



# PLANNED AIR POLLUTION RESEARCH

Fiscal Year 1998-1999

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TITLE: *Analysis of Particulate Matter from Tire and Brake Wear of On-Road Vehicles*

PROBLEM: Up to one-third of all directly emitted particulate matter from on-road motor vehicles has been attributed to either tire or brake wear; however, these emission estimates have not been updated in over a decade. New materials used in brake linings and the elimination of bias ply tires may have significantly reduced total emissions of particulate matter from these sources. The information regarding tire and brake wear for PM<sub>2.5</sub> emissions is in need of revision, and is poorly documented. Emission factors for PM<sub>2.5</sub> are currently not available for both brake wear and tire wear. Since PM<sub>2.5</sub> goes deeper into the lungs and

there is now a Federal PM<sub>2.5</sub> ambient air quality standard, it is necessary to determine PM<sub>2.5</sub> emissions from tire and brake wear.

PREVIOUS WORK:	Previous analyses have been performed on a limited number of vehicles, yielding four emission rates for tire wear based on vehicle type (autos, light trucks, medium trucks, and heavy trucks) and a single gram-per-mile emission rate for brake wear. Emission rates are probably affected by differences in brake and tire materials and by driving patterns. However, the most current data available, taken from the U.S. EPA's PART 5 particulate matter model, still lists a single value for brake wear.
OBJECTIVE:	To determine the gram-per-mile particle emission rate from tire and brake wear, the particle size distribution in these emissions, and the influence that different driving patterns may have on particulate emissions.
DESCRIPTION:	A number of vehicles would be tested with various tire and brake configurations in an evaporative emissions running loss enclosure adapted to sample ambient concentrations of particulate. These vehicles would be operated over two or more driving cycles to determine the effect of driving patterns on particulate emissions. Measurements of PM <sub>10</sub> and 2.5 would be performed, the emissions would be chemically analyzed, and the relative contributions of tire and brake wear to the emissions inventory would be determined.
BENEFITS:	Greater emphasis is now being placed on the health effects of exposure to particulate matter. This study would provide the information necessary to correctly identify the sources and to update the on-road emissions inventory.
COST:	\$100,000.
TITLE:	<i>Exhaust Emission Testing of Diesel-Powered Off-Road Equipment</i>
PROBLEM:	Currently, the emissions inventory of diesel-powered off-road equipment is based on very limited emissions testing data. The existing exhaust emissions data are based on testing of new engines, and the deterioration rates for most of the engine types are calculated using data from similar on-road motor vehicles. However, because usage patterns are different, on-road engine deterioration may not correctly represent off-road engine deterioration. Further, there is concern that the steady-state cycle used in the past for emissions testing of off-road engines does not adequately characterize emission of particulate matter (PM).
PREVIOUS WORK:	Limited emission data for off-road diesel equipment have been collected by engine manufacturers and the U.S. EPA. The U.S. EPA is currently involved in a research project to develop a transient cycle for testing off-road diesel engines.
OBJECTIVE:	To test various in-use diesel-powered off-road engines for exhaust emissions, including HC, CO, NO <sub>x</sub> , total PM, PM <sub>10</sub> , and PM <sub>2.5</sub> using a transient test cycle.
DESCRIPTION:	The project would require procurement and exhaust emission testing of diesel-powered equipment from construction and agricultural categories. Subsets of equipment from each of the equipment categories would be tested on California pre-1993 and reformulated diesel fuels. Testing of two different fuels would provide information on the effects of fuel properties on exhaust emissions.

BENEFITS:	This research would enable staff of the ARB to incorporate the latest emissions test data into the off-road equipment emissions inventory model. The updated emissions inventory model will be used to evaluate various emission control scenarios in a appropriate cost-effective manner to achieve the goals of the M9 and the M10 Ozone SIP measures.
COST:	\$220,000.
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TITLE:	<i>Development of an Analytical Test System for Heavy-Duty Diesel Vehicle Inspection and Maintenance</i>
PROBLEM:	About 70% of the particulate matter (PM) and 35% of the nitrogen oxides (NO <sub>x</sub> ) emitted in California are produced by diesel vehicles. These and other emissions produced by diesel vehicles present a significant health risk to Californians. The current method of emission testing for heavy-duty diesel vehicles is to measure opacity as a surrogate for all emissions. The 1994 State Implementation Plan (SIP) for Ozone has been modified to call for expanded heavy-duty-vehicle in-use emissions compliance and testing for NO <sub>x</sub> emissions. Test procedures and instrumentation are needed that are suitable for application to a diesel Inspection and Maintenance (I & M) program. Because inspections are to be performed on in-use vehicles under load, development of portable a unit is desirable.
PREVIOUS WORK:	Portable heavy-duty-vehicle steady-state chassis dynamometers and instrumentation designed to measure and quantify PM emissions from diesel engines have been developed over the past several years.
OBJECTIVE:	To develop an acceleration simulation mode-like dynamometer test for heavy-duty diesel vehicles that causes the vehicle engine to work and includes the adaptation of instruments that are capable of real-time measurement of PM and NO <sub>x</sub> emissions. The test should be capable of being implemented using a portable chassis dynamometer.
DESCRIPTION:	The investigator would integrate test equipment of various types (portable chassis dynamometers, sampling systems, dilution tunnels, etc.) for testing diesel vehicles for gaseous emissions (including NO <sub>x</sub> ) and PM. The PM analyzer would be integrated with a BAR97 analyzer that is currently used for testing gasoline-powered vehicles; this could permit measurements of hydrocarbons and carbon monoxide during the same test.
BENEFITS:	After completion of this study, California would have a methodology upon which to base a statewide I&M program for diesel vehicles. Such a program would comply with the Ozone SIP and help reduce human exposure to PM, NO <sub>x</sub> , and other air pollutants directly emitted by diesel vehicles or secondarily produced from diesel exhaust. It could also offset some of the NO <sub>x</sub> emission benefits lost through modifications that have been made to the Smog Check Program.
COST:	\$350,000.

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TITLE:	<i>Physical and Chemical Characterization of Size-Segregated Particulate Matter Emissions from Gasoline- and Diesel-Powered On-Road Motor Vehicles</i>
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- PROBLEM:** Particulate Matter (PM) emissions have become a concern worldwide. The U.S. EPA recently promulgated PM<sub>2.5</sub> standards for fine particulate matter, and a recent university study identified potential health concerns with ultrafine (<0.1 µm) and nanoparticle (< 0.05 µm) PM emissions from diesel engines. Members of the European community who have been studying the entire size domain of PM have proposed both ambient and occupational health standards for PM. The European studies point to the need for establishing standardized methods for measuring ultrafine and nanoparticle PM emissions.
- PREVIOUS WORK:** In September 1996, a study by the Health Effects Institute (HEI) found that a later 1 model year diesel engine had lower mass PM emissions than an earlier engine, but the newer engine produced many times greater numbers of particles, especially small, primary particles. At an August 1997, European conference on internal combustion engine nanoparticle measurement, the consensus was that measurements of ultrafine and nanoparticle emissions are influenced by dilution ratio, humidity, and temperature parameters for which no standardized measurement methods exist.
- OBJECTIVE:** To develop appropriate methods for sampling the entire size domain of gasoline- and diesel-fueled vehicle PM exhaust emissions under conditions that are representative of those that PM exhaust emissions experience in the atmosphere. If test procedures can be readily developed, a small fleet of gasoline- and diesel-powered vehicles would be tested using these new methods to obtain emission data from different classes of on-road motor vehicles.
- DESCRIPTION:** The contractor would identify existing studies regarding the fate of motor vehicle ultrafine and nanoparticle PM emissions in ambient air, perform data analysis, and do one of the following: a) If the data permit, propose test procedures for accurately representing these conditions, and then procure and test a small fleet of gasoline-powered light-duty autos and heavy-duty diesel-powered vehicles; or b) if data are lacking, recommend additional data collection of vehicle emissions in ambient air, collect these emission data, perform data analysis, and develop representative test procedures.
- BENEFITS:** The size-segregated and chemically characterized ambient PM data would provide ARB health effects staff with representative ambient exposure data. The motor vehicle exhaust PM emissions data would provide ARB emissions inventory and air quality modeling staff with a small set of vehicle-specific, size-segregated, chemically-characterized vehicle exhaust PM emissions data as a function of engine and fuel type, vintage, and mileage.
- COST:** \$325,000.

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**TITLE:** *Demonstration of High Power (Level 3) Electric Vehicle Charging*

**PROBLEM:** Critical to the Air Resources Board's zero-emission vehicle (ZEV) program's electric vehicle implementation (currently the only technology capable of meeting the ZEV requirements) is the development of a public recharging infrastructure. Deployment of high power ("level 3") charging stations has the potential for increasing consumer acceptance of electric vehicles by providing fast charging away from home, similar to a gas station for conventional vehicles. Some automakers have indicated that level 3 charging is critical to the success of the electric vehicle market.

**PREVIOUS** The ARB is supporting a project with the Advanced Lead-Acid Battery Council, the South

- WORK:** Coast Air Quality Management District, and Southern California Edison to demonstrate advanced lead-acid batteries. Included in the project are plans to install and test a level 3 charger.
- OBJECTIVE:** To demonstrate level 3 charging stations. The project would demonstrate safety, reliability, and other factors necessary for the commercial introduction of the technology.
- DESCRIPTION:** This project would provide data on durability of level 3 charging technology, installation costs, recharge time, costs to consumers, consumer comments, and appropriate placement of future installations. Five to 10 chargers would be installed at public locations. Both inductive and conductive charging technologies would be evaluated. Data would be collected from the test sites for 6 months. The duration of the project would be 18 months.
- BENEFITS:** This project would help support the ZEV program by demonstrating fast charging technology that would enhance the marketability of electric vehicles.
- COST:** \$750,000.  
Potential co-funders: the South Coast Air Quality Management District, the California Energy Commission, and the Electric Power Research Institute. ARB cost would be \$150,000.

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**TITLE:** *Development of Software for the Analysis of Spatially and Temporally Resolved Motor Vehicle Activity Data*

**PROBLEM:** Until recently, motor vehicle activity data have been collected using methods such as embedded roadway speed sensors, written and telephone surveys, and conventional instrumented vehicles. A major limitation of such methods is their inability to spatially and temporally resolve such motor vehicle activity data as trip starts and ends, trip distance and speed as a function of roadway type, and trip purpose. New tools capable of collecting and analyzing these types of data are needed to improve the accuracy and spatial resolution of the motor vehicle emissions inventory.

**PREVIOUS WORK:** A number of recent studies have shown the potential of using Global Positioning System (GPS) receiver-equipped vehicles, in conjunction with Geographic Information System (GIS) software, to infer the location and time of trip starts and ends, trip distance and speed by roadway type, and trip purpose. However, these studies also indicate that collection of representative activity data based on large-scale GPS-instrumented vehicle fleets is limited primarily by the time-intensive nature of current GPS/GIS analysis methods.

**OBJECTIVE:** To develop software for the automation of current methods of GPS/GIS analysis used to generate spatially and temporally resolved motor vehicle activity data.

**DESCRIPTION:** The proposed software would be a custom GIS application capable of overlaying second-by-second GPS-instrumented vehicle data on digital streetmaps and correctly inferring roadways driven for a given trip. Having identified the route driven, the software would then calculate the length of each trip as a function of different roadway types, as well as speed statistics for each roadway type driven. Also, by overlaying the GPS data on digital land-use maps, the software would provide the location, time, and land-use of trip starts and ends for inferring the trip purpose. This software application would be designed to be menu-driven and user-friendly, thus significantly reducing current analysis times.

**BENEFITS:** This software would assist in the spatial and temporal allocation of motor vehicle activity data, ultimately resulting in a more useful and accurate mobile source emissions inventory.

**COST:** \$100,000.

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**TITLE:** *Determination of Non-Registration Rates of On-Road Vehicles in California*

**PROBLEM:** The California vehicle emissions inventory is based on the number of vehicles that are registered. However, some of the vehicles driven in California are not registered. A 1989 study revealed that 8% of the passenger car fleet may be non-registered for up to a month, and 1% for two or more years. These vehicles need to be assessed for their contribution to California's emissions inventory.

**PREVIOUS WORK:** In the 1989 study, Valley Research determined the registration status of vehicles parked at shopping centers in the South Coast Air Basin through a review of DMV records.

**OBJECTIVE:** To determine the non-registration rate of the passenger fleet for each county and for the state overall; to assess the impact that these vehicles may have on the emissions inventory; and to determine the reasons for non-registration.

**DESCRIPTION:** Field observations performed in all of California's counties will be compared to DMV records to determine the rate of non-registered vehicles that are being driven. The reasons for non-registration will be determined through a survey of owners. The emissions of non-registered vehicles will be assessed by analysis of Inspection and Maintenance (I&M) Program histories maintained by the Bureau of Automotive Repair and testing of a sample of these vehicles at the Board's Haagen-Smit Laboratory.

**BENEFITS:** The results of this research will be used to improve the on-road motor vehicle emissions inventory. The analysis will also provide insight as to why some owners do not register their vehicles.

**COST:** \$300,000.

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**TITLE:** *Development of the Risk Assessment Module of the Hot Spots Integrated Computer Program*

**PROBLEM:** The development of California's Hot Spots Integrated Computer Program needs to be altered to incorporate risk assessment guidelines being developed by the Office of Environmental Health Hazard Assessment (OEHHA). The program will include stochastic modeling and the ability to overlay risk isopleths from multiple neighboring facilities to determine the cumulative risk posed to a neighborhood. The program will also be developed to be compatible with U.S. EPA's atmospheric modeling program (ISCST3).

**PREVIOUS WORK:** In 1996, Dillingham Software Engineering (DSE) developed three of the four modules comprising the California's Hot Spots Integrated Computer Program: the toxic emissions inventory module, the facility prioritization module, and the air dispersion modeling module.

**OBJECTIVE:** To develop a user-friendly Windows 95-based risk assessment module to use with the

existing Hot Spots Integrated Computer Program, thus completing the program.

- DESCRIPTION:** The risk assessment module would provide summary reports of Maximum Exposed Individual (MEI) risk, health hazard indices, and cancer burden using stochastic analysis to model data distributions included in the OEHHA guidelines. The module would also display facility property boundaries and risk isopleths using a Geographic Information System program.
- BENEFITS:** The computer program developed in this project would allow the ARB, districts, and facility operators to implement the programmatic aspects of California's Hot Spots Program in a consistent, efficient, and cost-effective manner.
- COST:** \$100,000.

- TITLE:** *Examination of Alternative Technologies for Wood Furniture Stripping Operations; Characterization of Methylene Chloride Uses in California*
- PROBLEM:** Risk assessments conducted for wood furniture stripping operations using methylene chloride have indicated that these facilities may pose a health risk to nearby residents. This potential risk needs to be better quantified. ARB staff are not aware of a cost-effective alternative process, alternative information, or control technology for wood furniture stripping operations.
- PREVIOUS WORK:** The Institute for Research and Technical Assistance is conducting a limited study to compare the effectiveness of several low- and non-methylene-chloride wood furniture stripping formulations. The results of this testing are expected in early 1998.
- OBJECTIVE:** To assess the emissions of methylene chloride from methylene chloride-based furniture stripping operations and alternative stripping formulations or control technologies.
- DESCRIPTION:** The contractor would develop an accurate inventory of methylene chloride use for furniture stripping in California over the last three years. Both top down and bottom up approaches would be used. Vendors can provide a gross estimation of the volumes of methylene chloride sold for wood furniture stripping operations by geographical areas.
- There are hundreds of wood furniture strippers operating in California that primarily use formulations containing in excess of 80 percent methylene chloride. The contractor would conduct a search for studies of low- and non-methylene chloride wood furniture stripping formulations. This information should include the emission reductions and effectiveness of these formulations. The contractor also would conduct testing to assess the effectiveness of facilities using these formulations.
- BENEFITS:** With the results of this study, ARB staff would be able to develop an appropriate control strategy for reducing methylene chloride emissions and the potential risk to the public.
- COST:** \$150,000.  
Potential co-funders: South Coast Air Quality Management District.

- TITLE:** *Near-Source Exposure to Crystalline Silica and Fine Mineral Fibers in California*

**PROBLEM:** Crystalline silica and fine mineral fibers are currently being considered for entry into the Assembly Bill (AB) 1807 Toxic Air Contaminant (TAC) Identification Program. However no data are available for near source exposure. ARB staff are proposing that crystalline silica be nominated for review for development of health values and for identification as a TAC. Over three million pounds per year of crystalline silica emissions were reported under the AB 2588 Air Toxics "Hot Spots" Program. Crystalline silica has been recently classified as Group 1, Known Human Carcinogen, by the International Agency for Research on Cancer. ARB staff are also considering whether an AB 1807 TAC Identification Program type risk assessment should be prepared for fine mineral fibers. The amount of fine mineral fibers emitted in California that meet the federal Clean Air Act definition of an average diameter of 1 micrometer (m) or less is unknown. The AB 2588 Air Toxics "Hot Spots" Program has defined mineral fibers as having a respirable size ( 3.5 m) and a length-to-diameter ratio greater than or equal to 3:1. The total emissions of mineral fibers from stationary sources in California are estimated to be at least 145 pounds per year, based on data reported under the AB 2588 Air Toxics "Hot Spots" Program. The International Agency for Research on Cancer has classified mineral fibers of respirable size (glasswool, rockwool, slagwool, and ceramic fibers) in Group 2B, Possible Human Carcinogen. The State of California has determined under Proposition 65 that glasswool and ceramic fibers (of respirable size) are carcinogens. Given the toxicity of crystalline silica and mineral fibers, near-source exposures for California must be determined.

**PREVIOUS WORK:** There is no known previous work in this area.

**OBJECTIVE:** To determine near-source exposure to crystalline silica and fine mineral fibers (including fiber size) throughout the state.

**DESCRIPTION:** The one-year research contract would focus on determining near-source concentrations. This would include, for example, sand and gravel operations for crystalline silica and facilities manufacturing glass, rock, or slag fibers (or other mineral-derived fibers) with an average diameter of 1m or less. The contractor would develop an exposure assessment by conducting sampling and analysis. The contractor would properly locate the sites, provide approved samplers and meteorological equipment, collect samples using approved quality assurance and quality control programs, and analyze the samples for quantity of fine mineral fibers (including fiber sizes) and crystalline silica using approved handling and laboratory practices. In addition, performance audits of the samplers and meteorological equipment would be conducted.

**BENEFITS:** Identifying near-source exposure to crystalline silica and fine mineral fibers (including fiber size) is necessary for assessing public exposure and setting priorities for review of substances of these types in the AB 1807 TAC Identification Program.

**COST:** \$125,000.

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**TITLE:** *Validation of Toxic Air Contaminant Concentrations Estimated from Air Dispersion Modeling for Distances Less Than 100 Meters from the Source*

**PROBLEM:** Air dispersion modeling is used to estimate the downwind concentration of a Toxic Air Pollutant (TAC) emitted from a facility. Conventional Gaussian-based air dispersion models are designed to estimate concentrations from 100 meters to 1 kilometer from the



source. Currently, modeling for distances less than 100 meters from the source is based on extrapolation of the Pasquill-Gifford dispersion curves. Human activity commonly occurs within 10 meters of a source, and risk assessment and risk management decisions impacting business costs, practices, and public relations are commonly based on estimated concentrations much closer to the source than 100 meters. Air dispersion modeling algorithms need to be validated or revised to address near-source concentrations of TACs.

**PREVIOUS WORK:** None at the Air Resources Board and none published by the U.S. EPA.

**OBJECTIVE:** To produce a valid air dispersion model for pollutant concentrations between the source and 100 meters.

**DESCRIPTION:** Analytical methods to estimate TAC concentrations between the source and 100 meters would be developed. This could include a review of the literature, an air monitoring program, or development of new air dispersion modeling algorithms to assess previous work.

**BENEFITS:** Because current risk assessment practices are based on air dispersion modeling results, it is important that the modeling be reliable and as accurate as possible. Valid modeling would enable us to better estimate the human health risks associated with exposure to TACs. This study would be a key component in assessing a facility's potential exposure and risk. This study would also address a component of the Risk Assessment Advisory Committee's recommendations to help improve the characterization of uncertainty in exposure assessment.

**COST:** \$150,000.

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**TITLE:** *Investigation of Low-Reactivity Solvents for Use in Consumer Products*

**PROBLEM:** The Board is developing mass-based and reactivity-based regulations for using VOCs having lower ozone-formation potential in consumer products. To comply with these regulations when they are implemented, manufacturers will need to have a diverse selection of VOC solvents that the Board has determined to be low in photochemical reactivity and which have other favorable characteristics. To better predict the environmental and economic impacts of such regulations as required by CEQA and the APA, Board staff also need a unified database of more comprehensive information on the physical characteristics of solvents that are potentially useful in product reformulations.

**PREVIOUS WORK:** The South Coast AQMD recently embarked on their Clean Air Solvents (CAS) program, which is designed as a pre-certification process for district approval primarily of industrial water-based cleaning solvents (similar to the Board's portable equipment pre-certification program). Certification under the CAS program involves meeting several criteria, including a reactivity criterion, for each applicant cleaning solvent. However, the certification process involves a "bright line" approach: approvable solvents must have a reactivity [based on the Maximum Incremental Reactivity (MIR) scale] less than toluene. This approach may limit the usefulness of CAS for the Board's purposes by eliminating candidate solvents that are useful in consumer products. Nevertheless, CAS contains some current information that may be useful.

- OBJECTIVE:** To identify and evaluate the effectiveness of a wide variety of solvents for use in reformulated consumer products. To compile information about a diverse set of physical properties for those solvents, including photochemical reactivity, efficacy, and potential for use in reformulations, so that Board staff can develop better regulations and manufacturers can make more intelligent reformulation choices.
- DESCRIPTION:** The contractor would compile a comprehensive database of all commonly used general solvents and the most useful specialty solvents available to consumer product manufacturers. The contractor would then determine -- through a combination of literature search, laboratory testing, and scientific analysis -- the applicable values for a series of physical properties to be established by Board staff. These would include, but not be limited to, vapor pressure, KB-solvency, boiling point, flammability, estimated MIR, overall toxicity index, greenhouse warming potential, and stratospheric ozone depletion.
- BENEFITS:** The study could significantly reduce reformulation costs by helping manufacturers eliminate, early in their reformulation process, those candidate materials that have higher environmental impacts than others. Ozone reductions may be improved if the database induces manufacturers to make more intelligent choices for reformulation approaches based on the solvent's potential impacts. The database could also be used to help reduce VOC impacts on human health, because an overall toxicity index could be useful in reformulation decisions.
- COST:** \$80,000.  
Potential co-funder: U.S. EPA.
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- TITLE:** *Demonstration of the High Volume Collection System (HVCS) for Direct Measurement of Mass Emission Rates of Hydrocarbon Leaks*
- PROBLEM:** Hydrocarbon emissions from leaking pumps, compressors, valves, flanges, and seals associated with natural gas, petroleum, and chemical production and processing facilities are an important source of volatile organic compound (VOC) emissions to the atmosphere. Current inspection and maintenance programs are based on U.S. EPA Method 21, a screening technique that measures leak concentration, and repairs are triggered at specific concentration levels that may not reflect the true VOC mass emissions impacts of the leaks.
- PREVIOUS WORK:** A new measurement technique, the High Volume Collection System (HVCS), offers the potential for providing an easy-to-use and cost-effective means for directly measuring mass emission rates of hydrocarbon leaks. The method uses a high-volume sampling device and a portable flame ionization detector for field analysis. A 1995 U.S. EPA study of HVCS performance included both field and laboratory testing at U.S. natural gas production facilities. Results demonstrated the HVCS to be an acceptable mass emission detection technique.
- OBJECTIVE:** To establish the HVCS as an acceptable method for measuring mass emission rates of hydrocarbon leaks in the petroleum industry.
- DESCRIPTION:** Laboratory and field testing of hydrocarbon leaks at a variety of petroleum production and processing facilities using the HVCS would be performed. Comparison with conventional bagging technique and Method 21 might also be performed.

**BENEFITS:** Successful demonstration of the HVCS will provide ARB, districts, and industry with a more accurate, reliable, easy-to-use, and cost-effective tool for quantifying fugitive hydrocarbon emissions from equipment leaks. With new emission data, existing regulations could be revised to consider mass emission rates as a criterion for equipment repairs, and this could result in less costly and more effective use of industry resources.

**COST:** \$100,000.

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**TITLE:** *Measurements of Ammonia Flux to Estimate Emission Factors for Stationary Sources*

**PROBLEM:** Ammonia may be the limiting factor for the formation of ionic salts such as nitrates and sulfates in PM<sub>2.5</sub>, but there is considerable uncertainty in the calculation of its source inventory since it is emitted primarily from area sources such as dairies, sewage treatment plants, fertilizer application, and other area uses of animal wastes. A critical need exists for an accurate and economical method to measure emissions from such sources.

**PREVIOUS WORK:** Previous work has relied on either flux chambers or upwind/downwind concentration measurements coupled with dispersion modeling to estimate source strengths. The first approach is difficult to apply to inhomogeneous sources, and the second requires intensive and expensive measurements of concentration and wind fields coupled with the application of a detailed model. In addition, ammonia sampling requires the use of denuder technology. Recently a direct monitor of ammonia flux has been made with passive denuder tubes, where the amount of ammonia collected is proportional to the product of the concentration and wind vector. The emission strength of a source, therefore, could be calculated from passive measurements about a source.

**OBJECTIVE:** To estimate the ammonia emission factors for a variety of area sources using a fabric denuder recently developed at the Center for Environmental Research and Technology at the University of California, Riverside. This approach would allow short-term sample collection periods for the measurement of ammonia flux using passive flux samplers.

**DESCRIPTION:** Fabric denuders coated with phosphoric acid would be mounted in both ends of an open Teflon tube. No flow restriction device is necessary. Each sampling point will consist of two tubes: one along an east-west axis, the other along a north-south axis. Tubes will be placed at elevations from 1 to 10 m or more at 3-meter intervals. (Sampling elevation depends on the results obtained; the goal is to sample sufficiently high that the ammonia flux goes to background.) Sampling will be conducted during the time of day when winds are consistently from a single direction. Vertical sampling arrays will be erected upwind of the source and at least two distances downwind. Denuder samples will be extracted in water and analyzed for ammonium. The data will be used to calculate the overall ammonia flux increase caused by the source and therefore allow the estimation of an emission factor. A feasibility study of six sources would be performed.

**BENEFITS:** The results will enable the development of more accurate emission inventories of ammonia and will allow for direct measurement of the effectiveness of control strategies.

**COST:** \$50,000.

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**TITLE:** *Chemistry of Primary and Secondary Organic Aerosols*

- PROBLEM:** Particulate matter has been implicated in human morbidity and mortality and many suspect that the organic fraction is the more potent portion of the PM10. It is now well recognized that primary and secondary organic matter constitute significant fractions of the particulate burden in the urban atmosphere. However, because of the enormous complexity of the chemical matrix of organic aerosol and the lack of direct chemical analysis methods for a majority of the compounds making up the organic aerosol fraction, estimates of secondary aerosol contributions in the urban environment have been restricted to indirect methods of determination.
- PREVIOUS WORK:** Turpin and Huntzicker used correlations between organic carbon and elemental carbon to estimate secondary organic aerosol contributions in the Los Angeles area during the 1987 summer Southern California Air Quality Study. The study showed that as much as 70 percent of the organic aerosol can be of secondary origin under peak photochemical conditions. Other estimates, based on chemical mass balance methods, suggest that on a yearly average, 20 to 30 percent of the fine organic particulate matter in South Coast Air Basin may be of secondary origin.
- OBJECTIVE:** To develop or improve methods capable of identifying and quantifying ambient air organic aerosol compounds.
- DESCRIPTION:** The primary goal of this study would be to obtain detailed, quantitative information on the kinetics, products and mechanisms of primary organic particle growth and gas-to-particle conversion for several atmospherically important organic compounds, and to investigate the photochemical oxidation of selected organics of anthropogenic and biogenic origin that are thought to be major contributors to urban smog. The mass spectral library of organic compounds typically found in secondary atmospheric aerosols will also be improved.
- BENEFITS:** The results of this project will help elucidate the fundamental processes governing organic aerosols, including gas-phase reactions that convert VOCs to condensable species, homogenous nucleation, and heterogeneous condensations. The information obtained from this study will directly benefit PM2.5 control measure development and the regional haze program, and will permit evaluation of the PM and visibility benefits deriving from ozone controls.
- COST:** \$300,000.

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**TITLE:** *Development of Reactivity Scales Via 3-D Grid Modeling of California Ozone Episodes*

**PROBLEM:** Reactivity scales currently used in connection with the California Low Emission Vehicle/Clean Fuels (LEV/CF) regulations were developed in the early 1990s using a sophisticated chemical mechanism, but the descriptions of an airshed's emissions and meteorology were simplistic. Considerable advancements in computing capabilities and understanding of chemical mechanisms have occurred since that time. Because of these developments, it is now possible to compute improved reactivity scales.

**PREVIOUS WORK:** The maximum incremental reactivity (MIR) scale (and other similar reactivity scales) were developed in the early 1990s using a then "state-of-the-science" chemical mechanism called SAPRC90. However, to cover a wide range of urban areas and meteorological conditions, a simplistic box model, EKMA, was used to compute MIR factors. Because of uncertainties introduced by this, it was necessary to apply a 3-D gridded photochemical model to verify and to adjust the reactivity adjustment factors that were developed in this manner.

- OBJECTIVE:** To conduct state-of-the-science 3-D grid modeling of several California ozone episodes. From each modeling case, develop a unique set of MIR factors.
- DESCRIPTION:** During the past several years, ARB, CRC, EPA, and other organizations have sponsored research to improve our understanding of ozone-formation chemical mechanisms. In the first phase of this proposed research project, this new information would be incorporated into an updated, detailed chemical mechanism (e.g., SAPRC98) that can be used in a 3-D gridded ozone model. The second phase of this project involves utilization of the updated airshed model to simulate several ozone episodes. To represent the diversity in emissions and meteorology that exist within California, modeling should be considered for the South Coast, San Diego, Sacramento, the Bay Area, and the San Joaquin Valley. For each episode, the emission inputs would be systematically varied following the same general approach as was used previously to develop the current MIR scale. The unique set of factors developed from each modeling case would then be compared among the different episodes, and contrasted with previously developed MIR factors.
- BENEFITS:** Use of improved chemical mechanisms and modeling approaches would lead to reactivity factors that have greater certainty. Also, investigating several different episodes would indicate the extent to which reactivity factors vary over a range of relevant atmospheric conditions within California.
- COST:** \$150,000.  
Potential co-funders: U.S. EPA, SCAQMD, and CRC.

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**TITLE:** *Improving Air Quality Forecasts*

- PROBLEM:** Daily predictions of ozone and PM10 are part of the U.S. EPA required pollutant standard index (PSI) program and provide guidance to the public, especially those with respiratory conditions sensitive to ozone and particulate matter. The public's daily activities may be affected by these predictions. Some work has been done to assess the accuracy of the predictions, but time and labor resources have been minimal. In addition, the U.S. EPA has adopted a new ozone standard, based on the maximum daily 8-hour average concentration, and a new particulate matter standard, based on 24-hour average PM2.5 concentration. Currently, no models exist to predict these concentrations.
- PREVIOUS WORK:** In 1977, Technology Service Corporation developed a 1-hour ozone predictor and performance evaluator for the SCAQMD. The SCAQMD has recently updated its 1-hour daily maximum ozone prediction scheme to take into account changes in emissions over the past decade. In 1996, Sonoma Technology Inc. (STI), under contract by the Sacramento Metropolitan AQMD (SMAQMD), completed the development of 1-hour daily maximum ozone prediction equations for the district's forecast area. The work done by STI included means for tracking forecast performance. In 1997, STI used the equations to forecast the 1-hour daily maximum ozone concentration for Yolo-Solano, Placer, and Sacramento counties.
- OBJECTIVE:** To improve existing 1-hour daily maximum ozone and 24-hour average PM10 prediction techniques, to develop 8-hour ozone and PM2.5 prediction techniques in response to the new U.S. EPA standards, and to develop prediction tracking systems for these techniques.
- DESCRIPTION:** The contractor would conduct a performance evaluation of the 1-hour daily maximum

ozone prediction technique used by the ARB and SMAQMD, and the 24-hour average PM10 prediction technique used by the ARB; improve the 1-hour daily maximum ozone and 24-hour average PM10 prediction techniques by building on previous work; develop a 24-hour average PM10 prediction technique for the SMAQMD; build on previous work to develop a system that records pertinent data and determines the air pollutant prediction performance for each of the techniques used by both the ARB and SMAQMD; and build on previous work to develop models that predict the daily maximum 8-hour average ozone and 24-hour average PM2.5 for the ARB and SMAQMD.

**BENEFITS:** This project is important for improving our ability to predict ozone and particulate matter concentrations, making it possible to provide the public with better information for living healthier lives.

**COST:** \$110,000.  
The SMAQMD may augment the contract funding to support its portion of the contract scope of work.

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**TITLE:** *Improvements to SAQM*

**PROBLEM:** The SARMAP air quality model (SAQM) is routinely applied in the study of air-quality related issues in Central California. In addition, efforts are underway to adapt SAQM to the SCOS97 region in Southern California, and SAQM with its aerosol capabilities will be tested using the particulate matter data from the Central California Fine Particulate Study. With this wide range of applications, it is highly desirable for SAQM to be computationally efficient and better documented. The latter is essential to promote SAQM as a regulatory model in California. Several versions of SAQM exist, and these versions cannot be used concurrently. The documentation and Users' Guides are also not detailed enough to meet the requirements for a regulatory model as required by ARB's Modeling Guidelines. It is desirable to modularize and parallelize the code, to generalize SAQM to work with meteorological models other than MM5, and to have the model independently reviewed.

**PREVIOUS WORK:** Under various ARB-sponsored research projects, improvements to SAQM were developed in several versions of the model. The improvements include: 1) CBM-IV or SAPRC chemistry, 2) one or two-way nesting, 3) course or fine grid resolution, 4) various numerical schemes for advection as well as chemistry solvers 5) plume-in-grid treatment, 6) surface-layer-splitting treatment, 7) aerosol chemistry, 8) tracer capabilities, 9) telescoping grid, and 10) an option for simulation 15 or 16 vertical layers.

**OBJECTIVE:** To modularize the code of the modeling program so that the aforementioned improvements can be used in a single simulation; to parallelize the code to increase its computational efficiency and to extend its applicability to the regional scale, and to document the code to meet regulatory model requirements.

**DESCRIPTION:** Various special-purpose modules would be modularized and optimized so that they could be incorporated into a more flexible framework, designed so that desired modules can be grouped easily for a given application. During this process the code for each module would be thoroughly tested and documented. After successful consolidation of the modules, a suitable strategy for parallelization would be identified. Since the most time-consuming module is the chemistry solver, it is expected that optimization and parallelization of this module alone would significantly improve the performance of SAQM.

**BENEFITS:** With the proposed improvements, staff will be able to respond to future requests to better understand ozone and particulate formation and to evaluate various emission control strategies for the SIPs.

**COST:** \$300,000.

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**TITLE:** *Development of a Meteorological Database to Support Multi-Faceted Research*

**PROBLEM:** High quality meteorological data are not available in a comprehensive and convenient database, and research concerning the relationships between meteorological conditions and air quality have suffered. Repeatedly, researchers and air quality analysts have needed to assemble meteorological data sets ad hoc; the costs of these efforts frequently consume 40-60% of a project's budget. Meteorological databases need to be prepared for the major air basins in California, starting with South Coast Air Basin (SoCAB), to promote effective and efficient research on topics such as forecasting pollutant concentrations, identifying episodes affected by "similar" meteorology, and adjusting air quality trends to remove meteorological effects.

**PREVIOUS WORK:** Most previous work in assembling meteorological data sets has been limited because of "ad hoc" goals; only the data needed for the immediate task have been gathered and the format of the data has often been difficult for others to handle. In recent years, several research contracts have included the assembly of meteorological data for the SoCAB as a major "Task". In each case, the data sets proved to be inadequate for later use by others pursuing other goals. Some efforts have been more comprehensive but remain incomplete. For example, the SCAQMD routinely archives meteorological data gathered from their network of instruments, but these data undergo little (if any) QA/QC review. The ARB also archives meteorological data from several sources, including the SoCAB, but the data are not in a convenient form for supporting important research and analysis.

**OBJECTIVE:** To create a standard database containing a comprehensive array of high quality meteorological data for the SoCAB from all routinely available sources for 1986-1997.

**DESCRIPTION:** Basic meteorological data would be gathered for the years 1986-1997 from SCAQMD, National Weather Service, ARB, and other sources such as municipal airports for locations in and around the SoCAB. The data would be quality-assured through Levels I, II, and III. Based on the quality-assured data, additional "derived" parameters, such as mixing heights and Pasquill stability classes, would be calculated. The data and derived parameters would be stored in an standard database format that would encourage the use of the database by a wide spectrum of individuals and organizations.

**BENEFITS:** Important activities such as forecasting pollutant concentrations, identifying episodes affected by "similar" meteorology, adjusting air quality trends to remove meteorological effects, and analyzing the effects of regulatory actions depend on the availability of sound methods and reliable meteorological data. These tasks and many others would benefit from the availability of the database developed under this project. The success of this project would promote the development of similar meteorological databases for other major air basins in California.

**COST:** \$100,000.

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- TITLE:** *Determination of Chemically Speciated Source Profiles Using Induction-Coupled Plasma Mass Spectrometry (ICPMS)*
- PROBLEM:** Source apportionment methods are used to estimate the relative contributions of measured species to the total observed ambient concentrations. Standard chemical analysis for particulate matter is sufficient for many cases, but it cannot resolve the contributions from sources that are similar, such as windblown dust from a dried lakebed and resuspended road dust because the chemical differences among fugitive dust source samples may be due to mineralogy, reflecting differences in the abundance of trace and rare-earth elements, or it may be a result of enrichment of the source material with exotic elements through anthropogenic processes.
- PREVIOUS WORK:** Induction-Coupled Plasma Mass Spectrometry has been used to identify specific elements (Wang et al. 1997) as well as multi-element characterization (Ahmed et al. 1993; Wang et al. 1996) in collected airborne particulate matter. The ICPMS instrument has detection limits in the 1-10 parts per trillion (ppt) range for most elements. This includes the trace elements: Li, Cs, Rb, Sr, Ba, Zr, Hf, Nb, Ta, Y, Sc, U, Th, and Pb, and the rare earths: La, Ce, Pr, Nd, Sm, Eu, Gd, Dy, Ho, Er, Tm, Yb, and Lu. However, using ICPMS to construct speciated source profiles for size segregated samples (PM10 and PM2.5) has not been reported.
- OBJECTIVE:** To develop, apply, and evaluate ICPMS as a technique for providing chemical speciation data to distinguish among different particulate matter sources. Unique and consistent patterns of chemical abundance for PM10 and PM2.5 source material determined with these methodologies would allow one fugitive dust source to be differentiated from another.
- DESCRIPTION:** In this 2-year project, typical sources of fugitive dust (e.g. playa lakes, construction sites, open vacant land, paved roads, and unpaved roads) would be sampled and analyzed using ICPMS. Approximately 50 samples, ten from each source category would be submitted for ICPMS analysis. The resulting data would be used to construct source profiles to be used in receptor modeling. For example, mobile source emissions of material from catalytic converters (e.g. platinum, palladium, rhodium, titanium, and vanadium) could be used to identify the resuspended road dust component of fugitive dust. Standard statistical methods used in the geological and air pollution sciences to differentiate compositional differences among samples would be used to identify the uniqueness of the different source profiles.
- BENEFITS:** The ability to separate the PM contribution from like sources is critical for the development and implementation of management policies and suitable control strategies. This analytical technique also has the potential for use in determining the presence and quantity of metal halides, sulfates, borates, arsenates, and other particulate toxins that can be present in ambient air samples.
- COST:** \$125,000.

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**TITLE:** *Health Effects Studies Using a Transportable Particle Concentrator*

**PROBLEM:** Particulate matter (PM) health effects mechanisms and physiologic changes need to be defined. Until recently, experimental exposures did not accurately reflect the complex mixture of pollutants that exists in the atmosphere. Using recent advances in exposure generation technology, facilities have been constructed in the eastern United States in



which pollutants can be concentrated 30-fold over ambient concentrations for both human and animal exposures. This new approach to measuring health effects shows promise for identifying health responses following pollutant exposure. However, atmospheres in the eastern U.S. do not reflect the types of exposures experienced in California because air pollution in California is different from that of other regions of the United States. A particle concentrator facility needs to be constructed and employed in California.

**PREVIOUS WORK:**

Epidemiologic studies show that PM even at ambient levels increases the risk of death or illness from cardiovascular and respiratory causes, especially among the elderly. Animal studies show that some of the components of simulated PM atmospheres can change cellular or biochemical processes of the lung. However, these animal studies and controlled human exposure studies have been unable to fully explain the observations of epidemiologic studies. Recent research conducted in the eastern United States using pollutant concentrator technology found changes in cardiac function in exposed dogs and biochemical changes in rats or guinea pigs; this technology may be able to aid in the identification of PM health effects mechanisms and physiologic changes.

**OBJECTIVE:**

To establish and operate a transportable concentrator facility to define the health effects of California PM exposures in human volunteers and animals.

**DESCRIPTION:**

It is essential that teams of investigators from various institutions collaborate in this study. One team would construct the transportable concentrator, which would include extensive air pollution monitoring capabilities, especially those needed to characterize the chemical and physical properties of particles. Because the chemistry of PM varies throughout the state, a transportable facility would permit the assessment of the different types of ambient PM in different parts of the State. Manipulation of chemical and physical properties of test atmospheres would allow assessment of alterations in toxicity. Other teams would perform health assessment studies that would include lung function assays and cardiovascular, cellular, and biochemical evaluations.

**BENEFITS:**

This research would provide unique information that would allow a new approach for assessing the effects of California PM exposures. The results would support ARB and Federal regulatory programs by providing an improved scientific basis for protecting the public health and welfare.

**COST:**

ARB funding: \$2,000,000 (\$500,000 per year for 4 years)  
Cooperative funding: \$6,000,000-\$8,000,000 (4 years)

**TITLE:**

*Particulate Air Pollution and Morbidity from Cardiovascular and Respiratory Causes*

**PROBLEM:**

Excess mortality and morbidity are associated with particle matter (PM) air pollution at concentrations commonly observed in many communities throughout the United States, including California. The elderly and those with pre-existing respiratory and cardiovascular disease appear to be most at risk. The mechanism(s) by which these effects are produced is unknown. No previous air pollution epidemiologic or human clinical studies have collected detailed cardiopulmonary clinical data in an elderly population; such a study could define the effects of different components of PM in this susceptible subgroup and yield insights into the mechanism(s).

**PREVIOUS**

A number of non-clinical epidemiologic studies, using existing data such as death or

- WORK:** hospital admission records, have been performed and have shown adverse effects associated with particulates. One animal study using exposure levels far exceeding ambient particle matter concentrations resulted in changes in cardiac function. Insufficient clinical data exist to explain the increases in mortality and morbidity from cardiopulmonary causes observed in previous epidemiologic studies.
- OBJECTIVE:** To evaluate physiologic changes resulting from short-term and long-term exposures to PM, alone and in combination with other criteria air pollutants, and to define the host characteristics that might be contributing to, or be predictive of, those changes and development/progression of cardiovascular disease in an elderly cohort.
- DESCRIPTION:** This proposed epidemiologic investigation would be ancillary to an existing National Heart, Lung, Blood Institute (NHLBI) prospective study, now in its ninth of eleven years, which is examining risk factors associated with development and progression of cardiovascular disease in a free-living elderly cohort. The proposed project would add an air pollution component to that study. The University of California, Davis (UC Davis) is the only California site of four sites participating in the NHLBI study; ARB Research Division staff would collaborate with the principal investigators at UC Davis and would be responsible for the air pollution component. To meet the objectives of this project, data from the NHLBI study and existing ambient air quality data would be used. In addition, through this proposed ancillary component, data would be collected from study participants that would allow enhanced estimates of exposure. The project is proposed for 18 months.
- BENEFITS:** This project is a very cost-effective approach to obtaining information ARB needs for its mandated review and evaluation of the California health-based ambient air quality standards for PM and other pollutants. Results from this project could also be used to guide clinical decisions and public health interventions. Information obtained from this project could be used directly to protect the health of Californians.
- COST:** \$100,000.

[About the Research Program](#)  
[Short Descriptions of the Research Projects](#)