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State of California
AIR RESOURCES BOARD

# Quarterly Report to the California Legislature on the Air Resources Board's Fine Particulate Matter Program

Third Quarter 2000

California Environmental Protection Agency
Air Resources Board

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## Executive Summary

This is the fifth in a series of quarterly reports to the Legislature on the Air Resources Board's (ARB) fine particulate (PM2.5) program required in fiscal year 1999-2000 budget language. This report provides background on ARB's particulate programs and covers ARB's recent accomplishments and planned activities in program areas including health and exposure research, air quality monitoring, emission inventory development, air quality modeling, planning, and control strategy development. This report includes activities funded through specific legislative appropriations, as well as programs funded through ARB's budget.

In this report, we provide a retrospective look at the last quarter (July through September) and a look forward at the upcoming quarter (October through December). Key activities from the third quarter include:

- In September, the Board adopted the *Proposed Risk Reduction Plan for Diesel-Fueled Engines and Vehicles*. Because of the high cancer risks posed by exposure to diesel particulate matter (PM), we recommended a comprehensive plan to further reduce PM emissions from diesel-fueled engines and vehicles. The plan builds upon existing regulations and initiatives in progress to reduce diesel PM emissions. The program includes the development of: additional regulatory emission standards for all new diesel-fueled on-road, off-road, and stationary engines and vehicles; retrofit requirements for existing diesel engines and vehicles; and requirements to reduce the sulfur content of diesel fuel. Low-sulfur fuel will enable the use of advanced diesel PM control technology to meet future emission standards. Full implementation of the plan is projected to result in a 75 percent reduction of diesel PM emissions and associated health risk by 2010 and an 85 percent reduction by 2020. In addition, reducing diesel PM emissions will result in decreased incidences of non-cancer heath effects, such as, diesel PM-induced bronchitis, and contribute to attainment of PM standards.

- In the fourth quarter of this year, we plan to embark on the development of the 2001 Statewide Control Plan that will provide ARB's long-range plan for reducing emissions that contribute to ozone, PM, and carbon monoxide pollution. The goal of the Statewide Control Plan is to further progress toward attainment of national and State ambient air quality standards across California. We will rely on the most recent emission inventories and improved air quality modeling, together with benefits of adopted controls, to define emission reduction needs. We will conduct a comprehensive assessment of emission reduction opportunities for all sources under ARB jurisdiction and coordinate with the Bureau of Automotive Repair, the Department of Pesticide Regulation and the U.S. Environmental Protection Agency (U.S. EPA) to define further strategies under their purview. The result will be potential State and national control measures and emission reduction goals for categories of sources, to satisfy both the federal and California Clean Air Acts. The plan will help integrate our efforts to attain criteria pollutant standards with our initiative for reducing health risk from air toxics. We anticipate bringing the Statewide Plan to the Board for consideration in mid 2001.

## Introduction

Particulate matter pollution is one of the most formidable air quality and public health issues facing California. Exposure to particle pollution is linked to increased frequency and severity of asthma attacks and bronchitis, and even premature death in people with existing cardiac or respiratory disease. Those most sensitive to particle pollution include people with existing respiratory and cardiac problems, children, and the elderly. Prolonged and repeated exposure can also have adverse impacts. In addition, particulate exhaust from diesel engines has been identified as a toxic air contaminant. All inhalable particles are harmful – both "coarse" particles over 2.5 microns to 10 microns in diameter and "fine" particles, those 2.5 microns or smaller.

Virtually all of California violates the State air quality standards for inhalable particulate matter less than 10 microns (PM10), which includes the subset of fine particles. Several areas, both urban and rural, also violate the federal PM10 air quality standards. In 1997, U.S. EPA promulgated new federal air quality standards for fine particulate matter 2.5 microns or less in diameter (PM2.5) to complement the existing PM10 standards. The PM2.5 standards have focused attention on understanding the nature of particle pollution and finding ways to reduce it.

Under the federal Clean Air Act, states must develop plans, known as State Implementation Plans (SIPs), describing how and when they will attain national ambient air quality standards. With ARB's technical support, the districts prepared the required PM10 SIPs. We expect PM2.5 SIPs to be due in the 2006 to 2007 timeframe. While State law does not require local districts to prepare plans for attaining the State PM10 standards, our statewide program to reduce ozone also reduces particulate levels.

The PM2.5 standards have been challenged in court by the American Trucking Association and a number of other business and industry groups. Last year, a three judge panel of the U.S. Court of Appeals for the District of Columbia returned the standards to U.S. EPA to provide a better rationale for how it selected the particular levels of the standards. In May, the Supreme Court granted a request filed by U.S. EPA and the Department of Justice to review the case. The Supreme Court has also granted a separate request from the plaintiffs to review the Court of Appeal's ruling in U.S. EPA's favor that air quality standards must be based only on health effects, not on other factors such as the economic costs of meeting the standards. The two cases will be consolidated, with arguments to be heard by the Supreme Court in November and the Court's final ruling expected sometime in 2001.

Since the inception of the Clean Air Act, U.S. EPA has used the guiding principles that air quality standards are set only on the basis of the health impacts of air pollution and that economic costs are considered in the implementation phase, when formulating policies and programs to attain the standards. We believe that U.S. EPA is correctly interpreting the Clean Air Act, and we strongly support U.S. EPA's position. In September, the California Attorney General filed an amicus brief, on behalf of a number of states, including California, supporting U.S. EPA's position. In California, we make

the same distinction between setting and implementing the State air quality standards. We only consider the economic cost of attaining the State standards when we craft implementation policies; the standards themselves are based only on the health effects of air pollution. We have also been challenged in court on this issue, and we have prevailed.

Although the federal PM2.5 standards remain in place, the U.S. Court of Appeals has prohibited U.S. EPA from implementing them. We expect that the standards will ultimately be implemented, either because U.S. EPA prevails before the Supreme Court or the agency provides the clarification requested by the Court of Appeals.

Unlike ozone, which is a single chemical compound, particulate matter is a complex mixture of many different species generated from a wide array of sources. Particulate matter can be either directly emitted into the air in forms such as dust and soot, or it can be formed in the atmosphere (like ozone) from the reaction of gaseous precursors such as nitrogen oxides (NOx), volatile organic compounds (VOCs), sulfur oxides (SOx), and ammonia. NOx and VOCs are also precursors of ozone pollution. Directly emitted particles are called "primary particles," while those formed in the atmosphere are referred to as "secondary particles." During some episodes of elevated particle levels in California, ammonium nitrate – formed secondarily from NOx and ammonia emissions – can account for over half of the PM2.5 mass. Understanding how ammonium nitrate is formed and how to effectively reduce it through controls on NOx and/or ammonia sources is a critical part of California's PM2.5 program.

Sources of ambient particulate matter include: combustion sources such as trucks and passenger cars, off-road equipment, industrial processes, residential wood burning, forest/agricultural burning; fugitive dust from roads, construction, mining, and agricultural activities; and ammonia sources such as livestock operations. In general, combustion processes form fine particles, whereas particles such as dust tend to fall in the coarse range. Diesel vehicles are a significant source of particle pollution from the motor vehicle fleet. Because ozone and particulate matter pollution are caused by many of the same sources and precursors, many of the control strategies in California's Ozone SIP – particularly NOx controls – provide dual benefits for public health by reducing particulate matter as well.

In the last decade, ARB has enhanced its technical and research program for particulate matter, building the scientific foundation for the PM10 SIPs adopted in the mid-1990s. ARB is now undertaking significant additional particulate matter work, including: health and exposure research; expanded air quality monitoring; emission inventory improvement; development of improved air quality models; and comprehensive field studies. Each of these technical areas plays an important role in developing California's SIP to address the federal PM2.5 standards and strategies to meet the state standards:

- *Health and exposure research* helps us understand both the impact of exposure to air pollutants (including who is susceptible to injury and the mechanisms of injury) as well as who is exposed, for how long, when, and where.

- *Air quality monitoring* provides information on which areas violate the standards and the nature and extent of the problem.

- *Emission inventories* provide an accounting of the sources of particulate matter emissions and the quantities of emissions produced from these sources.

- *Air quality models and data analyses* link air quality monitoring and emission inventory data with information on meteorology and atmospheric chemistry to tell us the relationship between emissions and air quality. Once we know this relationship, we can determine how much we need to reduce emissions to meet the air quality standards. We also use modeling to understand how air pollution is transported between regions. In support of our modeling efforts, we undertake extensive field studies to obtain the intensive meteorological, emissions and air quality data needed to run the models.

- *Clean air plans* describe how and when we will attain air quality standards. Plans include the technical foundation of monitoring data, emission inventories, and air quality models, as well as a control strategy for reducing emissions.

- *Control strategy development and implementation* is the critical step. Many ARB regulations provide multiple benefits. Because they reduce emissions of both ozone and PM2.5 precursors, these controls provide dual benefits for public health. In this step, we consider technical feasibility and cost-effectiveness as well as the socioeconomic and environmental impacts.

This report covers ARB's recent accomplishments and planned activities in each of these program areas. In addition, an appendix to the report contains brief summaries of ongoing research projects.

Our program to characterize and control PM2.5 is closely related to two other ARB programs: the particulate diesel exhaust risk management efforts and regional haze program. In 1998, ARB identified particulate emissions from diesel-fueled engines as a toxic air contaminant (TAC). We estimate the statewide average potential lifetime cancer risk from breathing outdoor particulate matter from diesel-fueled engines to be 540 chances in a million, which represents a significant threat to public health. We are now evaluating ways to reduce the risk associated with exposure to particulate emissions from diesel engines. These risk management efforts dovetail with existing efforts to control emissions to attain the particulate matter and ozone air quality standards.

In 1999, U.S. EPA finalized its new program to reduce the regional haze that impairs visibility in many national parks and wilderness areas. Because fine particles are a

main contributor to visibility impairment, our particulate matter control program will improve visibility as well. U.S. EPA intends to align the timelines for PM2.5 and regional haze planning so that the necessary technical work can be coordinated.

**California Regional PM10/PM2.5 Air Quality Study**

The $27 million California Regional PM10/PM2.5 Air Quality Study (CRPAQS) will provide the key technical information needed to develop PM2.5 SIPs and additional particulate reduction strategies for the San Joaquin Valley and surrounding areas. This is the largest particulate matter technical study ever undertaken. The study will enhance our fundamental understanding of mechanisms of particulate formation and transport; develop methods useful in formulating candidate control strategies for attaining PM10 and PM2.5 standards in central California; and provide means for estimating the impacts of control strategies developed for PM10/PM2.5 on visibility, air toxics, and acidic aerosols and on attainment strategies for other pollutants, notably ozone.

The start of a 14-month field program last December marks a major milestone for the study. In order to address the diversity of the particle pollution problem in central California, the field program is divided into several different elements. These include: (1) a long-term program from December 1999 through January 2001; (2) a summer field program to assess visibility in the southeast desert; (3) a fall episodic program in October and November of 2000; and (4) a winter episodic program in December and January of 2000/2001. Because different conditions and different sources lead to elevated particle levels in the fall and winter seasons, we are planning specific intensive monitoring programs targeting each season. The long-term program will characterize annual average concentrations and their causes.

The field program is being conducted over a domain extending from the Pacific Ocean on the west into the Mojave Desert on the east, and from the upper Sacramento Valley on the north to the Tehachapi Mountains in the south. The field program will provide an extensive database to support data analysis and air quality modeling for use in developing plans to attain the particulate matter standards. In addition to the monitoring program, an extensive emission inventory improvement effort is underway. The improved inventory is needed for future modeling efforts and evaluations of potential control strategies.

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- **Annual Field Program Continuing.** We are continuing the routine operations of the annual field monitoring program. The monitoring network consists of about 50 air quality monitoring sites and 13 meteorological monitoring sites. During the third quarter, CRPAQS measurements were coordinated with the Central California Ozone Study (CCOS) field program. The CCOS program builds upon the CRPAQS annual network, and provides additional air quality and meteorological measurements during the summer of 2000 to address the one- and eight-hour ozone standards in Central California.

- **Summer Field Program.** Monitoring for the summer field program ran from July 1 through September 15. The monitoring network consisted of six air quality sites, which were used to evaluate the magnitude, direction, and duration of visibility reduction along transport pathways from the San Joaquin Valley and the South Coast air basin into the southeast desert.

- **Fall and Winter Field Programs.** Contracting for additional air quality and meteorological monitoring to supplement the annual program during the fall and winter field programs continued. Twenty-five new monitoring sites were selected in the vicinity of Corcoran for the fall field program, and monitoring equipment for both the fall and winter studies was ordered. The fall field program will consist of continuous, daily sampling from October 9, 2000 through November 14, 2000. The winter field program is scheduled for December 1, 2000 through January 31, 2001. Air quality and meteorological measurements will be made continuously throughout this period, with supplemental measurements on 15 episode days (days with projected high particulate concentrations). A forecasting methodology is being developed which will be used for determining the selection of episode days for the winter program.

- **Emission Inventory Projects.** We are continuing work on several emission inventory related projects. We are developing chemical speciation profiles for key sources of organic particulate matter. These profiles will be used to correlate particulate matter samples collected in the air with contributing emission sources, which should ultimately help us effectively target our control strategy. We are also collecting improved activity data and spatial and temporal profiles of emission sources in the study area.

**Health and Exposure Research**

ARB has long recognized that particulate matter is harmful and has taken a lead in research to more clearly define how particle pollution impacts the health of Californians. Extensive research programs are underway both nationally and within California to clarify some of the uncertainties regarding who is at risk, whether a truly safe level of particulate matter can be determined, the mechanism of injury, and the role of specific components of particulate matter in producing harmful health impacts. ARB is also a leader in research on exposure to particles and their toxic components in indoor, outdoor, and in-vehicle environments. We also publish practical guidelines on how to reduce personal exposures to indoor and outdoor pollutants, including particles.

The ongoing particulate matter health and exposure studies being funded by ARB are highlighted in the appendix to this report. The following section provides updates on significant milestones from the past quarter.

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- **Vulnerable Populations Research Program.** Earlier this year, we took a major step toward implementing the Vulnerable Populations Research Program when the Board selected the University of California at Berkeley to conduct an investigation of how air pollutant concentrations at the neighborhood level impact the nature and progression of asthma in school-aged children. In September we began recruiting asthmatic children from the Fresno area for this study. Their respiratory health will be evaluated periodically over the next four years in conjunction with measurements of air pollution in the field. Intensive community, home, and school-based monitoring will be performed to produce a refined estimate of air pollution exposure for each participant. Fresno was selected as the study location because the community has a high level of childhood asthma, as well as persistent poor air quality. It is also the site of two extensive air-monitoring efforts, the California Regional PM10/PM2.5 Air Quality Study and a federal particulate matter monitoring supersite. These monitoring studies will provide baseline air quality data that will be augmented with the intensive monitoring effort described above to meet the needs of the health study.

- **Portable Classroom Study.** In August, ARB issued a Request for Proposals for a statewide study of environmental health conditions in portable classrooms. The study is part of a review being conducted jointly by ARB and the Department of Health Services (DHS). Particles, surface dust, allergens, volatile organic compounds (including formaldehyde and several other pollutants) will be measured. Building characteristics and maintenance activities will also be characterized. The study will enable ARB and DHS to: (1) assess the potential for adverse health impacts from environmental conditions and toxic pollutants that may be present in portable classrooms; and (2) identify effective actions that can be taken to remedy or prevent any unhealthful conditions found. The study is designed to meet specific milestones outlined in AB 2872 (Shelley, 2000). The study is expected to begin this fall.

## Air Quality Monitoring

California's air quality monitoring program provides information used for determining which areas violate standards, characterizing the sources that contribute to pollution, assessing pollution transport, and supporting health studies and other research. Monitoring data also provide the ultimate check on how effective our programs are – is the air quality improving? California already has a PM10 air monitoring network with over 150 monitors statewide. To assess the nature and extent of the PM2.5 problem in California, ARB and local air districts are enhancing and expanding the PM2.5 monitoring program. This effort began in 1998 and will continue for several years until our network is fully deployed. The first step in deploying this new network was the siting of PM2.5 mass monitoring equipment. We have already placed federally-approved PM2.5 mass monitors at 81 of 83 proposed sites across California.

These monitors collect particulate samples on filters, which are later weighed and analyzed in a laboratory. Because of this two step process, PM2.5 air quality data collected with these monitors are not immediately available. To provide "real-time" PM2.5 air quality information, we are adding continuous PM2.5 mass monitors to our network. These continuous PM2.5 monitors will be deployed at about 20 sites by the end of 2000, and at another 10 or so sites in 2001.

Another major stage of network implementation will be the deployment of PM2.5 speciation monitors. Speciation monitoring provides valuable information about the composition (and ultimately sources) of PM2.5 pollution. However, monitoring of the individual species that make up particulate matter is still an emerging field, with continuous speciation measurements the greatest challenge. To develop the best speciation network, California will need to take full advantage of emerging technologies – including instrumentation that is not yet commercially available. We are participating in the development of new sampling technology and critical research in this field, including special studies to evaluate newly emerging methods not currently used in routine monitoring. With previously allocated funds, we will complete the deployment of seven federally-required speciation monitors by the end of 2000. Additional speciation monitors are planned for future deployment, pending further assessment of which technologies are the most effective.

Two "supersites" -- one in Fresno and one in southern California -- complement our statewide particulate monitoring network. U.S. EPA is establishing seven supersites nationwide, which include an extensive array of monitoring equipment. Data collected at these sites will help in better understanding particle measurement technologies, source contributions, control strategies, and the health impacts of suspended particles.

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- **PM2.5 Speciation Monitoring.** There are two components to the PM2.5 speciation network in California. The first component, mandated by the U.S. EPA, requires filter-based PM2.5 speciation monitoring at seven California sites that will be part of a national trends network for PM2.5 speciation. These monitors will be the National Air Monitoring Stations (NAMS) monitors for the speciation network. We have already deployed PM2.5 speciation monitors at three of these sites, located in Fresno, Sacramento, and San Jose. Data collected at these sites will be used to support the California Regional PM10/PM2.5 Air Quality Study. We have ordered the speciation monitors for the remaining four sites (Bakersfield, El Cajon, Riverside, and Simi Valley) and expect them to be deployed by the end of 2000.

  The second component of California's PM2.5 speciation network is the selection and deployment of samplers at selected State and Local Monitoring Stations (SLAMS). Data from these sites will provide additional information needed for developing effective air quality attainment plans. The focus of the SLAMS PM2.5 speciation network will be potential nonattainment areas that do not have data

available from special studies. We propose a phased approach to the deployment of the SLAMS portion of the speciation network. The first phase will evaluate sampling technologies. While preliminary evaluations have identified promising technologies, additional study is needed before selecting monitoring technologies for the full SLAMS speciation network. Whereas the U.S. EPA is specifying the monitors to use at the seven required NAMS speciation sites, we can choose the type of monitoring technology to employ for this part of the network. We will consider both filter-based and continuous speciation samplers. As part of this evaluation, we are purchasing a number of speciation samplers employing several different sampling technologies. These advanced technology samplers include seven continuous nitrate analyzers that provide measurements of the nitrate fraction of fine particulates, one continuous carbon analyzer that measures the carbon fraction of particulate matter, one field ion chromatograph that allows continuous analysis of particulate species (such as nitrate, ammonium, and sulfate), and two aethalometers for the continuous measurement of particulate carbon. Based on the length of time required for the technologies to further develop, for field testing, and for evaluating the results, it is likely that selection and deployment of samplers in the SLAMS PM2.5 speciation network will not begin until 2001.

- **Continuous Mass Monitors.** Continuous PM2.5 mass monitors provide valuable information for public reporting, temporal representation, health studies, transport study, and background monitoring. By the end of 2001, we expect a total of about 37 continuous PM2.5 mass monitors to be deployed. We received 29 continuous Beta Attenuation Monitors (BAM) at the end of the second quarter. Despite initial problems with the monitors detected as part of our acceptance testing, the first unit was deployed to Gridley to support the agricultural smoke management program. Most of the remaining units will be deployed by the end of 2000. These monitors will support many facets of the PM2.5 program, including background monitoring, public notification, smoke management, U.S./Mexico border monitoring, and complete temporal coverage for given locations.

- **Continuous Nitrate Monitors.** We received seven continuous nitrate monitors at the end of the second quarter. Of these, five were deployed in the beginning of the third quarter to support the CCOS study. The remaining two units were deployed by the end of the third quarter in support of the CRPAQS study.

- **Other Continuous Monitors.** Other continuous monitors we have purchased include a continuous carbon analyzer, portable nephelometers (for special purpose studies), and a field ion chromatograph. In the third quarter, we received the continuous carbon monitor that we tentatively plan to deploy in the San Joaquin Valley. We expect to receive seven portable nephelometers in the fourth quarter and the field ion chromatograph in the first quarter of 2001.

- **PM2.5 Background Sites.** ARB's PM2.5 monitoring network will include three background sites, two of which are Interagency Monitoring of Protected Visual Environments (IMPROVE) sites – Point Reyes National Seashore in northern California and San Rafael Wilderness in southern California. The third site will be located on San Nicholas Island in southern California. Each site will house a continuous BAM. The two IMPROVE sites, which already have federally operated IMPROVE samplers, will also be augmented with meteorological sensors. The San Nicholas Island site, which already has the capability of measuring meteorological parameters, will also include a chemical speciation sampler.

  - Point Reyes National Seashore. Pending final approval of interagency agreements and contract awards for meteorological tower installation, we plan to begin installing the site early in the fourth quarter.

  - San Rafael Wilderness. Due to the BAM's operational requirements, we concluded the IMPROVE shelter is inadequate to house the monitor. In August, we evaluated alternative sites and found a nearby location that can be modified to accommodate the BAM and the meteorological tower. We plan to prepare the site and install the BAM in the fourth quarter.

  - San Nicholas Island. Site selection is in a preliminary stage. U.S. Navy staff has proposed a site. Pending permits and approvals, we plan to upgrade the site and install the BAM in the fourth quarter. This site will also host the chemical speciation sampler, called the "Two Week Sampler," devised by ARB.

**Emission Inventory Development**

Over the last year, ARB has embarked in a program to identify and characterize the sources of emissions of PM2.5 and its precursors. This work will lead to the development of a statewide inventory of the emissions and sources of PM2.5. The inventory will include estimates of future emissions, which consider growth and the benefits of adopted air quality programs. By accurately quantifying PM2.5 emission sources, we can better target our control strategies.

ARB's existing emission inventory includes particulate emissions estimates for directly emitted PM10. Our inventory also includes estimates for gaseous precursors, such as NOx, SOx, and VOCs. We are now incorporating emission estimates for PM2.5, as well as additional particulate precursors such as ammonia. Because PM2.5 emissions are difficult to measure and characterize, this will be a multi-year effort. By 2001, we intend to produce draft emission inventories for PM2.5 and ammonia, which can be used for identifying the most important sources of PM2.5 air pollution. These inventories are being developed in coordination with the air districts, air agencies in other states, U.S. EPA, industry, and researchers.

ARB funds a number of projects to quantify and better understand PM2.5 emissions from stationary, area, and mobile sources. These are summarized briefly in the appendix to this report.

In addition, ARB has taken over the operation of the chassis dynamometer testing facility originally managed by the Los Angeles Metropolitan Transit Authority. This facility is being used to perform both engine- and chassis-based emissions tests (including PM2.5) of heavy-duty vehicles on a regular basis. (Chassis dynamometers are treadmill-like devices that test engine-vehicle combinations. Engine dynamometers test engines that have been removed from, or are not yet installed in, vehicles.) The use of chassis dynamometers that accommodate trucks and buses will allow us to measure in-use emissions from these vehicles. Previously, we had only very limited opportunities to make these types of measurements. Data will be used to update the emission inventory.

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- **Fiscal Year 2000-2001 Research Concepts.** We have identified four priority emission inventory research projects for fiscal year 2000-2001. These include (1) measuring ammonia emissions from natural soils and natural vegetation, (2) enhancing the ARB prescribed burn and wildfire emissions model, (3) measuring hydrocarbon emissions from plants which react to form PM2.5, and (4) measuring size and chemical components of PM2.5 from diverse combustion and other sources.

- **Ongoing Research Projects.** We have developed a model to estimate biogenic emissions using geographic information systems (GIS). The model, called BEGIS, was originally designed to estimate plant emissions that contribute to ozone formation. We will be building on the concepts and structure of BEGIS to develop a GIS-based model to estimate ammonia emissions from plants.

  The inventory research projects described in the appendix are continuing to progress. In addition, we have added our projects list and description to the research database maintained by the National Research Council (NRC) Committee on Research Priorities for Airborne Particulate Matter. This database helps to share our results and to better coordinate our work with other agencies at the national level.

- **Coordination with Other Agencies.** In this quarter we joined the Interagency Confined Animal Coordination Group (ICACG), which examines the multimedia impacts of confined livestock production such as beef and dairy cattle.

  In addition, we are working with the California Energy Commission (CEC) to understand the possible air quality, water quality, and energy production impacts of using anaerobic digesters. These digesters, which could be used at dairies, produce clean burning methane gas, which could be used for electricity

generation while substantially reducing the overall pollutant emissions to air and water.

We have been invited to make presentations on our ammonia and biogenic emission inventory work at the three following workshops: the fine particulate emissions inventory workshop sponsored by the Lake Michigan Air Directors Consortium; the Western States Air Resources Council (WESTAR) technical conference on emission inventories; and the National Emission Inventory Workshop, sponsored by U.S. EPA and the Emission Inventory Improvement Program. Participating in these types of workshops allows us to keep abreast of state-of-the-science activities in emission inventory development and share the results of our work.

**Air Quality Modeling**

ARB develops air quality models and runs these models to predict how emissions, weather, and terrain influence ambient levels of pollutants, based on monitoring data, emission inventories, and atmospheric chemistry. Air quality models are also used to determine the emission reductions needed to achieve air quality standards and to evaluate the effectiveness of control strategies. Regional models are used to assess pollution transport from one area to another. These types of transport assessments are needed to ensure that necessary actions are taken in both upwind and downwind districts to meet air quality standards.

California has developed some of the most advanced photochemical models in the nation for ozone. However, the state of modeling is not as advanced for particulate matter, in part because of a lack of the extensive air quality and meteorological data needed to run modeling simulations. We are working to advance the state of particulate matter modeling for use in developing PM2.5 attainment plans and particulate matter control strategies. Data collected during the California Regional PM10/PM2.5 Air Quality Study field program will be used to evaluate and improve the performance of our meteorological and air quality models.

For attainment planning, the PM2.5 modeling analyses must show the "carrying capacity," or how many tons of emissions each affected area can hold before it exceeds the daily or annual PM2.5 standards. The carrying capacity for PM2.5 and precursors determines the type and amount of emission reductions needed from new control measures. PM2.5 models will also form the basis for regional haze models to assess the impact of our control strategies on visibility in California and in downwind states.

**Planning**

The timeline for developing PM2.5 attainment plans (SIPs) is dictated by when nonattainment areas are designated, which in turn is dictated by when sufficient PM2.5 air quality monitoring data are available. Although California had a small pre-existing PM2.5 monitoring network, no nationwide PM2.5 monitoring network or federally

approved monitor for measuring PM2.5 existed when the new federal standards were promulgated in 1997. In 1999, we began collecting PM2.5 monitoring data using the federal reference method for comparison to the standards. Three years of monitoring data are needed to designate areas as attainment or nonattainment. In addition, when U.S. EPA promulgated the PM2.5 standards, it agreed to complete its next health review of the standards prior to designating areas. That review is scheduled to be finished in 2002. Thus, we expect nonattainment areas will be designated in 2003, at the earliest. SIPs would then be due three years later – or 2006 at the earliest. In the meantime, PM10 nonattainment areas will continue implementing their PM10 SIPs. Many of the strategies in these plans reduce PM2.5 as well because PM2.5 is a part of PM10.

This schedule is still tentative – in part, due to an ongoing legal challenge to the new standards. Because the planning timelines are relatively long and deployment of the monitoring network is not being delayed, it is likely that the legal challenge will be resolved without ultimately delaying the schedule for submitting PM2.5 SIPs. Once the court case is resolved, U.S. EPA will issue guidance detailing the specific planning requirements and timelines for the PM2.5 standards.

For regional haze, U.S. EPA intends to require visibility SIPs at the same time as PM2.5 SIPs. The new regional haze regulation also provides an alternative approach for the nine states that participated in the Grand Canyon Visibility Transport Commission (including California). These states may choose to pursue an accelerated plan submittal in 2003, based on the Commission's recommendations for improving visibility at the Grand Canyon. We will coordinate with other western states to address our contribution to visibility impairment in the Grand Canyon region in 2003, and plan to address visibility concerns for national parks and wilderness areas in California in coordination with our PM2.5 SIPs in the 2006 timeframe.

**Third Quarter 2000 Update**

- **2001 Statewide Control Plan.** We are embarking on the development of the 2001 Statewide Control Plan. The plan will describe ARB's long-range plan for reducing emissions that contribute to ozone, PM, and carbon monoxide pollution. The goal of the Statewide Control Plan is to further progress toward attainment of national and State ambient air quality standards across California. The Statewide Control Plan will help integrate our efforts to attain criteria pollutant standards with some of our initiatives to reduce health risk from air toxics. For example, reducing exposure to diesel particulates will also contribute to attainment of PM standards.

  We will rely on the most recent emission inventories (including the benefits of all adopted controls) and improved air quality modeling, to define emissions reduction needs. We will conduct a comprehensive assessment of emission reduction opportunities for all sources under ARB and U.S. EPA jurisdiction (motor vehicles, off-road vehicles and equipment, fuels, the refueling process,

consumer products, etc.). At the State level we will also coordinate with the Bureau of Automotive Repair and the Department of Pesticide Regulation to define further strategies under their purview. For sources subject to federal control, we will work with the U.S. Environmental Protection Agency to identify appropriate national regulations. The result will be potential State and national control measures and emission reduction goals for categories of sources to satisfy both the federal and California Clean Air Acts.

Elements of the plan will be incorporated into upcoming SIP revisions for the South Coast Air Quality Management District in 2001 and San Joaquin Valley in 2002. The 2001 South Coast SIP will revise the PM as well as the ozone portion of the plan. We will also use strategies from the Statewide Control Plan in the ozone attainment plans for the California Clean Air Act due in 2003. Additionally, we anticipate employing the Statewide Control Plan in plans for the new federal eight-hour ozone standard (likely due in 2003 or 2004), and the PM2.5 standard (required between 2006 and 2008, pending Supreme Court action). We intend to kick off the Statewide Control Plan this fall with workshops, and anticipate bringing it to the Board for consideration in July 2001.

- **Western Regional Air Partnership Meeting in Sacramento.** On September 25, California hosted a meeting of the Western Regional Air Partnership (WRAP) in Sacramento. The primary agenda item was to ratify an update, or Annex, to the 1996 Grand Canyon Visibility Transport Commission's final report. Approved by a consortium of nine Western states, including California, the 1996 recommendations lay the foundation for a regional approach to meet national visibility goals in the Grand Canyon as well as 15 other national parks and wilderness areas in the Colorado Plateau. The Annex will serve as a regional road map for reducing SOx emissions from large stationary sources. A unique feature of the Annex is an emissions trading program that would be triggered, should voluntary measures and plant retirements be insufficient to meet negotiated SOx emission reductions in the first planning cycle between 2000 and 2018. California does not expect to participate in the trading program because its sources already meet federal requirements for controlling SOx emissions. Nevertheless, we intend to continue to honor our Grand Canyon Commission commitment to comply with federal regional haze requirements, contribute to overall improvement in regional visibility levels, and collaborate with other Western states in technical visibility plan elements.

## Control Strategy Development and Implementation

ARB develops control strategies for stationary, area, and mobile sources to reduce emissions and achieve air quality goals. The development of control strategies is based on emission inventories and modeling data, considering the need for additional reductions to meet state and federal requirements, existing controls, and technical feasibility. Control strategies are also evaluated for cost-effectiveness, and socioeconomic and environmental impacts. Our assessment of the controls needed to

attain State and federal standards will include estimating the PM2.5 benefits from current and planned control programs for PM10 and ozone.

In addition to regulations, we are pursuing emission reductions from voluntary programs, such as the Carl Moyer Program. This program provides grants for the incremental cost of cleaner trucks, buses, boats, agricultural equipment, and other diesel engines. To date, the program has been funded with one-time State budget appropriations of $25 million for FY 1998-99, $23 million for FY 1999-00 ($19 million for heavy-duty engine projects and $4 million for infrastructure and advanced technology development), and $50 million for FY 2000-01 ($45 million for heavy-duty engine projects and $5 million for infrastructure and advanced technology development). Local air districts administer the program and must provide a one dollar match for every two dollars of State funds. The program has been well-received with demand for project funding about three times the available funding. The program has been successful in accruing approximately 4 tons of NOx and 100 pounds of PM emission reductions per day with first year funding alone.

Assembly Bill 1571 (October 1999) codified the program and created the Carl Moyer Program Advisory Board (Advisory Board) to develop a report for the Governor and the Legislature on recommendations for continuing the Carl Moyer Program. In March 2000, in its report to the Legislature and the Governor, the Advisory Board recommended that the Carl Moyer program consider PM emission reductions from the overall program. The Advisory Board recommended a 25 percent PM reduction target for the statewide program, and a 25 percent PM reduction requirement for individual district programs where a district is designated as non-attainment for the federal PM standard. We have incorporated these recommendations into the proposed revisions to the Carl Moyer Program Guidelines, tentatively scheduled for public hearing in November 2000.

Efforts to develop and implement control strategies to meet particulate matter air quality standards relate closely to our efforts to characterize and manage the risk associated with toxic particulate emissions from diesel engines. An advisory committee of representatives from industry, environmental groups, government agencies, and the public is assisting with our risk management activities.

**Third Quarter 2000 Update**

- **Carl Moyer Program (Reduction of Diesel Emissions) Update.** For FY 2000-2001, the Governor made a one-time budget appropriation of $50 million ($45 million for ARB and $5 million for CEC) to continue the program for a third year.

  We are currently developing technical modifications to the Carl Moyer Program Guidelines as directed under AB 1571 (October 1999) and recommended by the Carl Moyer Program Advisory Board. The most significant proposed modifications to the guidelines include the addition of a 25 percent particulate

matter reduction target/requirement for district programs, recommendations for considering incremental fuel costs under the program, and modifications to the emission factors. The proposed modifications were released in July 2000 and presented to the public at three workshops during August 2000. A 45-day public comment period will conclude in mid September 2000. The technical modifications to the guidelines are scheduled for presentation to the Board for its review and approval in November.

All districts participating in the program were required to provide ARB with a written report documenting the status of their programs by June 30, 2000. Each district report included a summary of all the projects a district has funded with 1998-99 fiscal year funds, both project and program NOx reductions and associated cost-effectiveness. We are currently evaluating all district reports and developing a status report, which we will present to the Board in summer 2001. A second year program report is due from each participating district in late September 2000.

- **Diesel Risk Management.** In September, the Board adopted the *Proposed Risk Reduction Plan for Diesel-Fueled Engines and Vehicles* and the *Draft Risk Management Guidance for the Permitting of New Stationary Diesel-Fueled Engines.*

Because of the high cancer risks posed by exposure to diesel PM, we recommended a comprehensive plan to further reduce PM emissions from diesel-fueled engines and vehicles. The plan builds upon existing regulations and initiatives already underway to reduce diesel PM emissions. The program includes the development of: additional regulatory emission standards for all new diesel-fueled on-road, off-road, and stationary engines and vehicles; retrofit requirements for existing diesel engines and vehicles; and requirements to reduce the sulfur content of diesel fuel. Low-sulfur fuel will enable the use of advanced diesel PM control technology to meet future emission standards. Full implementation of the proposed plan is projected to result in a 75 percent reduction of diesel PM emissions and associated health risk by 2010 and an 85 percent reduction by 2020. In addition, reducing diesel PM emissions will result in decreased incidences of non-cancer heath effects, such as diesel PM-induced bronchitis, increased visibility, and contribute to attainment of the PM standards.

The risk management guidance will assist local air districts in making risk management decisions associated with the permitting of new stationary diesel-fueled engines. In the guidance, we suggest two control options, compliance with either diesel PM exhaust performance standards or minimum technology requirements. We also recommend districts conduct site-specific risk assessment before issuing permits for engines that operate extended hours. As part of our comprehensive plan to reduce risk from diesel engines, we are

proposing the development of a statewide air toxic control measure for new engines based on this guidance.

- **Lower Emission School Bus Program.** In the FY 2000-2001 State budget, Governor Davis included $50 million for a lower emission school bus program. The program will be a cooperative effort between the California Energy Commission, ARB, and the air districts. The California Highway Patrol and the State Department of Education are also participating in program development. This program will provide funds to school districts for purchase of new low-emission school buses and fueling infrastructure, and for installation of PM retrofits on existing diesel school buses. We are preparing guidelines for use of the funds and will present them to our Board for consideration in December 2000. The funds will be available to all school districts in the State. The primary purpose of replacing and retrofitting California's high-emitting older school buses is to reduce children's exposure to airborne toxic emissions, specifically diesel particulate matter. There are over 24,000 Type 1 and 2 school buses in California - about 4,300 of which were built before 1987 and 2,300 of which were built before 1977. These buses do not meet the current more stringent engine emission standards. Thus older school buses emit as much as three times more oxides of nitrogen and ten times more PM than current low-emission buses fueled with compressed natural gas. Replacing or retrofitting these buses and providing necessary fueling infrastructure will result in ambient air quality improvements and reduced direct exposure to toxic air contaminants. Because school districts have very limited funds available, we expect that the program will cover the majority of the new bus cost, and all of the retrofit cost. Two workshops were held in September to discuss the proposed guidelines and significant outreach efforts to school districts is planned.

- **Rice Straw Conditional Burn Regulation.** On September 28, the Board approved the proposed rice straw conditional burn permit regulation that defines how farmers verify disease infestation to obtain a permit to burn rice straw despite Legislative ban. This regulation is meant to reduce the impacts of smoke from rice burning (particulate matter is a significant component of smoke). State law requires that, beginning in September 2001, Sacramento Valley air districts may grant rice straw burning permits only if the county agricultural commissioner finds that a farmer's rice fields are likely to experience quantifiable and significant reduction in yield resulting from rice disease.

- **Heavy-Duty Vehicle Roadside Inspection Program.** Under the Heavy-Duty Vehicle Inspection Program, inspectors conduct random roadside tests of diesel trucks to ensure that smoke emissions are within acceptable levels and that emission control devices have not been tampered with. Owners of failing vehicles are issued citations and required to make repairs. Through the end of August, we have inspected close to 47,000 vehicles since the program was restarted in June 1998 (with over 8,000 inspections since our last report). The inspections have resulted in more than 2,600 citations and more than 800

non-penalty "fix-it" tickets. The failure rate has decreased from 11 percent when the program was first restarted to a current 7.4 percent. More than 2,400 trucks and buses have been repaired to date. We have instituted a formal program to pursue those owners who are delinquent in clearing their citations in order to ensure that repairs are made. Industry acceptance of the program is good, as indicated by the low rate of citation appeals – two percent. The penalties that we collect though the inspection program are recycled back to the industry in the form of incentive programs that promote cleaner heavy-duty engines.

- **Periodic Self-Inspection Program.** The Periodic Smoke Inspection Program requires all California fleets with two or more trucks or buses to perform annual smoke and anti-tampering inspections and repair failing vehicles. The first annual self-inspections of heavy-duty diesel-powered vehicle fleets had to be completed by October 1, 1999. Through the end of August, we have conducted nearly 3,400 fleet audits and found a compliance rate of 50 percent. We are working with owners of non-complying fleets to bring their fleets into compliance.

# Appendix

## Summary of Ongoing Particulate Matter Research Projects

### Health Effects and Exposure Research Projects

- **Children's Health Study:** This major epidemiological study follows the lung development and respiratory health of approximately 5,000 school children from 12 southern California communities in 4$^{th}$ through 12$^{th}$ grades. The study will continue through 2003.

- **Cardiovascular Health Study:** This study evaluates how air pollution, including particulate matter, impacts the well-being of a group of elderly people, especially as related to their cardiac health status.

- **Health Impacts of Smoke:** This study evaluates the respiratory health impacts experienced when people breathe smoke from burning such common materials as rice straw, wood wastes, and wood used to heat homes.

- **Toxicological Studies of Particles:** Studies are underway in which rats are exposed to synthetic components of ambient particulate matter. These studies are evaluating cellular and tissue responses to these components, and how factors such as animal age and particle size affect observations. We hope this research will provide information on the physiological mechanisms that produce the adverse impacts observed in community health studies.

- **Kaiser Hospital Study:** This is a study of how air pollutants impact the rates of hospitalization in the Kaiser Hospitals located in the Central Valley. This study should help clarify the role that particulate matter plays in cardiovascular and respiratory illness in the region.

- **Vulnerable Populations Research Program:** We are currently planning several studies as part of our vulnerable populations health research initiative. The focus of this program is to determine how air pollution, including particulate matter, impacts health, and how environmental and individual health, lifestyle, and socioeconomic factors effect sensitivity to air pollution. The initial research efforts include a study of how children with asthma respond to air pollution. We recently contracted with the University of California at Berkeley to conduct this study and have begun recruiting participants. The study will be performed in Fresno, which has a persistent and complex particulate air pollution problem and a high rate of asthma. This study is being coordinated with major particulate air pollution monitoring efforts in the Fresno area.

- **Residential Indoor Cooking Exposures Study:** This is the most comprehensive study of cook and occupant exposures to indoor PM2.5, PM10,

ultrafine particles, and gaseous co-pollutants during residential cooking. We will use the data from this study to improve exposure estimates and to further explore the correlation between elevated personal exposure levels and cooking activities seen in previous studies. The data will also be used to provide guidance to the public on reducing their pollutant exposure.

- **Sources of Personal, Indoor, and Outdoor PM Exposures of Chronic Obstructive Pulmonary Disease Patients:** The main objective of this study is to quantify the contribution of outdoor air to indoor and personal PM2.5 exposure levels. Results of this study will enable us to better understand the link between outdoor PM2.5 and the health effects seen in sensitive individuals.

- **Exposure Model Enhancement:** This project will enhance the capabilities and accessibility of a model to estimate total exposure to particles and other air pollutants from all microenvironments – indoor and outdoor. The model is based on California data for pollutant concentrations, building ventilation, and human activity patterns. We will use the model to more accurately estimate Californians' exposures to particles, including toxic components such as diesel particles and metals. We can also use it to evaluate the effectiveness of different risk reduction strategies.

**Air Quality Monitoring/Atmospheric Processes Research Projects**

- **Biological Fingerprinting for Dust Sources:** Source apportionment models are used to relate monitored particulate species back to emission sources. Work is underway to explore the use of biochemical markers (such as fatty acids and microbial DNA) to distinguish among soil sources of airborne dust and to test these markers in source apportionment for fugitive dust. If we can distinguish the specific source of dust contributing to elevated particle levels, we can more effectively target controls to reduce emissions.

- **Remote Sensing of Ammonia:** Measuring ammonia emissions – both from sources and in ambient air – is technologically challenging. Using an advanced remote sensing device, ammonia emissions from complex sources, such as cattle feedlots or fertilized fields, can be more completely characterized. In addition, ammonia can be present in significant concentrations several hundred meters above the surface. With this ground-based remote sensing lidar technology, ammonia concentrations aloft can be measured. This technique will be used during the California Regional PM10/PM2.5 Air Quality Study.

- **Comparison of Particulate Matter Concentrations on Weekdays and Weekends:** We are analyzing particle concentrations by day of the week to see if there are any consistent variations in concentrations between weekdays and weekends. Because of the contribution of NOx and VOC precursors to secondary particle formation, we are also analyzing whether the variations by day of week in these precursors are evident in ambient particle levels.

## Emission Inventory Development Projects

- **Ammonia Emissions From Fertilizer Application and Soils:** Working closely with the agricultural community, this project will apply various ammonia-based fertilizers to different soil and crop types in the San Joaquin Valley. The ammonia emissions that result from the fertilizer application will be quantified, and the data used to generate regional and seasonal estimates of fertilizer related ammonia emissions.

- **Commercial Charbroiling and Deep-Fat Frying Operations:** The results of this project will allow us to estimate regional and statewide particulate emissions resulting from commercial charbroiling and deep-fat frying based on the number and location of these sources, and estimates of the quantities of food cooked.

- **Dust Emissions From Vehicle Travel Over Paved Roads:** This project will use a vehicle instrumented with real-time particulate measuring devices to develop more accurate estimates of dust from vehicular travel on paved roads. This information will help provide an understanding of what activities lead to high road dust emission rates and what can be done to reduce them.

- **Emissions From Wildland Fires:** This project will provide a consistent, statewide method for estimating smoke emissions from wildland fires, incorporating satellite data, geographic vegetation data, fire modeling, and other available information. The work is being closely coordinated with staff from the California Department of Forestry and the U.S. Forest Service to take full advantage of the wildland burning expertise these agencies possess.

- **Vehicle Travel on Unpaved Roads:** This project will provide better estimates of vehicle activity on unpaved roads within California. This information will help to correct deficiencies in how unpaved road dust estimates are currently calculated and will aid in producing more effective dust control strategies.

- **Evaluation of Geologic Dust Near Emission Sources:** Based on analysis of ambient air, it appears that existing estimates of particulate matter emissions from dust sources may be too large. This project will explore how the dust from sources such as unpaved roads and agricultural fields travels in the air and how long it stays suspended. This work will help us better understand the contribution of dust sources to regional particulate levels.

- **Emissions from Wood-Burning Stoves and Fireplaces:** This project will develop better estimates of particle and precursor emissions from woodstoves and fireplaces by improving our understanding of when and where these emissions occur.

- **Emissions from Agricultural Burning:** This project will evaluate and improve the methods used in California to estimate particulate and other emissions from burning prunings and other agricultural residues. This work will be coordinated with industry representatives and burn managers to help us better quantify the impacts of agricultural burning.

- **Ammonia Measurement Instrumentation:** This project will develop instrumentation that will allow characterization of ammonia plumes in near real-time. The results of the project will ultimately help to evaluate ammonia emission levels from sources that are difficult to measure using standard techniques and determine how to best reduce ammonia levels if needed.

- **Testing for Exhaust Emissions of Diesel Powered Off-Road Engines:** This project will develop test cycles for off-road equipment based on real world activity and use. In this project, a variety of diesel powered equipment will be instrumented to record their activity in the field. Based on the measured in-use activity parameters such as engine speed and torque collected during this task, an appropriate emissions testing cycle will be determined. Engines from the in-use equipment will be removed and tested for Reactive Organic Gas, NOx, and particulate matter.

- **Duty-Cycle Development and Emission Testing of Personal Watercraft:** The objectives of the project are to: (1) instrument personal watercraft that are representative of the in-use fleet in California and collect in-use activity data; (2) derive a real-world emissions test cycle; and (3) perform emissions tests (including particulate matter) using the cycle developed during this study.

- **Particulate Emissions from Marine Outboard Engines, Personal Watercraft, and Small Off-Road Equipment:** The purpose of this contract is to: (1) develop a sampling methodology for measuring PM emissions from outboard marine and personal watercraft engines; (2) measure PM (including PM2.5) and polycyclic aromatic hydrocarbon (PAH) levels from outboard marine, personal watercraft, and two-stroke, small off-road engines; and (3) determine particle size distribution and mutagenic toxicity of PM from these engines.

- **Emissions Testing of Low-Emitting Two-Stroke Utility Engines for Criteria Pollutants, PM10 and PM2.5:** During this project, low-emitting, two-stroke engines will be tested in a brand new condition and after several hours of usage in order to evaluate how emissions change with usage. Testing will include the measurement of particulate matter and other criteria pollutants.

- **Characterization of Particulate Matter Emissions from Motor Vehicles:** In November 1999, we began an 18-month study to measure ambient emissions of ultrafine particles (less than 0.1 microns) and nanoparticles (less than 0.05 microns) from motor vehicles. Measurements will be made on and near roadways where concentrations are expected to be highest. Both the physical

and chemical attributes of particulate matter emissions from gasoline and diesel vehicles will be characterized, with an emphasis on ultrafine and nanoparticles.

- **Heavy-Duty Vehicle Chassis Dynamometer Testing at Los Angeles Metropolitan Transit Authority (MTA) Facility:** ARB has taken over the heavy-duty vehicle chassis dynamometer testing facility originally managed by the MTA. This facility will be used to perform both engine- and chassis-based emissions tests (including PM2.5) of heavy-duty vehicles on a regular basis. Data will be used to update the emissions inventory.

- **Ammonia Emissions from Motor Vehicles**: We are investigating ammonia in motor vehicle exhaust as a significant contributor to secondary pollutant formations. Ammonia is suspected to be formed as by-product of catalytic combustion in vehicles.

**Air Quality Modeling Research Projects**

- **Particulate Matter Modeling Improvements:** We are currently evaluating potential particulate matter models using data collected during a 1995 field study in central California. We have applied ARB's urban airshed model to simulate a January 1995 episode and found limitations in the model's ability to accurately simulate the formation of secondary organic particles. We have already started a research contract to address this issue. We are also planning a collaborative project with the University of California at Davis to improve the way we model chemical reactions in the atmosphere and to make other improvements to the model. In the near future, we will evaluate the same episode with an updated version of the model.

- **Atmospheric Model Development:** This research project is to develop the next generation of models to better simulate the atmospheric reactions among precursors that form secondary particles. The model will include, for the first time, treatment of inorganic and organic constituents simultaneously. This research is crucial to our ability to model both the inorganic and organic fractions of PM2.5 and, therefore, to construct comprehensive photochemical models for attainment plans.

**Control Strategy Development and Implementation**

- **Evaluation of Technologies to Meet Future Diesel Off-Road Engine Emission Standards:** The purpose of this project is to evaluate potential technologies that could be used to meet future lower NOx and PM emissions standards for diesel off-road engines.