community stakeholders; we will look for opportunities to draw upon the expertise and insights from CHAPS – SJV advisory board members.

3.4 Project Goals

Our work will compare near-road pollution levels at locations with and without vegetative barriers, and will plant trees to protect against pollution exposure, sequester carbon, and beautify the community. Overall, the proposed project proposed will serve multiple goals:

1. Develop a more robust scientific understanding of the efficacy of near-road vegetative barriers by measuring and comparing air pollution levels at locations with and without a vegetative barrier.
2. Reduce pollution exposure near-roads with heavy truck traffic by planting trees and vegetation that will mature into an effective air pollution barrier.
3. Reduce GHGs by sequestering carbon through tree planting while providing the community co-benefit of enhancing the quality of life in EJ locations with improved landscaping.
4. Improve the scientific understanding of how long it takes for vegetative barriers to mature into effective pollution exposure resources. This will involve measuring air quality upwind and downwind of a road before tree planting, and repeating those measurements twice afterwards to track impacts as the barrier grows and matures.
5. Improve the scientific understanding of how vegetative barrier characteristics influence pollution exposure. This will involve measuring air pollution upwind and downwind of different barrier conditions such as dense vs. sparse vegetation, broad-leafed vs. conifer-type vegetation, shorter vs. taller vegetation, vegetation alone vs. vegetation in combination with

[7] See: http://chaps.berkeley.edu/Community.html.

sound walls, and vegetation adjacent to roads of varying grades (at-grade vs. a depressed roadway).

6. Test how well lower-cost air quality sensor technology performs compared to traditional air pollution measurement methods.
7. Develop an analysis tool to help others quantify the impact of near-road vegetation on downwind air quality.
8. Educate youth about how their surrounding environment affects pollution exposure. We will use the nationally recognized KMS air pollution outreach program to enable high school youth to use low-cost sensor technology; personally measure, record, and upload pollution data to the web; and present their findings in the classroom.
9. Educate community leaders and air quality and transportation professionals about air pollution issues, the benefits of reducing near-road pollution exposure, and the efficacy of planting trees to reduce pollution and improve the community.

3.5 Questions Considered During Project Design

3.5.1 Tree Planting Considerations

- **What types of trees are reasonable to plant?** We have planned tree selection with environmental co-benefits in mind. It is expected that three species will be planted; two very large species (*Cedrus deodara* and *Pinus eldarica),* which will maximize GHG and air quality co-benefits, and one small tree species (*Archostaphyllos spp*), which will be under-planted to increase the density of the vegetative barrier and resulting near-road pollutant concentration reduction benefits.

- **How can trees be cared for and maintained to ensure their long-term health?** The project design ensures tree maintenance during the critical first years following planting, utilizing care provided by TF, and transitioning longer-term tree care to Caltrans and others.

- **How can tree planting complement public health and community improvement objectives?** The tree planting efforts proposed here are designed to serve multiple community objectives. The overall focus will be on planting trees and other vegetation in near-road settings to help create barriers that reduce exposure to traffic-related air pollutants. However, the planned work will also develop and help implement CLPs, which will give communities a strategic vision to support tree planting and community beautification. The planned work will also help Fresno achieve its vision for a region-wide greenway system called the Valley Arboretum, which has been adopted into the Fresno General Plan and was developed with support from TF.

3.5.2 Pollutants of Interest

- **What near-road pollutant concentrations are of greatest interest?** Since there is substantial interest in understanding and addressing traffic-related PM exposure, the project focuses on measuring forms of PM pollution. Interest in PM covers several pollutant forms, including both size ranges regulated as criteria pollutants ($PM_{2.5}$, PM_{10}), the PM portion of diesel exhaust (DPM), and the concentration of UFP. In California, there is substantial interest in DPM as it is the single most important contributor to air toxics health risk;[8] in addition, there is substantial interest in UFPs, since motor vehicle exhaust (especially diesel vehicle exhaust) is the major contributor to UFP number concentrations and those concentrations are elevated close to major roads. As noted recently by the Health Effects Institute:

  > …in urban areas, particularly in proximity to major roads, motor vehicle exhaust can be identified as the major contributor to UFP concentrations. Diesel vehicles have been found to contribute substantially, sometimes in disproportion to their numbers in the vehicle fleet.
  >
  > *Health Effects Institute, 2013, p. 4*[9]

- **What near-road pollutant measurements can be deferred to help reduce costs?** Work done by EPA and STI shows that measurements from the EPA-mandated U.S. near-road air quality monitoring network indicate gaseous pollutant concentrations of CO and NO_2 do not violate National Ambient Air Quality Standards (NAAQS).[10] In addition, other traditionally regulated (criteria) air pollutants (O_3, SO_2, lead) are typically not U.S. or California near-road pollution problems.

- **What is the recommended list of pollutants to measure?** Based on the relative interest in and importance of near-road pollutants, the project design included here proposes to measure BC as a surrogate for diesel PM, UFPs, and $PM_{2.5}$ and PM_{10}.

3.5.3 Air Quality Field Study Design

- **Can the study minimize field measurement costs while evaluating vegetative barrier concentration influences?** The study design balances the number of monitors deployed against per-monitor deployment costs. To keep costs low, we have proposed using six monitoring sites to assess upwind and downwind conditions at a variety of study areas, to gain quantitative insight into barrier impacts. We have also included a mix of traditional measurement instruments and lower-cost air quality sensors to best utilize the available funding.

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[8] See, for example, the final SCAQMD Multiple Air Toxics Exposure Study, available at: http://www.aqmd.gov/home/library/air-quality-data-studies/health-studies/mates-iv.

[9] See: https://www.healtheffects.org/publication/understanding-health-effects-ambient-ultrafine-particles (Executive Summary).

[10] See: http://www.trbairquality.org/files/2016/03/Graham-TRB-2015-National-Near-Road-Data-FINAL.pdf.

- **How can the work effort inform a variety of vegetative barrier situations?** To better understand how vegetative barriers influence near-road air quality, we will measure barrier impacts under an array of situations. Because of monitoring site availability, safety considerations, and other factors, the study team needs to be flexible and prepared to substitute alternative study areas. Through many years of practical field experience, we understand that finding near-road study location areas is often difficult, complicated by obstructions, land ownership, on-ramps and off-ramps, and roadway grade changes. An important component of our initial planning work is to assess candidate sites.

- **How can the work effectively assess PM concentration changes given the importance of background concentrations?** The study team recognizes that in near-road settings, $PM_{2.5}$ background concentrations are high (relative to roadway contributions) and variable; thus, our upwind/downwind comparisons may have difficulty discerning an incremental PM mass concentration from the roadway. To help address this challenge, our technical approach includes measurements at adjacent study areas with and without vegetative barriers to control for similar background concentrations, traffic, and meteorological conditions while measuring changes in concentrations with and without vegetation. In addition, our study includes measurement of BC and UFP concentrations; the roadway increment to BC and UFP is more easily distinguished, while BC is a useful surrogate for DPM.

- **Will low-cost sensors yield sufficiently reliable concentration data?** To optimize use of CARB funding, we have proposed to measure $PM_{2.5}$ and PM_{10} using low-cost air quality sensors. However, we recognize these types of sensors do not yet yield measurements with the same level of precision of traditional monitoring equipment. To help interpret measurement findings, we have proposed to co-locate one Federal Reference Method (FRM) traditional $PM_{2.5}$ and PM_{10} monitoring instrument with one of the six low-cost sensors when measuring concentrations at study areas with and without vegetation. We plan for the co-location site to be at one of the high-concentration (closest to the road) downwind locations. In addition, we propose to take advantage of the educational value of low-cost sensors through deployment of the KMS program. Through KMS, STI has successfully used low-cost sensors to educate high-school aged youth in the U.S. and Asia about air pollution.

3.5.4 Data Analysis

- **How can the study account for fleet turnover?** The work proposed here covers a five year project window. During that period, vehicle fleet turnover is forecasted to substantially reduce per-vehicle on-road mass-based emission rates. For example, CARB on-road emissions factors for the Fresno area forecast a more than 50% reduction in fleet-average DPM, $PM_{2.5}$, and PM_{10} per-vehicle emission rates from 2017 to 2021 (based on CT-EMFAC2014 Version 6.0). Our data analysis work will use CARB EMFAC-based emissions information to help normalize study results and account for fleet turnover effects when comparing findings across analysis years, using DPM (available via CT-EMFAC, which STI created) as a surrogate for BC emissions. Existing emissions models such as EMFAC and CT-EMFAC are unable to track fleet turnover impacts on UFP emissions. During our work effort, we will confer with CARB staff to identify whether appropriate literature findings are available to support characterization of UFP fleet-average emission changes over time.

- **Will the study account for near-road pollution sources other than on-road vehicles?** This question is of interest since our study sites will likely include areas adjacent to Highway 99, and a rail line runs east and parallel to Highway 99 throughout the Fresno region. Given the proximity of the rail line to Highway 99, diesel locomotive emissions may contribute to measured pollutant concentrations. Since the study objective is to discern how well vegetative barriers reduce exposure to traffic-related pollutants in the near-road environment, measurements will be taken upwind and downwind of the studied roads, with and without vegetation. The upwind/downwind measurement plan, combined with the rail line distance from Highway 99 (typically more than 400 m), should help the study team differentiate on-road traffic contributions and vegetative barrier effects. In addition, we plan to avoid, as much as is practical, siting our air quality measurements near rail yards and rail lines, unless our objective is to measure air quality at a particular study location influenced by rail-related activities.

- **How can the study findings be used to contribute to decision making?** The proposed work includes tool development to help synthesize findings and enable stakeholders to estimate vegetative barrier benefits. Creation of an easy-to-use tool will help disseminate findings and improve land-use decision making.

- **Will the potential confounding effects of meteorology be addressed during data analysis?** When comparing findings across time periods and locations, one issue for consideration is differentiating meteorological from barrier impacts. The issue is more important the shorter the duration for the analysis period (e.g., one hour vs. six weeks). To help understand how meteorology can affect the measurement study findings, our data analysis work will use a dispersion model to test selected cases in study years two through five to examine how meteorological differences can affect measured outcomes. Our field studies include meteorological data collection, and we will use site specific meteorological data when completing our modeling assessments. The findings will help us better isolate barrier impacts from meteorological impacts.

3.6 Summary of Proposed Scope of Work

The overall effort includes planning and project coordination, air quality measurements and analysis, tree planting and tree care, outreach and education, and reporting. We are proposing a package of base and supplemental work efforts spread across five years. The base work efforts are needed to meet project objectives, while the supplemental efforts are designed to expand knowledge and understanding and to improve implementation. The proposed work efforts are described in detail in Section 3.8, Work Tasks, and approximate costs are described in Section 7, Project Budget. We describe both base efforts and supplemental efforts; these efforts can be scheduled singly or in combination, and can be scheduled to accommodate funding availability.

3.7 Relationship of Proposed Work to Other Studies

Several of our proposed advisory committee members are actively engaged in related or complementary work. The CARB Research Division is sponsoring a UCLA study of near-road vegetation focused on collecting data in southern California and Sacramento; Research Division management (Linda Smith) has encouraged the TF and STI team to improve on the sparse near-road vegetation/air quality data available and to obtain measurements in the San Joaquin Valley. EPA recently collected limited pollution measurements next to roads with vegetation in an area not far from Palo Alto, and has collected and published related information from studies conducted in the eastern United States. Like CARB, EPA is seeking access to more near-road vegetation data. In 2014, STI, under EPA sponsorship, developed educational materials on near-road pollution mitigation—including use of near-road vegetation—based on the limited data available to date; this work can inform the efforts proposed here. Caltrans is evaluating near-road PM pollution for substantial highway projects, and is sponsoring STI to develop guidance and training classes in near-road assessment. Caltrans is further interested in the efficacy of near-road vegetation as a potential mitigation approach. HCD has been actively working with its partner agencies to identify potential methods of mitigating near-road pollution exposure for residents in existing housing located adjacent to roads. The SJVUAPCD recently sponsored STI to test less-costly air quality measurement methods, and our experience completing that work will help speed implementation of our low-cost sensor work here. STI is also the sole contractor for an eight-agency pooled fund on near-road air pollution (scheduled to run from 2014 to 2019), which sponsored STI to complete near-road barrier literature review and modeling assessments; that work will help inform the effort proposed here. Within the past several years, STI has completed year-long near-road pollution measurements in Arizona, Nevada, and Utah. Data collected by our proposed project will supplement these past efforts and help interested stakeholder agencies improve their ability to assess and implement effective tree planting in near-road settings.

3.8 Work Tasks

3.8.1 Planning and Project Coordination Task

PPC Task 1: Initial planning and ongoing project coordination (base work). Once a contract is executed, the initial project task will be to develop comprehensive work plans for the air quality measurement and analysis, tree planting, outreach, and reporting tasks. We will also develop a list of candidate public schools for the KMS education and outreach program. In addition, we will hold a kick-off project initiation meeting with CARB, and work to select an outreach and education coordinator for the life of the study. We will also perform planning each year for the air quality measurement and analysis, tree planting, outreach, and reporting tasks to be performed that year. Note that to ensure effective collaboration in order to accomplish tree planting, air quality, and outreach work, the proposed budget for our overall work includes resources to enable TF and STI to coordinate implementation of these multiple tasks. Initial task work, including work plan development and the kick-off meeting, will take place following contract and subcontract execution for both TF and STI.

PPC Task 2: Advisory team assembly, periodic meetings, and ongoing project planning and coordination (base work). We will establish and coordinate with our proposed advisory panel, provide ongoing project planning and coordination throughout the life of the project, and produce monthly progress reports. We will also be available for limited informal phone discussions with CARB staff and advisory panel members on an ad hoc basis.

3.8.2 Air Quality Measurement and Analysis Tasks

This section describes air quality tasks. STI will measure air quality upwind and downwind of major freeways or roads with heavy truck traffic, as well as in areas with and without existing vegetation, to measure the air quality benefits of tree planting. Unless noted, all air quality measurement work is planned to occur over a six-week period. We will use traditional air quality measurement equipment to monitor concentrations of BC, which serves as a marker for diesel vehicle particulate pollution, and UFP. We will also use innovative low-cost air quality sensors to measure the $PM_{2.5}$ and PM_{10} near-road concentration gradient, and we will operate a traditional FRM $PM_{2.5}$ and PM_{10} monitor at one site to compare with the sensors. The findings will help assess how well emerging sensor technology performs as an air quality management resource. We will also measure meteorological variables during all periods. Measurement work will be scheduled at various times of year, depending on the tasks funded. In general, we recognize that background pollution levels vary by season in the Fresno area. For some pollutants, such as $PM_{2.5}$, the higher background concentrations become the more difficult it can be to discern near-road pollution levels originating from nearby traffic. In Fresno, PM background pollution levels tend to be higher in Fall and Winter (**Figure 3**). For this reason, we have proposed base and supplemental measurement work that will vary the collection season for the near-road concentration data.

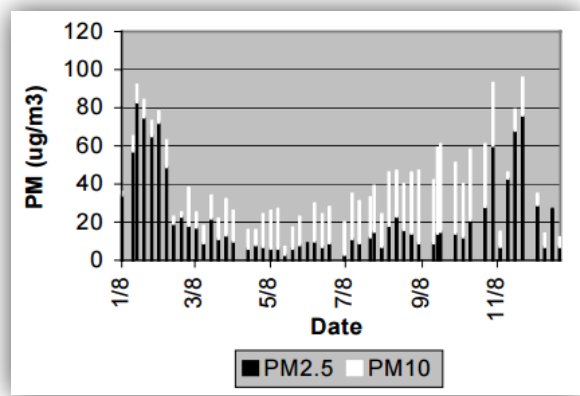

Figure 3. Seasonal variance in 24-hour PM concentration in the Fresno area (X axis is a calendar year).[11]

AQ Task 1: Initial ("before tree planting") air quality measurements at two tree-planting locations (base work). This work involves taking BC, UFP, $PM_{2.5}$, and PM_{10} air quality measurements for six weeks at two near-road tree-planting locations (three monitors per location) before TF's tree planting work begins (planting is described in Section 2.5.3). This work will occur in study year one. As part of this work and the base work proposed for subsequent years two through five, we will assess how well low-cost sensor technology compares to traditional (more expensive) air quality monitors. The intent is to test the ability of the low-cost sensors to duplicate particulate-based measurements ($PM_{2.5}$, PM_{10}); this work will compare measurements between sensors and a federally approved FRM PM monitor known as a "T640x".[12] The findings will assist in helping advance citizen science by enabling the regulatory community to gain a better understanding of how well low-cost sensors perform. There is widespread interest within the regulatory community to better understand how to best take advantage of the emergence of low-cost sensors in identifying pollution problems and educating the public.[13]

AQ Task 2: Post-tree planting ("after") air quality measurements, to track impacts over time as planted trees mature (base work). This work involves taking BC, UFP, $PM_{2.5}$, and PM_{10} air quality measurements for six weeks per year in study years four and five (after TF completes tree planting). The purpose is to measure, as vegetation becomes more mature over time, when air pollution exposure reduction benefits begin to materialize downwind of the vegetative plantings. When evaluating these "before and after" benefits, fleet turnover and resulting on-road emissions changes will be accounted for based on San Joaquin Valley-specific on-road vehicle emissions factor information available from the CT-EMFAC model. Although TF will plant trees at multiple near-road locations, to meet this objective,

[11] Reproduced from CARB; see https://www.arb.ca.gov/pm/pmmeasures/pmch05/sjv05.pdf.
[12] For an illustration of recent findings from STI work comparing traditional measurement methods to low-cost sensors, see: http://www.sonomatech.com/assets/projects/STI%20BAQ%20-%20Low-cost%20PM%20sensors.pdf. Information on the T640x is available here: http://www.teledyne-api.com/products/T640.aspx.
[13] See, for example, U.S. EPA efforts to encourage low-cost sensor use: https://www.epa.gov/air-sensor-toolbox.

the "after tree planting" air quality work can be completed with measurements upwind and downwind (using three monitors per location) of the same two near-road tree-planting locations used in AQ Task 1.

AQ Task 3: Mature vegetation impacts (base work). This task involves measurement work at a site where mature vegetation is already present next to a major road. To meet this objective, we plan to select an at-grade freeway area for evaluation. We will pair study locations along a stretch of the freeway; one location with mature trees and vegetation (the experiment), and one location without vegetation (the control). For six weeks we will simultaneously measure BC, UFP, $PM_{2.5}$ and PM_{10} air quality upwind (one monitoring station) and downwind (two monitoring stations) of the road at both of these locations. With these paired locations, we can measure roadside pollution with and without trees and other vegetation, quantify vegetation benefits, and keep traffic and meteorological conditions similar for both locations. Figure 4 illustrates this approach.

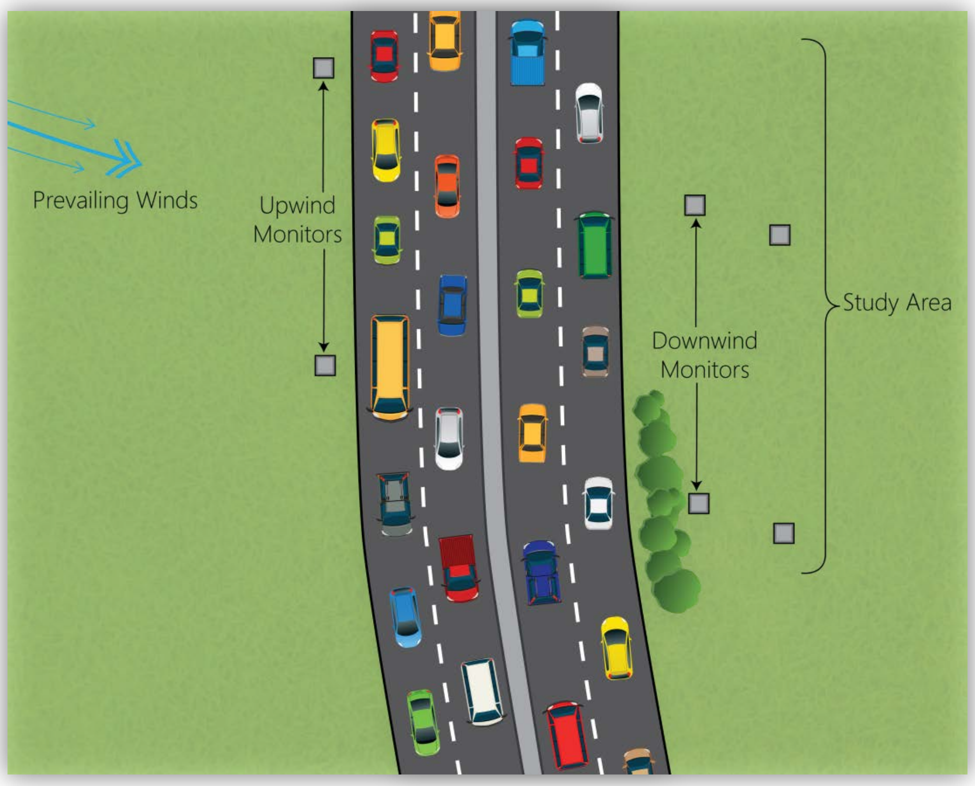

Figure 4. Illustration of air quality measurements in a single study area with and without vegetation.

AQ Task 4: Sensitivity test one – evaluate whether seasonal differences substantially alter estimated impacts from vegetation (supplemental work). To identify whether vegetation benefits differ at different times of the year, measurement work at the mature vegetation study location will be extended to obtain data during a different season. Sampling will take place for a six-week period similar in duration to the AQ Task 3 study period.

AQ Task 5: Sensitivity tests two through five – evaluate vegetation variables (supplemental work). This work involves selecting location pairings that allow us to assess different existing vegetative conditions. Scenario options include densely packed vegetation vs. more porous tree stands, conifer plantings vs. broad-leafed trees, relatively low vegetation (10 to 12 feet tall, or about sound wall height) vs. substantially taller vegetation (e.g., 20 feet or more), and vegetation alone vs. vegetation combined with sound walls. Ideal project areas will be adjacent to at-grade roads where prevailing winds cross the highway and monitors can be safely deployed and accessed. For example, we have visited candidate areas with desirable attributes between Fresno and Kingsburg on Highway 99, near Selma (e.g., agricultural land with and without vegetation).

AQ Task 6: Sensitivity test six – road grade impacts (supplemental work). This work involves comparing at-grade BC, UFP, $PM_{2.5}$, and PM_{10} air quality measurement findings to those obtained in an area where the road is depressed (below-grade). The goal is to find a depressed roadway area with vegetation, traffic, and meteorological conditions comparable to those observed in the base case. Recognizing that such a location may be difficult to find, the intent is to match as many site conditions as possible to other study locations and see whether there are substantially different outcomes that can be related to road grade.

AQ Task 7: Near-freeway parks and schools (supplemental work). In study years three and five, STI will complete supplemental BC, UFP, $PM_{2.5}$, and PM_{10} air quality measurement work at one additional near-freeway park or school site per year. The purpose of this work is to help community members understand near-road pollution levels, especially in areas serving children. The work will be designed to meet outreach, education, and community engagement needs that arise during the study.

AQ Task 8: Near-freeway neighborhoods (supplemental work). In study years four and five, STI will complete supplemental BC, UFP, $PM_{2.5}$, and PM_{10} air quality measurement work in one residential near-freeway neighborhood per year. The purpose of this work is to help community members understand near-road pollution levels in residential areas. The work will be designed to meet outreach, education, and community engagement needs that arise during the study.

AQ Task 9: Valley Arboretum air quality measurements (paired with Tree Planting Task 7, base work). This work involves measuring BC, UFP, $PM_{2.5}$, and PM_{10} air quality within the planned Valley Arboretum greenbelt area. Similar in scale and duration to the other air quality measurement tasks, this work will focus on assessing existing conditions within the planned greenbelt to establish benchmark conditions and help inform tree planting discussions.

AQ Task 10: Tool development and refinement. STI will create a new analysis tool to quantify the impact of near-road vegetation on downwind air quality. Although the air quality community *qualitatively* understands that vegetation can reduce pollution exposure, robust analysis methods and tools have yet to become available to *quantitatively* evaluate impacts. This work will (1) use the air quality literature and our Fresno-based measurement findings to develop quantitative relationships between vegetative barriers and downwind pollution impacts; (2) code those relationships into an easy-to-use analysis tool; and (3) refine the tool to address CARB and advisory committee feedback and to reflect new data that become available. To develop the tool, STI will create simplified algorithms to account for concentration impacts that vary with selected barrier characteristics and meteorological conditions. The purpose of the tool will be to help inform stakeholder decision-making about whether to establish vegetative barriers, and to help approximate the concentration benefits expected to occur. The tool will not serve as a regulatory support resource to complete mandated analyses, such as those required under the transportation conformity regulations. The work proposed here will build on STI's experience developing transportation-related air quality analysis tools.[14]

AQ Measurement Study Design Summary. The list below summarizes our study area selection plan; some types of study areas may be substituted with areas that have different attributes, depending on site availability, safety considerations, and other factors.

1. Two TF near-road tree planting areas (before and after tree planting)
2. A base case area with at-grade road segments with and without mature vegetation (measured during one season as the base study, and a second supplemental season)
3. A sensitivity test area where vegetation is less dense than the base case area
4. A sensitivity test area where the vegetation type is different than the base case area
5. A sensitivity test area where the vegetation height is different than the base case area
6. A sensitivity test area where vegetation is paired with a sound wall
7. A sensitivity test area where the roadway is depressed (below grade)
8. Four supplemental near-road locations (park, school, and/or residential neighborhood)
9. A base case area within the planned Valley Arboretum

In most areas, we will measure BC, UFP, $PM_{2.5}$, and PM_{10} air quality to obtain six-week measurements at six monitoring sites (one upwind, two downwind, and at locations with and without vegetation). In the project budget discussion presented later, we note that it is possible to extend the measurement periods beyond six weeks at modest incremental costs, depending on how many base and supplemental studies are scheduled for a given year.

3.8.3 Tree Planting Tasks

This section describes tree planting tasks. TF plans to plant about 1,200 trees (4 sites per year, 60 trees per site, for 5 years) at freeway locations in Caltrans ROW, about 900 trees (6 sites per year, 50 trees per site, for 3 years) within public parks and/or schools located near freeways, about 480 trees (2 sites per year, 60 trees per site, for 4 years) near major roads within the Fresno Valley Arboretum, and about 1,200 trees spread among eight communities selected for CLP development and

[14] For example, STI created the Caltrans-sponsored CT-EMFAC on-road mobile source emissions model; see: http://www.dot.ca.gov/hq/env/air/pages/ctemfac_license.htm.

implementation. These tree planting efforts will provide near-road pollution exposure reduction and GHG sequestration benefits.

Linking Near-Road Planting with Regional Goals

TF has a long history of supporting tree planting in the Fresno area, and the plan is to complete the work proposed here to complement and help achieve the community tree-planting goals established by the City of Fresno (with TF support). TF has spearheaded the creation of the Valley Arboretum, a signature greenway system for the Fresno region. The Arboretum (illustrated in **Figure 5**) will serve many purposes, including education, environmental stewardship, economic, health, recreation, wildlife habitat, transportation, and land use planning, while advancing the local understanding of earth sciences. The Arboretum was adopted by reference in the City of Fresno General Plan in December, 2014. TF will work to use the near-road tree planting effort proposed here to complement or help achieve the vision included in the Valley Arboretum plan.

TP Task 1: Establish near-freeway vegetation plans (base work). This work has two components; (1) planning to plant trees on Caltrans ROW, and (2) planning to plant trees within parks or schools located near major roads. TF will develop planting plans with tasks and schedules, select final species, engage Caltrans and parks officials on location selection, and acquire Caltrans permits with the City of Fresno. Caltrans Fresno (District 6) staff have expressed support for the project and identified several sites on Caltrans ROW that may be suitable for tree planting. TF has also been in contact with parks officials, and has received informal commitments of support to assist with implementation within Fresno area parks located near major roads.

TP Task 2: Near-freeway tree planting (base work). TF will secure and prepare locations, and obtain and plant trees. Prospective ROW locations identified to date are (1) along the east/downwind side of Highway 99 and include a low-income neighborhood and other settings, (2) Herndon Avenue to Veterans Boulevard, (3) Stanislaus Street to Ventura Avenue, (4) Jensen Avenue to North Avenue, and (5) North Avenue to American Avenue. In addition, TF has identified a potential planting area adjacent to Highway 168 that is the site of a planned senior care center. The tree-planting plan for parks located near major roads covers approximately a half-dozen parks. It is expected that three species will be planted; two very large species (*Cedrus deodara* and *Pinus eldarica*) to maximize GHG and air quality co-benefits, and one small tree species (*Archostaphyllos spp*) to help fill in the gaps. The trees will be approximately 1.5 inches DBH (diameter at breast height) at planting, although more mature trees may also be planted depending on the available tree-planting budget. The overall tree planting schedule includes completing preparatory base work (planning, staffing, tree acquisition scheduling) in study year one, beginning tree planting in the Caltrans ROW in study year two, and beginning tree planting in parks in study year three. As a supplement, we have scheduled tree planting to begin in study year one, depending on the availability of funds.

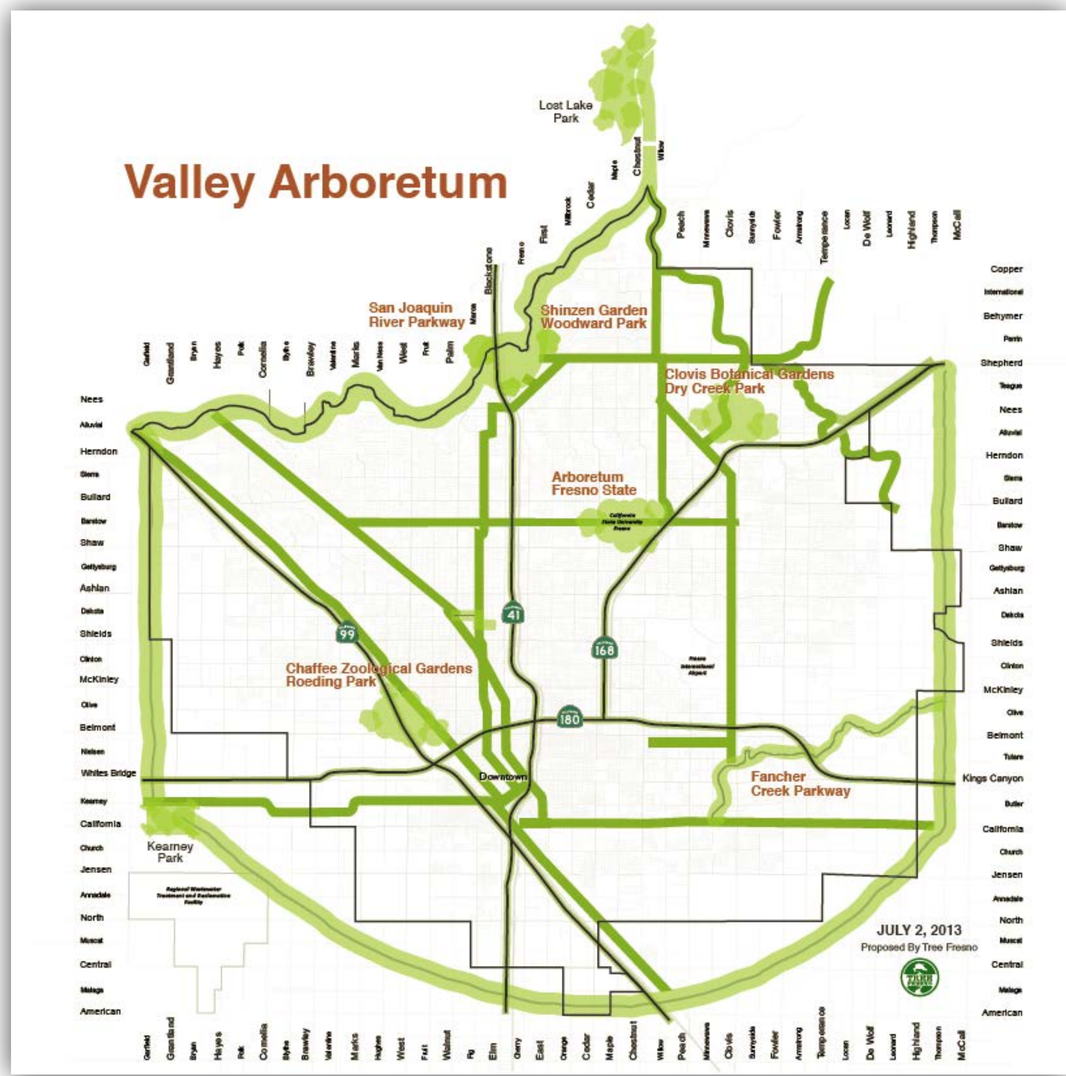

Figure 5. Planned Valley Arboretum system included in the Fresno General Plan.[15]

TP Task 3: Near-freeway tree care (base work). Following tree planting, TF will perform quarterly maintenance. Tree maintenance will include developing care protocols and procedures consistent with CAL FIRE Procedural Guides; employing (or contracting for) and training staff; and performing quarterly maintenance through December 2021. To ensure long-term maintenance, TF will work with Caltrans (pending final negotiation) to transition over to Caltrans-administered long-term care for trees in the ROW. TF has already had discussion with Caltrans Fresno (District 6) staff, and they have confirmed their willingness to negotiate such a deal. In addition, to supplement Caltrans support, TF will solicit support from CAL FIRE to fund this ongoing maintenance from 2022 through 2024; this funding request will be intended to lessen the tree-care burden for Caltrans and facilitate an easier

[15] See http://www.fresno.gov/NR/rdonlyres/34DF414A-15FB-4C92-9CE7-3CD69A7A5451/0/consolidatedGP.pdf.

transition to Caltrans for long-term care (note that planned work can proceed even without CAL FIRE support, depending on the timing of funding provided by CARB). Similarly, TF will work with city parks officials to transition long-term tree care over to city parks staff. We may engage other local partners to ensure long-term care at one or more sites if opportunities emerge to supplement care at the Caltrans tree planting locations.

TP Task 4: Develop community landscapes plans (CLPs) for urban/rural districts in the Fresno area (base work): TF will prepare approximately one CLP per year; each CLP will target a specific community within the Fresno area. The purpose of the CLPs is to plan for strategic use of properties to foster tree planting in EJ areas within urban and rural districts. The CLPs will be developed to consider how to take advantage of near-road tree planting opportunities.

TP Task 5: CLP tree planting (supplemental work). TF will secure and prepare locations, and obtain and plant trees. Similar to the near-road tree planting discussed above, it is expected that three species will be planted, including the two very large species to maximize GHG and air quality co-benefits. The planned schedule is to plant trees in one community per year, beginning in study year two. Locations will be selected to try and optimize pollution exposure reductions near major roads.

TP Task 6: CLP tree care (supplemental work). Similar to the near-road tree care discussed above, TF will initiate and perform quarterly maintenance through December 2021. To ensure long-term maintenance, TF will work with community officials in each area to transition long-term tree care over to city and/or community staff. We may engage other local partners to ensure long-term care at one or more sites if opportunities emerge to supplement care at the tree planting locations.

TP Task 7: Valley Arboretum landscape design, planting, and care (paired with AQ Task 9, base work). This work will identify tree planting opportunities to create forested parcels and greenways, assist in assessing air quality within the Valley Arboretum circumferential greenbelt, and plant and care for trees in locations that, ideally, achieve the Valley Arboretum vision while simultaneously reducing exposure to near-road pollutants.

3.8.4 Outreach, Education, Engagement Tasks

We have proposed to complement the air quality and tree planting work with supplemental outreach, education, and community engagement designed to improve knowledge about air pollution and educate the community about the benefits of planting trees and reducing near-road pollution exposure. An important component of our planned outreach is to educate community youth, which will be done through high-school-aged student participation in the “Citizen Science” KMS program. KMS enables youth to use inexpensive hand-held air quality monitors to measure pollution in real-time, observe spatial pollutant differences within their community, and post results to the web for later classroom use and discussion. As part of our base work, we have also proposed a tree mapping program to engage community members; this mapping will help identify areas deficient in tree stock and where tree planting can enhance the community and reduce pollution exposure.

In addition, as part of the base effort, TF is proposing to hire an outreach, education, and community engagement coordinator for the life of the project, to ensure the EJ community in the Fresno area is well served to learn about air pollution, near-road air quality, and tree-related mitigation. Finally, the base work effort will include preparation of various reports that summarize and share major findings. Reporting work will include information sharing with air quality management practitioners, stakeholder agencies, and interested community groups.

Outreach to Local, State, and Federal Stakeholders

OE Task 1: Education and outreach to local, state, and federal stakeholders (base work). Our work products will include (1) reports documenting findings about the efficacy of trees to reduce pollution exposure in roadside communities; (2) educational material with graphical, easy-to-read insights on tree planting near roads; (3) presentations that highlight findings and recommendations for scientific conferences, public meetings, and educational events; and (4) a peer-review manuscript to educate the air quality management community about the benefits of roadside trees. TF and STI will present a webinar to our multi-agency advisory committee; and submit findings at national settings such as the U.S. Transportation Research Board (TRB) conference.[16] In addition, the partner agencies serving on our advisory team will be enabled to leverage our project findings, encourage effective near-road vegetation use, and provide statewide delivery of GHG reduction and air quality co-benefits. The schedule for these actions will be detailed when work plans are developed; in concept, outreach will take place across the life of the project as implementation insights and findings become available, and will be supported by an on-site education and outreach coordinator hired by TF.

Kids Making Sense

OE Task 2: Kids Making Sense™ youth outreach program (supplemental work). A key focus of our planned outreach is to engage high-school-aged youth and lead them to better understand air pollution issues, levels, and exposure in their community. With support from EPA and others, STI has developed the KMS education program, which unites Science Technology Engineering and Mathematics (STEM) education with a complete measurement and environmental education system that teaches youth about air pollution and empowers them to drive for positive change. KMS is a licensed trademark and includes a licensing agreement.

Within this program, students learn about particle pollution and its sources and health effects. A half-day lecture is followed by a hands-on lesson using handheld air sensors paired with a smartphone app that lets students measure air quality around schools and their local community, allowing

[16] STI's Chief Scientist for Transportation Policy and Planning, Dr. Douglas Eisinger, will become chair of the TRB Air Quality Committee in April 2017. See: http://www.sonomatech.com/project.cfm?uprojectid=1248.

participants to discover pollution sources and cleaner areas. Next, data collected are crowdsourced on a website for discussion and data interpretation.

In KMS workshops, students

- Learn air quality basics
- Experiment with and understand a low-cost air quality sensor
- Plan a sensing route for measuring air quality
- Collect particle measurements
- Analyze and discuss the resulting data
- Learn how to identify and avoid sources of air pollution
- Share data and results with other schools

This program meets Next Generation Science Standards and Common Core, encourages project-based learning and deep understanding of applied science, and allows students to engage with science as if they were air quality professionals. KMS has been successfully deployed in the U.S. and Asia, including successful workshops in New York City, San Francisco, Los Angeles, and Sacramento, as well as in Taipei and Taichung, Taiwan, and Bangkok, Thailand. Figure 6 illustrates KMS student participation and web-based data uploads.

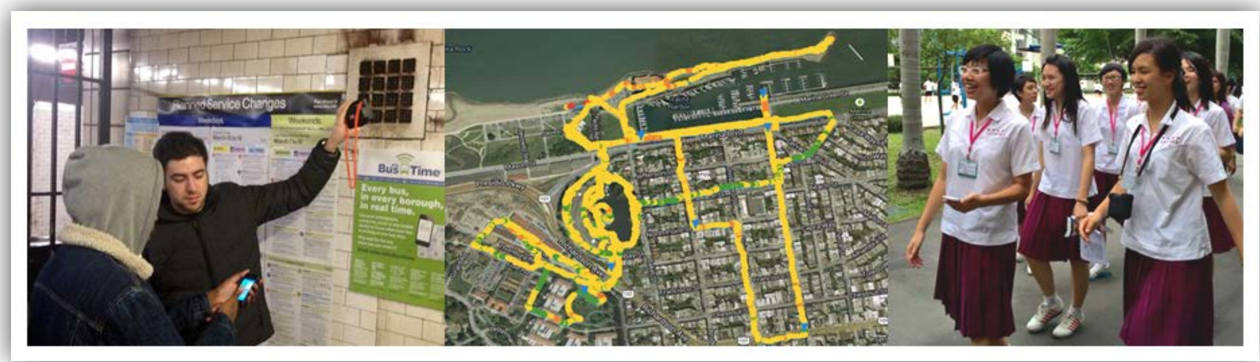

Figure 6. Kids Making Sense participation and data uploads. Left: students locate and detect high particle levels in the subway and low particle levels in other areas. Center: individual measurements showing one-second readings; warmer colors indicate higher particle levels. Right: students view particle measurements on smartphones (right).

The Fresno region includes several public school districts, including the Central, Fresno, and Washington Unified School Districts. We propose to have STI deliver one KMS youth outreach program at one high school in study year one, followed by programs at four high schools each subsequent study year. These programs are planned to occur during the beginning of the school year (Fall), and will take advantage of the new KMS Student Workbook and Teacher Guide released by STI in 2016.[17] By the completion of the five-year study period, we will have delivered the KMS program 17 times to students in Fresno public high schools, giving a large number of area students an opportunity to learn and benefit from the KMS program. During work task PPC-1, we will identify candidate schools and schedule initial KMS outreach efforts, assuming the KMS effort is funded.

OE Task 3: Tree mapping program ("Citizen Science") (base work). TF will engage community members in a public education program to map community tree resources. The objective of this work is to educate community members about the importance of trees, identify areas where additional tree planting can enhance EJ communities, and educate community members about the benefits of using trees and other vegetation to reduce near-road pollution exposure. As mapping is completed, TF will post results on its website, helping to identify areas where future tree planting will have the most beneficial impact.

3.8.5 Reporting Tasks

R Task 1: Planned reporting (base work). STI and TF will submit monthly invoices and progress reports, and provide annual overview reports that describe completed and planned work, and major study findings. In addition, the study team will host twice-yearly webinar briefings for CARB and advisory panel members, during which we will present PowerPoint presentations to communicate progress, problems and recommended solutions, and study findings. The study team will also present study findings at two-to-three professional conferences during the five-year study period. An example conference venue is the annual Transportation Research Board conference held in Washington D.C. We will also share findings approximately once per year to CARB and/or SJVUAPCD staff, and will submit overall study findings to at least two peer-review scientific journals. In addition, the proposed budget includes time to informally discuss work progress and findings over the phone with CARB staff and the Advisory Panel on a quarterly basis, and for TF to help administer CARB reporting paperwork as the prime contract.

3.9 Air Quality Benefits

This work will enable CARB and other stakeholder agencies to better understand, communicate about, and encourage the use of vegetation as a way to reduce near-road pollution exposure. As documented in the literature by STI and others, vehicle-related air pollution levels are higher within the first few hundred meters of a major road (see Figure 2). By providing a barrier between the road and downwind locations, vegetation can help lower pollution concentrations in the areas immediately adjacent to roads. The air quality benefits are important for reducing those pollutants directly emitted by motor vehicles, such as diesel PM (an air toxic), fine particles (PM_{10} and $PM_{2.5}$),

[17] See: http://kidsmakingsense.org/2016/02/kids-making-sense-program-publishes-new-student-workbook-and-teachers-guide/.

CO, and other traffic-related air pollutants. STI, together with scientists from EPA and ARUP, illustrated the air quality benefits of a roadside barrier in a June 2015 keynote presentation at a conference on using roadside vegetation; Figure 7 shows a graph from that talk.

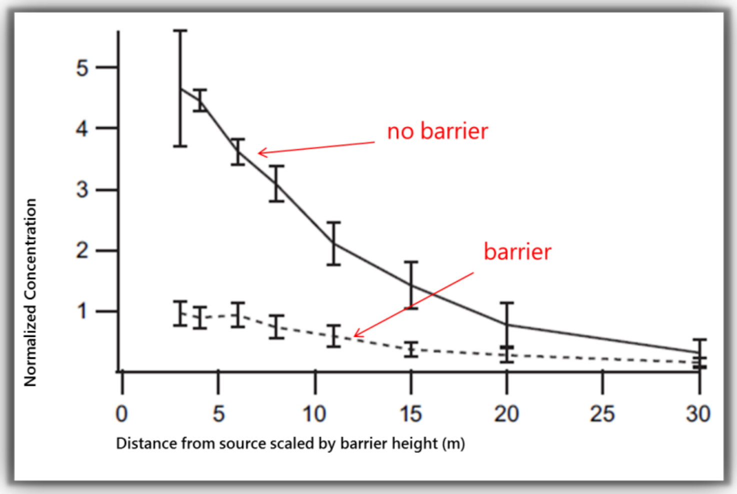

Figure 7. Excerpt from STI-EPA-Arup talk on near-road pollution; figure shows air quality benefits of a solid barrier, as measured by EPA during a tracer test field study.[18] The literature indicates that the efficacy of vegetative barriers likely varies based on the characteristics of the barrier; the figure uses solid barrier impacts to illustrate the concept of how a barrier can affect near-road air quality.

The expected air quality benefits of vegetative barriers was stated in a 2013 article published by scientists from the U.S. EPA, U.S. Forest Service, California HCD, and several other organizations:

> Roadside vegetation barriers can improve near-road air quality and can affect the public health positively for populations near high-volume roadways. Although questions remain about the optimal design features for vegetation barriers, the current scientific understanding warrants pilot studies to investigate this potential strategy for mitigating air quality.
>
> *Baldauf et al.; Integrating Vegetation and Green Infrastructure into Sustainable Transportation Planning (TR News 288, September-October 2013, p. 18)*

3.10 Benefits to Disadvantaged Communities

The work proposed here will be performed in Fresno, California. As illustrated in Figure 1, Fresno is an area with the highest CalEnviroScreen rankings (most heavily impacted) for environmental justice (EJ)

[18] Graham A.R., Eisinger D.S., Chazan D., Baldauf R., Thomas J., Zeller L., Bailey C., and Stewart K. (2015) Best practices for reducing exposures to traffic emissions near larger roadways. Presented at the *Educational Conference on the Use of Vegetation as Near-Roadway Mitigation for Air Pollution*, Sacramento, CA, June 2. STI-6294.

concerns. As shown in the literature, pollution levels are elevated near major roads, and those who reside near major roads are more likely to be minority and low-income households. For example, recently published work found that, "While 19.3% of the US population lives near high volume roads, 27.4% of the non-white population (including 23.7% of the black population and 29.4% of the Latino population) live near high volume roads."[19] As shown in Figure 8, the fraction of non-whites living near major roads climbs as distance from the road decreases.

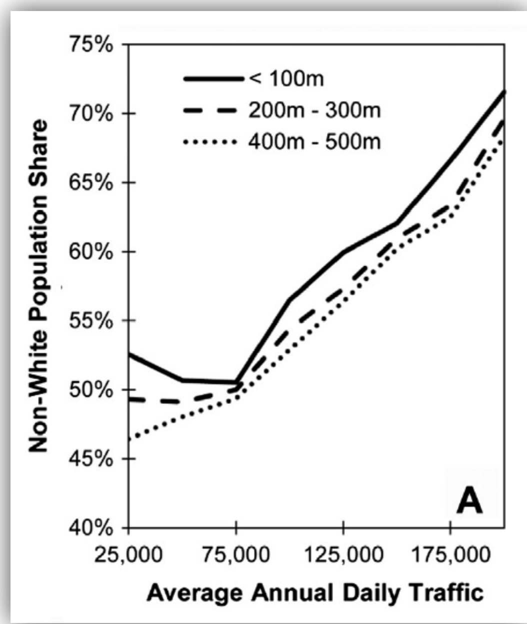

Figure 8. Share of non-white residents as a function of distance from road. Reproduced from Rowangould 2013, Figure 3.[19]

There are both direct and indirect benefits to disadvantaged communities from the work proposed here. Direct benefits include air quality improvements for those in Fresno who are downwind of the near-road tree planting sites. As the trees mature into an effective barrier, the downwind areas will experience reduced pollution concentrations. In addition, as the findings from this work are used to support tree planting and vegetative barrier development throughout the state, this work will indirectly serve those individuals located downwind of areas where future near-road vegetation barriers will be placed.

[19] See: Rowangould G.M. (2013) A census of the US near-roadway population: public health and environmental justice considerations. *Transportation Research Part D: Transport and Environment*, 25, 59-67; p. 61.

4. Project Location

As noted earlier, TF and STI are proposing to use locations in Fresno. We have visited candidate areas with desirable attributes between Fresno and Kingsburg on Highway 99 near Selma (e.g., agricultural land with and without vegetation), where analysis work can proceed to assess existing (more mature) near-road vegetation. Tree planting is planned for areas within the Caltrans Right of Way (ROW) and within near-road parks. Prospective ROW locations identified to date are along the east/downwind side of Highway 99 and include a low-income neighborhood and other settings: Herndon Avenue to Veterans Boulevard, Stanislaus Street to Ventura Avenue, Jensen Avenue to North Avenue, and North Avenue to American Avenue. In addition, TF has identified a potential planting area adjacent to Highway 168 that is the site of a planned senior care center. Air quality and tree planting work will also take place within the area encompassed by the planned Valley Arboretum (see map shown in Figure 6). Overall, the study team will keep in mind opportunities to plant trees and reduce near-road pollution exposure in areas of the Fresno region where truck traffic is heaviest. **Figure 9** illustrates truck routes in the Fresno region.

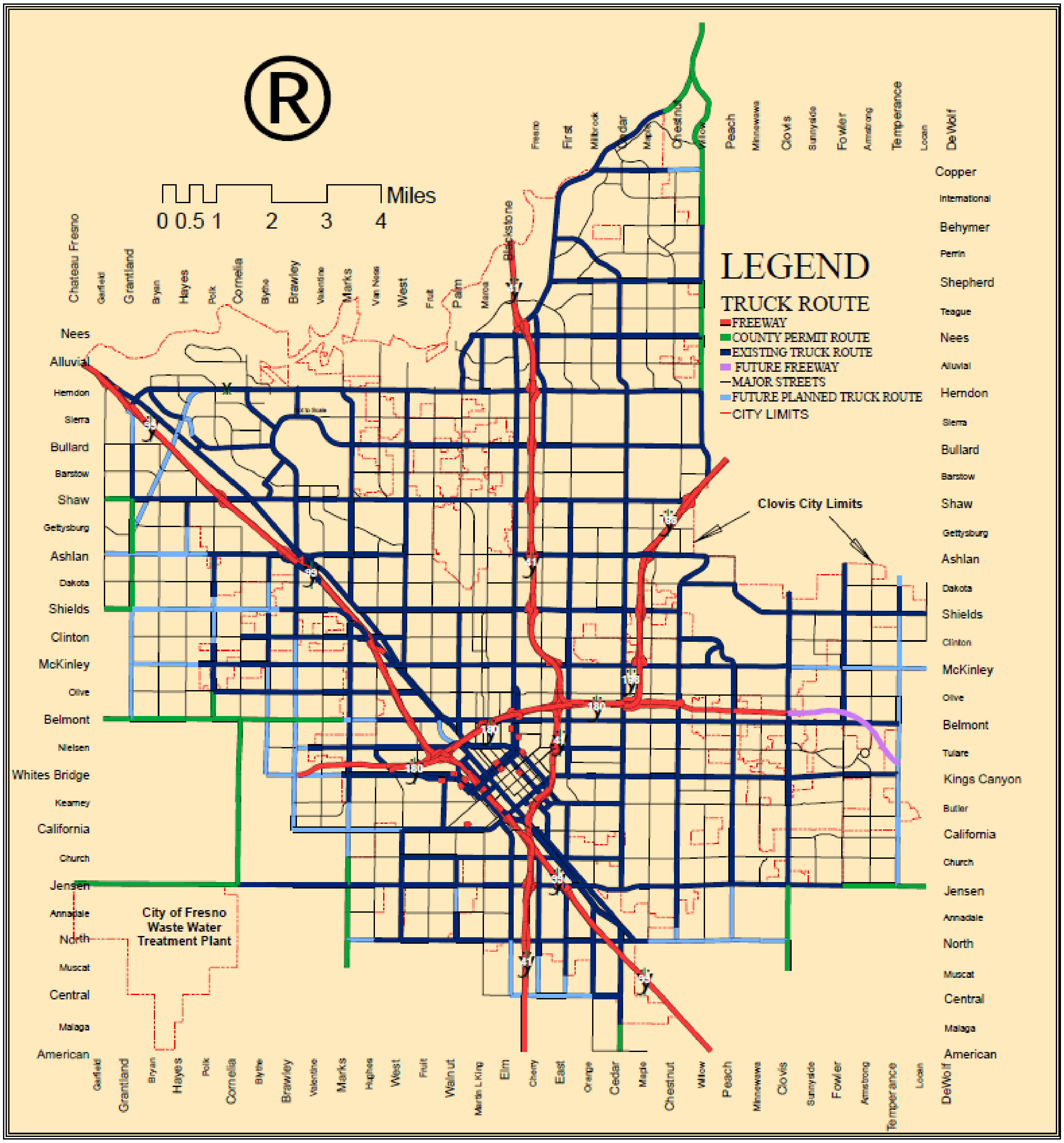

Figure 9. Designated truck routes in the City of Fresno. Source: City of Fresno.

5. Emissions Benefits

The work described here will focus on air pollutant concentrations and exposure in the near-road zone, rather than reducing automotive emissions. In addition, the tree planting component of the work will achieve CO_2 sequestration co-benefits to help offset some of the CO_2 emissions generated by on-road motor vehicle use.

6. Project Timeline

Figure 10 illustrates the overall schedule for proposed tasks. Work is assumed to begin by January 1, 2017, and continue until December 31, 2021. The tasks illustrated parallel those described earlier. Note that some of the measurement work shown here can be moved to an earlier date, based on CARB interests, needs, and funding.

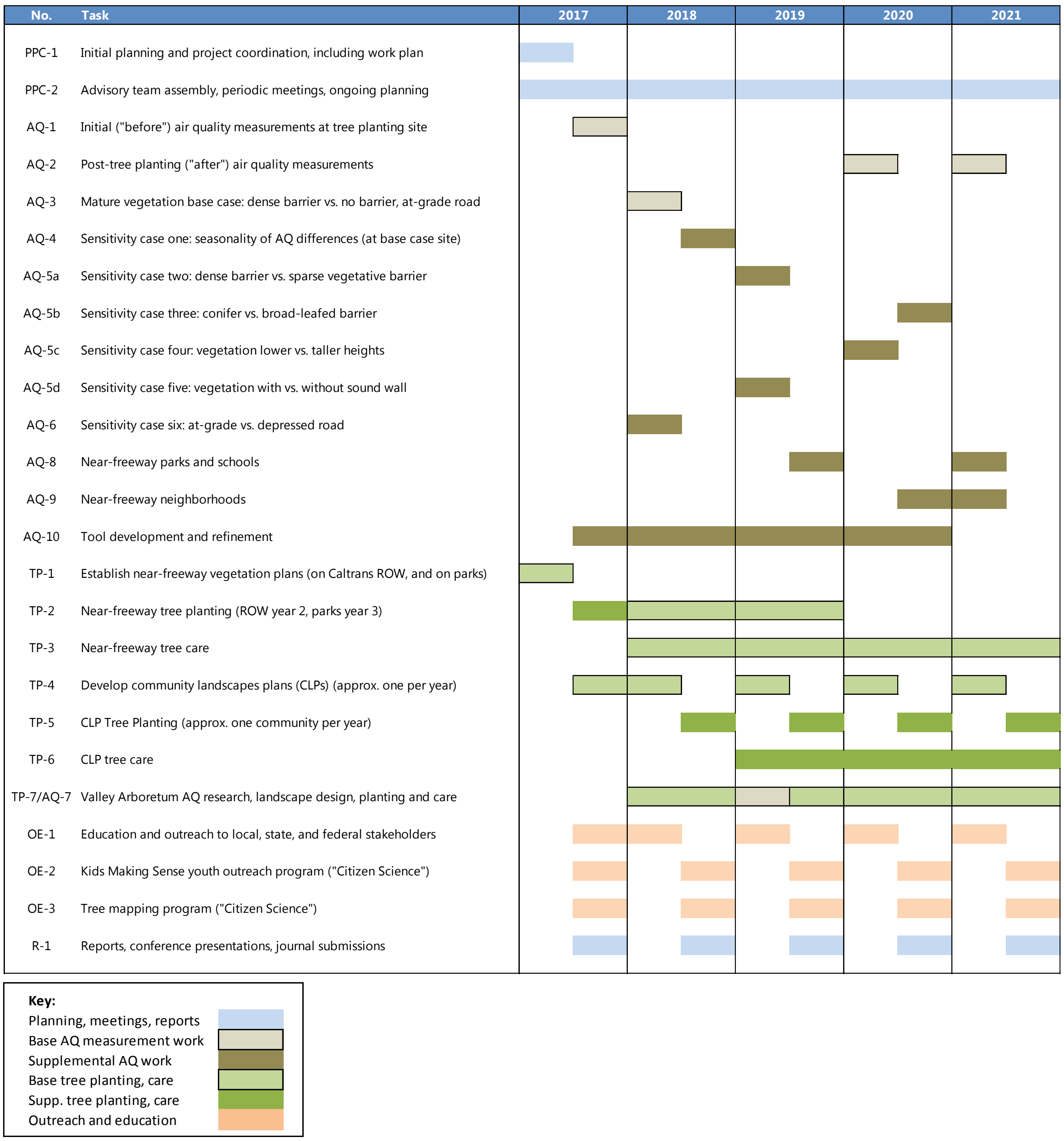

Figure 10. Anticipated tasks and approximate time periods for task completion.

7. Project Budget

7.1 Base and Supplemental Work

The total proposal package includes tasks to be funded for both TF and STI; TF is proposed as the prime contractor, with STI as the subcontractor. Both TF and STI are flexible in how the contracting arrangement is established with CARB; if CARB prefers to enter into separate contracting arrangements with both organizations, or to have STI be the prime contractor and TF be the subcontractor, the study team partners can work with CARB to implement the preferred contracting approach. **Table 1** presents the overall project budget for the combined work efforts of TF and STI, broken down by base and supplemental work; base work is noted in blue, and supplemental work in red (italics).

Table 1. Summary of proposed base (in blue) and supplemental (italicized in red) estimated costs for the Fresno TREES project.

Task/Cost	2017	2018	2019	2020	2021
Planning and Project Coordination					
PPC-1. Initial/ongoing planning	41,889	18,843	19,364	20,231	20,752
PPC-2. Advisory team/meetings	34,712	27,950	28,728	30,024	30,801
Air Quality Measurement and Analysis					
AQ-1. "Before" tree planting (base)	604,389				
AQ-2. "After" tree planting (base)				454,632	463,751
AQ-3. Mature vegetation (base)		430,316			
AQ-4. Seasonality test (supp.)		*324,198*			
AQ-5 Different vegetation types (supp.)					
- dense vs. sparse			*332,227*		
- leaf vs. conifer				*347,854*	
- low vs. high height				*347,854*	
- with sound wall			*332,227*		
AQ-6. Different road grade (supp.)		*324,198*			
AQ-7. Parks/schools (supp.)			*332,227*		*355,670*
AQ-8. Neighborhoods (supp.)				*347,854*	*355,670*
AQ-9. Valley arboretum (base)			439,434		
AQ-10. Tool development/refinement (supp.)	*30,389*	*243,987*	*84,994*	*28,102*	
Tree Planting					
TP-1. Near-freeway plan (base)	125,000	96,700	99,481	102,345	105,296
TP-2. Near-freeway planting (base)	*240,000*	240,000	120,000	240,000	120,000
TP-3. Near-freeway tree care (base)		14,000	16,000	30,000	32,000
TP-4. CLP plans (base)	80,000	86,350	87,741	89,173	90,648
TP-5. CLP planting (supp.)		*48,000*	*96,000*	*144,000*	*192,000*
TP-6. CLP tree care (supp.)			*4,000*	*6,000*	*8,000*
TP-7. Valley Arboretum plans (base)	40,000	126,350	49,741	51,173	52,648
TP-7. Valley Arboretum planting (base)		48,000	48,000	48,000	48,000
TP-7. Valley Arboretum tree care (base)			2,000	4,000	6,000
Outreach, Education, Engagement					
OE-1. Stakeholders (base)	80,960	103,607	120,218	110,825	127,784
OE-2. Youth (supp.)	*25,055*	*102,992*	*105,764*	*110,384*	*113,152*
OE-3. Tree mapping (supp.)	7,040	7,251	7,469	7,693	7,924
Reporting	91,568	94,242	96,923	101,235	103,931
Base Funding Totals	1,065,558	1,293,609	1,135,098	1,289,331	1,209,534
Supp. Funding Totals	*295,444*	*1,043,375*	*1,287,440*	*1,332,048*	*1,024,492*
Overall Funding Totals	**1,401,002**	**2,336,984**	**2,422,538**	**2,621,379**	**2,234,026**

Table 2 includes a cost breakdown for the tree planting and related support work to be completed by TF. The data shown are divided into the four tree planting program areas described earlier: work near freeways, near parks and schools, in urban/rural districts in support of CLPs, and for the Valley Arboretum. As in Table 1, base work is noted in blue, and supplemental work in red (italics).

Table 2. Summary of Tree Fresno's proposed base (in blue) and supplemental (italicized in red) estimated costs.

Task/Cost	2017	2018	2019	2020	2021
On Freeway - AQ Collaboration, Project Admin., and Consulting Services (e.g., Landscape Architect, Arborist, Ecologist, Civil Engineer)	40,000	46,350	47,741	49,173	50,648
On Freeway - Landscapes Plans - 20 sites at $1,500; plus annual update to program at $2,000	30,000	2,000	2,000	2,000	2,000
On Freeway - Landscapes Planting - 4 sites per year, 60 trees per site at $500 per tree/shrub pair	*120,000*	120,000	120,000	120,000	120,000
On Freeway - Landscapes Care - $500 per 60 tree-site each quarter, 3 years per tree		2,000	4,000	6,000	8,000
On Freeway - Education/Engagement (with 3% inflation)	22,000	22,660	23,340	24,040	24,761
Parks & Schools - AQ Collaboration, Project Admin., and Consulting Services (e.g., Landscape Architect, Arborist, Ecologist, Civil Engineer)	40,000	46,350	47,741	49,173	50,648
Parks & Schools - Landscapes Plans - 6 sites at $2,500 (first year, then $2000/year)	15,000	2,000	2,000	2,000	2,000
Parks & Schools - Landscapes Planting - 6 sites per year, 50 trees each at $400 per tree/shrub pair	*120,000*	120,000		120,000	
Parks & Schools - Landscapes Care - $500 per 50 tree-site each quarter, for 3 years for each tree		12,000	12,000	24,000	24,000
Parks & Schools - Education/Engagement (with 3% inflation)	22,000	22,660	23,340	24,040	24,761
Urban/Rural CLPs - AQ Collaboration, Project Admin., and Consulting Services (e.g., Landscape Architect, Arborist, Ecologist, Civil Engineer)	40,000	46,350	47,741	49,173	50,648
Urban/Rural Districts - Community Landscapes Plan at $40,000 each; 1 each year.	40,000	40,000	40,000	40,000	40,000
Urban/Rural Districts - Landscapes Planting - 2 sites per year for each community with a CLP; 60 trees per site at $400 per tree. For example, we would plant trees in SW Fresno starting in 2018 and each year thereafter. We would plant trees in the 2nd community in 2019 and each year thereafter.		*48,000*	*96,000*	*144,000*	*192,000*
Urban/Rural Districts - Landscapes Care - $500 per 50 tree-site each quarter, for 3 years for each tree			*4,000*	*6,000*	*8,000*
Urban/Rural Districts - Education/Engagement (with 3% inflation)	22,000	22,660	23,340	24,040	24,761
Valley Arboretum - AQ Collaboration, Project Admin., and Consulting Services (e.g., Landscape Architect, Arborist, Ecologist, Civil Engineer)	40,000	46,350	47,741	49,173	50,648
Valley Arboretum - Landscapes Plans - 8 sites at $10,000; plus annual update to program at $2,000		80,000	2,000	2,000	2,000
Valley Arboretum - Landscapes Planting - 2 sites per year, 60 trees per site at $400 per tree/shrub pair		48,000	48,000	48,000	48,000
Valley Arboretum - Landscapes Care - $500 per 60 tree-site each quarter, for 3 years for each tree			2,000	4,000	6,000
Valley Arboretum - Education/Engagement (with 3% inflation)	22,000	22,660	23,340	24,040	24,761
Reporting support funds	8,000	8,240	8,487	8,742	9,004
Subtotal: base costs per year	341,000	710,280	524,808	669,593	562,640
Subtotal: supplemental costs per year	*240,000*	*48,000*	*100,000*	*150,000*	*200,000*
Total	**$581,000**	**$758,280**	**$624,808**	**$819,593**	**$762,640**

Table 3 includes a cost breakdown for the work proposed by STI. As in Tables 1 and 2, base work is noted in blue, and supplemental work in red (italics).

Table 3. Summary of STI's proposed base (in blue) and supplemental (italicized in red) estimated costs.

Task/Cost	2017	2018	2019	2020	2021
Planning, Project Coordination, Advisory Communication (Base Effort)					
Labor, travel	76,601	46,793	48,092	50,255	51,553
Base Air Quality Measurement, Analysis, Reporting (Excluding Tool Development)					
Labor, travel	451,557	437,518	449,070	468,325	479,878
Equipment	236,400	78,800	78,800	78,800	78,800
Total Base Air Quality Cost	**687,957**	**516,318**	**527,870**	**547,125**	**558,678**
Supplemental Air Quality Measurement, Analysis, Reporting (Costs per Supplemental Effort per Year)					
Labor, travel		*320,098*	*328,127*	*343,754*	*351,570*
Equipment		*4,100*	*4,100*	*4,100*	*4,100*
Subtotal		*324,198*	*332,227*	*347,854*	*355,670*
Number of supplemental air quality efforts per year		2	3	3	2
Total Supplemental Air Quality Costs		***648,396***	***996,682***	***1,043,562***	***711,340***
Tool Development (Supplemental Effort)					
Labor, travel	*30,389*	*243,987*	*84,994*	*28,102*	
Outreach and Education to Stakeholders (Base Effort)					
Labor, travel		20,218	34,328	22,358	36,663
Outreach and Education via Kids Making Sense (Supplemental Effort)					
Kids Making Sense labor/travel cost per school	*16,067*	*16,472*	*16,877*	*17,552*	*17,956*
Kids Making Sense equipment cost per school	*8,988*	*9,276*	*9,564*	*10,044*	*10,332*
Number of schools per year	1	4	4	4	4
Total Kids Making Sense Costs per Year	***25,055***	***102,992***	***105,764***	***110,384***	***113,152***
Subtotal: Base Costs per Year	**764,558**	**583,329**	**610,290**	**619,738**	**646,894**
Subtotal: Supplemental Costs per Year	***55,444***	***995,375***	***1,187,440***	***1,182,048***	***824,492***
Total Costs per Year	**820,002**	**1,578,704**	**1,797,730**	**1,801,786**	**1,471,386**

Table 4 summarizes total estimated costs for base and supplemental work, by year, by proposal team member.

Table 4. Summary of proposed costs by year and proposal team member.

Proposal Team Member	2017	2018	2019	2020	2021	Total
Tree Fresno	581,000	758,280	624,808	819,593	762,640	**3,546,321**
Sonoma Technology	820,002	1,578,704	1,797,730	1,801,786	1,471,386	**7,469,608**
Totals	**1,401,002**	**2,336,984**	**2,422,538**	**2,621,379**	**2,234,026**	**11,015,929**

7.2 Optional Work

In addition to the work detailed and costed above, there are several optional efforts that the study team can discuss with CARB, depending on interest level and need. Brief examples are included here, and additional work options can be discussed either before initial work plans are prepared, or once work is underway.

7.2.1 Near-Road NO_2 Measurements

As discussed earlier, data available to date from the EPA-mandated U.S. near-road monitoring network indicate that near-road NO_2 concentrations are unlikely to violate the NAAQS. However, CARB may have interest in monitoring and assessing vegetative barrier impacts on near-road NO_2, for reasons such as to track fleet turnover impacts, to build mitigation information for gaseous pollutants, and/or to obtain needed data in case NO_2 air quality standards are made more stringent over time. If CARB believes there is sufficient interest in NO_2 to warrant field work, STI can work with CARB to better define a study design and to provide cost estimates for adding near-road NO_2 measurement work.

7.2.2 Additional FRM Mass-Based PM Measurements

The proposal package as written includes one FRM measurement device to obtain $PM_{2.5}$ and PM_{10} data at a study area. The data will be compared with low-cost sensor measurement findings. As an option, STI could help CARB compare near-road concentration gradient measurements for $PM_{2.5}$ and PM_{10} obtained by both low-cost sensors and FRM measurement equipment. This option would involve the purchase and deployment of two additional FRM monitors (we have proposed to use one T640x measurement device to obtain FRM $PM_{2.5}$ and PM_{10} values). The incremental costs to obtain, deploy, and quality-check the additional equipment are on the order of $45,000 to $55,000 per device.

7.2.3 Time-Extended Measurements at Study Areas

The study design described earlier assumes six-week deployments for air quality measurement equipment at each study area. The six-week study period was selected to ensure sufficient data collection during the base measurement work, while still allowing sufficient calendar time to deploy the same equipment at other sites during the year to complete supplemental measurement work. For some of the study years, CARB may elect to defer supplemental measurements. In those situations, the equipment used to complete base work efforts could remain at the same location for longer periods. As an illustration, once air quality monitors have been deployed at six measurement sites in a given study area, for a six-week measurement campaign, the incremental cost of extending the use of that equipment at that same study area for an entire calendar year would be on the order of $100,000 to $120,000 in year one; costs for subsequent years would need to be escalated by about 3% per year to allow for inflation. STI can develop more precise cost estimates if CARB has interest in extending the measurement period made at a given study area.

7.2.4 Additional Data Analysis Work in Response to CARB, Stakeholder, or Advisory Committee Interest

One of the benefits of the work proposed here is that a substantial amount of air quality and meteorological data will be collected in a variety of near-road settings. The study team anticipates that, given substantial stakeholder interest in the vegetative barrier study topic, there may be additional questions and analysis topics identified while work is ongoing. As additional analysis needs are identified, the study team can provide CARB with cost estimates to complete optional data analysis work.

7.2.5 Additional Rail-Related Analysis Work

The study team recognizes that because of the rail lines and rail yards in the Fresno area, there may be interest in more detailed analysis to examine the air quality in areas near rail facilities, or to plant trees and other vegetation between rail facilities and sensitive downwind areas. Various work efforts could be completed, such as air quality measurements and related data analysis to compare (1) time periods when trains are operating near the monitors to periods when there is no train-related activity; (2) air quality "before and after" tree planting work adjacent to rail facilities; and (3) air quality near rail facilities with and without existing vegetative barriers. If CARB has interest in those or other rail-related efforts, the study team can prepare cost estimates to complete the desired work.

7.3 Cost Terms and Conditions

The cost estimates provided here reflect TF's and STI's best approximations given the information available at the time of proposal preparation. By its nature, field work, including tree planting and air quality measurement work, entails situations involving unexpected circumstances. In addition, when forecasting costs over a multi-year period, the ability to forecast with certainty becomes reduced the longer the planned time duration for the work. Both TF and STI will work to complete the work described here within the budgets proposed. However, both TF and STI reserve the right to work with CARB to revise work scopes or budgets to reflect unanticipated challenges or circumstances that may arise during the completion of the work.

STI, as a California Small Business, has standard government contracting terms and conditions, and these are included here for reference.

7.3.1 Labor Billing Rates

All work performed on the project will be billed at the STI Government Time and Materials rates in effect at the time the work is performed. These rates are fully loaded with benefits, overhead, and fee. Time spent in travel will be billed at these rates except that no more than eight hours per day of travel time will be charged. For expert testimony or participation in hearings, trials, or depositions, STI uses a separate rate schedule which can be provided on request. Individuals receiving promotion to different labor categories during the life of the contract will be billed at the appropriate labor category in effect at the time work is completed.

7.3.2 Other Direct Costs

Materials and other direct costs (M&ODC) will be billed at actual cost plus twelve percent (12%) General & Administrative cost (G&A) and ten percent fee (10%). Examples of M&ODC expenses include travel, shipping, subcontracts, printing, communications, special insurance or permits, and materials or equipment leased or purchased for the project.

7.3.3 Standard Commercial Items

Charges for STI standard commercial items will be billed at the rates in the current STI lease rate schedule without additional markup. Examples of these items are field measurement equipment, computer time, equipment leased, and aircraft flight time. A copy of the schedule is available upon request.

7.3.4 Invoicing and Payment

Invoices will be sent monthly, itemizing the labor hours worked by each person and the charges for materials and other direct costs. All payments are due within thirty (30) days of the invoice date. Invoices not paid within thirty days shall be subject to interest from the 31st day at the rate of 1.5% per month.

7.3.5 Warranty

STI will perform all work on a best effort basis using staff members having the required skills and experience. All field activities are subject to the constraints of weather and safety. STI's liability, if any, for any damages, including indirect or consequential, resulting from this work shall be limited to the amount paid STI under this agreement or to $25,000, whichever is less, unless otherwise negotiated.

Supporting Documentation Provided by Potential Recipient

Via email: maria.loera@arb.ca.gov

December 21, 2016 STI-716095

Ms. Maria Loera
Enforcement Division, California Air Resources Board (CARB)
1001 I Street, Sacramento, CA 95812-2815

Re: Supplemental Environmental Project (SEP) Proposal, "The Fresno TREES Project: **T**ree planting along **R**oads to help **E**liminate pollution **E**xposure and **S**equester carbon" **Addendum**

Dear Maria,

We appreciate the helpful feedback given by you and Kristen McKinley following submission of our Fresno TREES Project proposal on October 21, 2016. As we explained in our October submission, the TREES Project will address three high priority environmental issues in Fresno, one of the state's most important environmental justice regions. Our project will (1) assess the efficacy of using vegetative barriers to reduce near-road pollution exposure; (2) plant trees and shrubs in the near-road environment to improve the Fresno community while reducing exposure to traffic-related air pollutants; (3) help sequester carbon through tree planting and contribute to the California goal of reducing climate change impacts; and (4) engage students and residents.

In response to the discussions we have had with you, Tree Fresno (TF) and Sonoma Technology, Inc. (STI) have prepared this proposal addendum. We recognize it is difficult to predict the funding that may become available to initiate work, so we subdivided some of the larger, more expensive first-year tasks into smaller, less costly work elements. These smaller work elements should enable CARB to initiate work with a smaller starting dollar amount.

The work elements listed in Table 1 will enable us to (1) complete overall study planning, (2) inventory and rank existing trees and sites suitable for tree planting and air quality measurement work, (3) initiate tree planting, (4) initiate air quality measurements, (5) begin the process of community education and engagement—especially for schools, and (6) initiate tool development work to quantify vegetative barrier benefits. The rate of progress made on each work element will be determined by the funding available.

Many of the items listed are discrete, meaning they can be funded and completed individually. To reduce start-up costs, some of the Table 1 work elements include subsets of the work we included in the full study design presented in October. For example, for the air quality measurement work itemized in Table 1, we modified the pollutant mix and number of instruments to focus initial measurement work on black carbon and ultrafine particles—two pollutant types for which near-road concentrations are typically high and health effects are a key concern, and which can serve as excellent cases to test the benefits of near-road trees and vegetative barriers. Later work can, as more funding becomes available, implement additional measurement elements. Once you have specific settlement fund amounts to deploy, we can explain in greater detail the work costed in Table 1.

As noted in our October proposal submission, TF is a 501(c)(3) organization founded in 1985; TF is the applicant for this project. TF will contribute to the site analysis and lead the tree planting and tree care. STI is an air quality research firm founded in 1982; STI will subcontract to TF and lead air quality measurement, analysis, and tool development. TF and STI will each work on outreach and education.

Table 1. Potential first-year work elements to launch the Fresno TREES Project.

First-Year Opportunities to Begin Work with Various Funding Levels[a]			
Work Element	**TF**	**STI**	**Total**
Initial study planning	15,000	25,000	40,000
Corridor assessment (Highway 99): tree inventory, topography, soils, and structures. Identification and ranking: tree planting and air quality measurement sites.	20,000	15,000	35,000
Tree planting at one location	36,000		36,000
Tree planting at a second location	36,000		36,000
Air quality (AQ) initial measurements, first location (3 sites)		280,340	280,340
AQ initial measurements, second location, same year (3 sites)		196,060	196,060
Kids Making Sense education and outreach program (1 school)		25,055	25,055
Initial barrier benefits estimation tool planning and development		30,389	30,389
Community education/engagement (including schools)	22,000	10,109	32,109

[a] There are many work element combinations that can be assembled to match specific dollar amounts. The examples shown here can be replaced or modified as needed to address ARB feedback and funding.

Please contact us with questions or comments. We look forward to working with you to select initial work elements and to begin work on this effort.

Sincerely,

Lee Ayres
Tree Fresno Executive Director

Douglas Eisinger, Ph.D.
STI Vice President and Chief Scientist for Transportation Policy and Planning

cc: Kristen McKinley, CARB Enforcement Program
Attachment: Original October 21, 2016 TF-STI proposal package