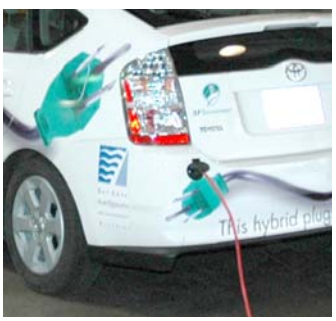
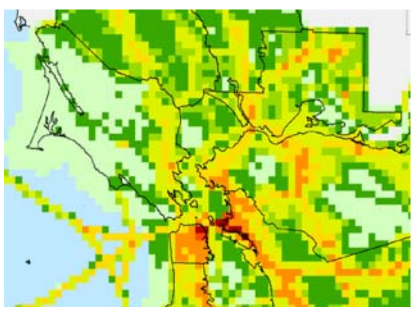
Bay Area Air Quality Management District

Bay Area 2010 Clean Air Plan





Final Clean Air Plan - Volume I

Adopted September 15, 2010

Association of Bay Area Governments

bcdc

Metropolitan Transportation Commission

Final
BAY AREA
2010 CLEAN AIR PLAN

Adopted September 15, 2010

BAY AREA
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Bay Area 2010 Clean Air Plan

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Acronyms and Terms

ABAG	Association of Bay Area Governments
ARB	(California) Air Resources Board
ATCM	Airborne Toxic Control Measure
BAAQMD	Bay Area Air Quality Management District
BACM	Best Available Control Measures
BACT	Best Available Control Technology
BAR	Bureau of Automotive Repair
BARCT	Best Available Retrofit Control Technology
BART	Bay Area Rapid Transit District
BCDC	Bay Conservation & Development Commission
CAA	(Federal) Clean Air Act
CAP	Clean Air Plan (for State ozone standard)
CAPCOA	California Air Pollution Officers Association
CARB	California Air Resources Board
CARE	Community Air Risk Evaluation program
CCAA	California Clean Air Act
CCOS	Central California Ozone Study
CEQA	California Environmental Quality Act
CMA	Congestion Management Agency
CMAQ	Congestion Management and Air Quality (Improvement Program)
CMP	Congestion Management Program
CO	Carbon Monoxide
CO_2	Carbon Dioxide
ECM	Energy & Climate Measure
EIR	Environmental Impact Report
EMFAC	CARB model (including emission factors) to calculate motor vehicle emissions
EPA	(United States) Environmental Protection Agency
EPDC	Expected Peak Day Concentration
FSM	Further Study Measure
GHG	Greenhouse Gas
HOV	High-Occupancy Vehicle
I & M	(Motor Vehicle) Inspection and Maintenance Program ("Smog Check")

ISR	Indirect Source Review
JPC	Joint Policy Committee
LEV	Low Emission Vehicle
LUM	Land Use & Local Impact Measure
MSM	Mobile Source Measure
MTC	Metropolitan Transportation Commission
NAAQS	National Ambient Air Quality Standards
NH3	Ammonia
NO_x	Oxides of Nitrogen
NSR	New Source Review
O_3	Ozone
OBD	On-Board Diagnostic program
$PM_{2.5}$	Particulate Matter less than 2.5 microns in diameter
PM_{10}	Particulate Matter less than 10 microns in diameter
ppb	Parts per billion
pphm	Parts per hundred million
ppm	Parts per million
RACM	Reasonably Available Control Measure
RFP	Reasonable Further Progress
ROG	Reactive Organic Gases
RTP	Regional Transportation Plan
SIP	State Implementation Plan
SSM	Stationary Source Measure
TAC	Toxic Air Contaminant
TCMs	Transportation Control Measures
TDA	Transportation Development Act
TFCA	(BAAQMD) Transportation Fund for Clean Air
TIP	Transportation Improvement Program
TLC	(MTC) Transportation for Livable Communities Program
tpd	Tons per day
VMT	Vehicle Miles Traveled
VOC	Volatile organic compounds
ZEV	Zero Emission Vehicle

Executive Summary – Bay Area 2010 Clean Air Plan

Purpose of the CAP

The Bay Area 2010 Clean Air Plan (CAP) provides a comprehensive plan to improve Bay Area air quality and protect public health. The 2010 CAP has been prepared in close collaboration with the Air District's regional agency partners, and has been informed by extensive outreach to the public and interested stakeholders.

The CAP defines a control strategy that the Air District and its partners will implement to: (1) reduce emissions and decrease ambient concentrations of harmful pollutants; (2) safeguard public health by reducing exposure to air pollutants that pose the greatest health risk, with an emphasis on protecting the communities most heavily impacted by air pollution; and (3) reduce greenhouse gas (GHG) emissions to protect the climate.

The legal impetus for the CAP is to update the most recent ozone plan, the Bay Area 2005 Ozone Strategy, to comply with state air quality planning requirements as codified in the California Health & Safety Code. Although we have made steady progress in reducing ozone levels in the Bay Area, the region is designated as non-attainment for both the one-hour and eight-hour state ozone standards. In addition, emissions of ozone precursors in the Bay Area contribute to air quality problems in neighboring air basins. Under these circumstances, state law requires the CAP to include all feasible measures to reduce emissions of ozone precursors and to reduce transport of ozone precursors to neighboring air basins.

The Bay Area was recently designated as non-attainment for the national 24-hour fine particulate matter (PM2.5) standard, and will be required to prepare a PM2.5 State Implementation Plan (SIP) pursuant to federal air quality guidelines by December 2012. The 2010 CAP is not a SIP document and does not respond to federal requirements for PM2.5 or ozone planning. However, in anticipation of future PM2.5 planning requirements, the CAP control strategy also aims to reduce PM emissions and concentrations. In addition, U.S. EPA is currently reevaluating national ozone standards, and is likely to tighten those standards in the near future. The control measures in the CAP will also help in the Bay Area's continuing effort to attain national ozone standards.

A Multi-Pollutant Plan

In addition to updating the Bay Area's state ozone plan, the 2010 CAP will also serve as a multi-pollutant plan to protect public health and the climate. This effort to develop its first-ever multi-pollutant air quality plan is a voluntary initiative by the Air District. The Air District believes that an integrated and comprehensive approach to planning is critical to respond to air quality and climate protection challenges in the years ahead. In its dual roles as an update to our state ozone plan and a multi-pollutant plan, the 2010 CAP addresses four categories of pollutants:

- Ground-level ozone and its key precursors, ROG and NOx;
- Particulate matter: primary PM2.5, as well as precursors to secondary PM2.5;
- Air toxics; and
- Greenhouse gases.

The major purpose for developing a multi-pollutant plan is to achieve the greatest possible public health benefit by reducing emissions, ambient concentrations, and public exposure across the four categories of air pollutants addressed in the 2010 CAP. In developing the CAP control strategy, the Air District has attempted to maximize co-benefits, while at the same time minimizing any potential trade-offs among pollutants.

Evaluating control measures on the basis of their potential to reduce multiple pollutants is complex, and little guidance or precedent is currently available. To address this issue, the Air District developed a Multi-Pollutant Evaluation Method (MPEM) which integrates the three core goals of the 2010 CAP: improving air quality, protecting public health, and protecting our climate. The MPEM analyzes how a given reduction (or increase) in emissions of each pollutant will affect ambient concentrations, population exposure, and health effects related to that pollutant. The MPEM then aggregates the impacts of each control measure on a multi-pollutant basis. Finally, the MPEM monetizes the value of the health and climate protection benefits for each control measure and expresses these benefits in dollar terms, in order to facilitate comparison of the relative benefit of the various control measures.

CAP Control Strategy

The proposed 2010 CAP control strategy builds on a solid foundation established by the 2005 Ozone Strategy, and previous ozone plans prepared in the 1991 to 2005 period. But the 2010 CAP also moves in new directions to address emerging challenges and opportunities. The 2010 CAP control strategy includes revised, updated, and new measures in the three traditional control measure categories: Stationary Source Measures, Mobile Source Measures, and Transportation Control Measures. In addition, the CAP identifies two new categories of control measures: Land Use and Local Impact Measures, and Energy and Climate Measures.

The draft control strategy proposes a total of 55 control measures, including:

- 18 Stationary Source Measures;
- 10 Mobile Source Measures;
- 17 Transportation Control Measures;
- 6 Land Use and Local Impact Measures; and
- 4 Energy and Climate Measures.

The 2010 CAP also describes 18 Further Study Measures, which will be further evaluated as potential control measures. In addition, the CAP includes a Leadership Platform. The Leadership Platform is intended to complement the control strategy by identifying policies and actions, such as legislation or adoption of regulations by other agencies, which will support or enhance the control measures identified in the CAP.

In sum, the Bay Area 2010 CAP provides a control strategy designed to:

- reduce emissions of ozone precursors, PM, air toxics, and greenhouse gases;
- continue progress toward attainment of state ozone standards;
- reduce transport of ozone precursors to neighboring air basins;
- protect public health by reducing population exposure to the most harmful air pollutants; and
- protect the climate.

Key Findings

In preparing the 2010 CAP, Air District staff analyzed air pollutant trends and the health risks associated with past levels and current levels of air pollution. Key findings of this analysis for the Bay Area can be summarized as follows:

- Bay Area air quality has improved significantly in recent decades. Ambient concentrations of - and population exposure to - harmful air pollutants, including ozone, PM, and air toxics, have all been greatly reduced.

- The improvement in air quality in recent decades has greatly reduced health effects related to air pollution.

- Premature deaths related to air pollution have declined by several thousand per year, from approximately 6,400 per year in the late 1980's to approximately 2,800 per year in 2008.

- The estimated lifetime cancer risk (over a 70-year lifespan) from all toxic air contaminants combined declined by 70 percent between 1990 and 2008, from approximately 1,330 cases per million people to approximately 405 cases per million.

- The improvement in air quality has extended average life expectancy in the Bay Area by approximately 6 months over the past two decades.

- In economic terms, the public health dividend of the improvement in air quality provides billions of dollars in benefits to the Bay Area each year.

Despite this progress, air pollution still has negative health impacts for many Bay Area residents. These effects include acute and chronic respiratory problems, asthma, cardiovascular effects, and premature mortality.

- Exposure to PM2.5 is by far the leading public health risk from air pollution in the Bay Area, accounting for more than 90% of premature mortality related to air pollution.

- Implementation of the proposed control measures in the 2010 CAP should result in approximately 85 fewer premature deaths per year in the Bay Area.

- Implementation of the proposed control measures in the 2010 CAP will, collectively, provide benefits with a monetary value in the range of $270 million to $1.5 billion per year, with a likely value on the order of $770 million per year, in terms of reduced medical costs, increased life expectancy, and reduced impacts of climate change.

- Roughly 80% of the estimated economic benefits from the CAP control measures can be attributed to reductions in PM2.5 (66% non-diesel PM2.5 and 14% diesel PM2.5). Reductions in greenhouse gases account for approximately 20% of the economic benefits.

- Although emissions and ambient concentrations of criteria pollutants and air toxics have been declining in the Bay Area, emissions and concentrations of greenhouse gases have been increasing in the Bay Area and elsewhere.

- Climate change due to increased emissions and concentrations of greenhouse gases is expected to result in an increase in the number of high heat days and wildfires in the Bay Area and adjacent areas. These impacts are likely to exacerbate air pollution and complicate efforts to attain air quality standards for ozone and PM.

- The control measures in the CAP will reduce emissions of greenhouse gases. Some CAP measures will directly reduce GHG emissions; many other measures will provide GHG reductions as a co-benefit.

- To provide a comprehensive plan that addresses multiple pollutants and protects public health and the climate, new types of control measures, such as the Land Use and Local Impact Measures and the Energy and Climate Measures, have been incorporated in the 2010 CAP control strategy.

Looking Forward

The 2010 CAP moves the Bay Area toward a new approach to air quality planning. The key goals defined in the CAP are to protect air quality, public health, and the climate. Despite impressive progress in improving Bay Area air quality in recent decades, we face significant challenges as we strive to achieve these goals in the future. The challenges include tighter air quality standards, limited resources, the dearth of new "low-hanging fruit" in terms of emissions control programs, future economic and population growth in the region, and the potential impacts of climate change and higher temperatures on air quality.

Under these circumstances, the multi-pollutant framework can provide a means to evaluate and balance competing objectives, maximize co-benefits from control strategies, improve the cost-effectiveness of programs to reduce emissions of criteria pollutants and greenhouse gases, and optimize the use of limited resources by the Air District, its partner agencies, and the regulated community.

Looking forward, the Air District will continue its efforts to achieve the CAP goals and to build its multi-pollutant planning capacity by:

- Developing an integrated emissions inventory that includes all pollutants;
- Developing an integrated air quality modeling platform;
- Enhancing the Multi-Pollutant Evaluation Method developed for the 2010 CAP to include a wider range of pollutants and health effects;
- Enhancing its capacities to measure and analyze ambient concentrations and population exposure in impacted communities;
- Developing better measurements of population exposure to pollutants on a region-wide basis;
- Evaluating the potential benefits, and considering the policy and technical issues, related to extending the risk-weighted multi-pollutant approach to programs such as stationary source permitting and New Source Review; and
- Better integrating strategies to reduce criteria pollutants and greenhouse gases.

The Air District elected to develop the 2010 CAP as a multi-pollutant plan as a matter of choice. However, future challenges are likely to make multi-pollutant planning a necessity in years to come. In addition to serving as a blueprint for the Bay Area, the Air District offers the 2010 CAP as an example of a multi-pollutant plan that other agencies can build upon to advance this concept.

Bay Area 2010 Clean Air Plan – Framing the Challenge

Protecting air quality in the San Francisco Bay Area air basin[1] is the core mission of the Bay Area Air Quality Management District (Air District). Clean air is fundamental to public health and to the high quality of life that makes the Bay Area a desirable place to live, work, and visit. In addition, good air quality:

- Supports healthy ecosystems, diverse flora and fauna, and productive agriculture;
- Provides economic benefits by stimulating human productivity, reducing health care costs, enhancing property values, and helping to attract investment and tourism; and
- Enhances the natural beauty of the Bay Area.

Despite the importance of good air quality, the fact is that we all breathe air pollution every day. There are millions of emissions sources in the Bay Area – oil refineries, manufacturers, dry cleaners, cars and trucks, construction equipment, lawn mowers, fireplaces, wood stoves, consumer products, and many other sources – that collectively emit many different types of air pollutants. And there are millions of receptors: all of us – children, teens, adults, and seniors - who inhale these emissions. Air pollution has a wide range of negative impacts on public health. Exposure to air pollutants can damage the pulmonary and cardio-vascular systems, and may cause or contribute to both acute and chronic health effects including bronchitis, asthma, stroke, and heart attack.

In an urban environment it is impossible to completely eliminate air pollution. But through a combination of strong laws, good planning, improved technology, strategic partnerships, and voluntary actions, we can greatly reduce air pollution and its negative impacts on public health and ecosystems.

Although we have made tremendous progress in improving air quality, today we face new challenges related to emissions of carbon dioxide (CO2) and other greenhouse gases (GHGs) that contribute to climate change.[2] Climate change presents many environmental and economic challenges for the Bay Area, not least of which is that it threatens to degrade air quality.

The air we breathe and the climate that supports us have no natural defenses. Just as we all deserve to breathe clean air, we all need to be part of the solution to protect our air quality and climate. We still have a great deal of work to do to improve Bay Area air

[1] The San Francisco Bay Area air basin consists of all of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo and Santa Clara counties, and the southern portions of Solano and Sonoma counties.

[2] In the CAP, the term "climate change" is used in lieu of "global warming."

quality and protect the climate. But to put our challenges in perspective, it is important to first recognize that we have made great strides in reducing air pollution in the Bay Area.

Achievements

Air quality control is an incremental proposition - a marathon, not a sprint. The regulations and plans that the Air District and its partners have developed and implemented over the past several decades have served the region well, enabling us to make steady progress in improving air quality. Over the past 40 years, the Bay Area has made great strides in reducing emissions of air pollutants, as well as the health impacts related to public exposure to air pollutants. We have been able to accomplish this even as the region's population, vehicle fleet, vehicle miles of travel (VMT), and economic output have all increased sharply.

Nearly 40 years have passed since Congress adopted the federal Clean Air Act (CAA) of 1970. The CAA led to the establishment of standards for ambient concentrations of six "criteria" air pollutants: ozone (O3), carbon monoxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), lead, and particulate matter (PM).[3] Today, outdoor air in the Bay Area is much cleaner than it was 40 years ago. Air quality monitoring data shows that concentrations of each of the six criteria pollutants in the air we breathe have all been reduced by more than half in the Bay Area since the CAA was enacted.[4]

In 1970, the Bay Area frequently violated standards for ozone, particulate matter, carbon monoxide and lead, and violations often exceeded the standards by a wide margin. Thanks to aggressive state and regional regulatory programs for both stationary and mobile sources of emissions,[5] the Bay Area meets, or is close to meeting, current national air quality standards. In fact, for four of the six criteria pollutants - lead, carbon monoxide, sulfur dioxide, and nitrogen dioxide - the Bay Area is well below all existing standards. However, the Bay Area does not yet attain national ozone and PM2.5 standards, or the more stringent California standards for particulate matter and ozone. In addition to reducing ambient levels of criteria air pollutants, great progress has been made in reducing emissions of, and exposure to, toxic air contaminants. Although the effort is by no means complete, progress in improving Bay Area air quality has been impressive.

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[3] The 1970 Clean Air Act identified six pollutants – ozone, PM, carbon monoxide, nitrogen dioxide, sulfur dioxide, and lead – as being particularly dangerous. It mandated that each be regulated based on concentration standards. These standards were based upon "criteria documents" – compendia of scientific information on the formation, concentrations, distribution, and health effects of the pollutants. Hence, these are referred to as "criteria pollutants."

[4] See Chapter 2 for more detailed data regarding Bay Area attainment status and air quality trends.

[5] In California, vehicle emission standards and fuel standards are established by the Air Resources Board.

So what does this improvement in air quality mean in terms of reducing health impacts related to air pollution? To answer this question, Air District staff performed an analysis to compare air pollution levels and population exposure from earlier decades to the pollution levels that prevail today, using the best available air quality monitoring data. The analysis then estimated how the improvement in air quality translates into reductions in key health impacts and the economic benefit of reducing these health impacts. The results of this analysis, summarized below, are presented in greater detail in Appendix A.

The analysis found significant reductions in each of the seven health impacts analyzed.[6] In economic terms, we estimate that improved Bay Area air quality provides health benefits with a value on the order of $25 billion per year. The benefit of the reduction in our health burden is most dramatic in relation to mortality; i.e., the reduction in the number of deaths caused by or related to air pollution. Premature mortality related to air pollution has decreased from approximately 6,400 per year in the late 1980's to approximately 2,800 per year in 2008. Also, the estimated lifetime cancer risk in the Bay Area from exposure to airborne toxics has been reduced by 70 percent from 1990 to 2008.

The reduction in mortality risk can be expressed in terms of increased life expectancy. Overall, due to a variety of factors including improved health care, reduced smoking, and cleaner air, Bay Area life expectancy has increased significantly in recent years. Data shows that Bay Area life expectancy has increased by almost 5 years, from 75.7 years in 1990 to 80.5 in 2006. Of the 5-year increase in life expectancy during this period, we estimate that improved air quality can be credited with extending average life expectancy in the Bay Area by 6 months.[7] Thus, the Air District analysis suggests that approximately 10% of the improvement in Bay Area average life expectancy over the 1990-2006 period can be attributed to cleaner air.

This is very good news, indeed. The bad news, however, is that current levels of air pollution in the Bay Area still cause or contribute to several thousand deaths and billions of dollars in health costs and social costs each year. We estimate that there are approximately 2,800 premature deaths in the Bay Area per year related to current air pollution levels, and that the vast majority of these deaths - more than 90% - are related to exposure to fine particulate matter (PM2.5).[8]

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[6] The health impacts included asthma emergency room visits, respiratory hospital admissions, cardio-vascular hospital admissions, chronic bronchitis, non-fatal heart attacks, cancer onset, and mortality.

[7] A recent study that looked at the benefits of reducing PM in 51 metro areas across the US found a direct correlation between reductions in PM concentrations and increased life expectancy. See Pope et al. "Fine Particulate Air Pollution and Life Expectancy in the United States." *New England Journal of Medicine*, January 22, 2009.

[8] For purposes of comparison, the total number of deaths from all causes in the Bay Area is about 45,000 per year, and the annual number of transportation-related deaths (primarily auto-related fatalities) in the Bay Area is 600 to 700.

So despite substantial and well-documented progress in reducing air pollution, we must continue to work to further improve air quality and to better protect public health. And even as we make progress in reducing air pollution, we face significant challenges that demand fresh thinking and new approaches.

Challenges

The Bay Area must plan today to meet the challenges that we will face in the years to come. Key factors that will influence future conditions include:

- Population and economic growth in the Bay Area;
- Development patterns: where and how we accommodate future growth;
- Changes in infrastructure, including our roadway and transit systems, goods movement systems, and high-speed rail;
- Technological change;
- Climate change;
- Potential local impacts from pollutants emitted by expanding economies in Asia; and
- Public awareness and action to support air quality and climate protection strategies.

Major challenges that we face in the realm of air quality and climate protection, and the opportunities that flow from these challenges, are summarized below.

Criteria Pollutant & Air Toxics Challenges

More stringent standards: Air quality standards are becoming progressively more stringent in response to epidemiological research that shows adverse health effects at lower pollution concentrations than previously known. To attain these increasingly stringent standards, air districts throughout California will need to pursue innovative strategies to complement our traditional, command-and-control, technology-based approach.

Protecting Impacted Communities: Recent health studies related to particulate matter and air toxics highlight the need to focus on reducing pollution exposures in the most heavily-impacted communities that bear the brunt of pollution from ports, freeways, and industry. Analysis performed for the Air District's CARE program indicates that mobile sources, including cars, trucks, and off-road equipment, account for most of the emissions and health risks in impacted communities. These sources are not under the regulatory jurisdiction of the Air District. Improving air quality in impacted communities will entail reducing emissions from all sources, especially heavy-duty vehicles and equipment. And it will require local governments to consider new approaches in land use decision-making.

Reducing PM: Fine particulate matter (PM2.5) is the pollutant that imposes the greatest public health burden on the Bay Area. Exposure to fine and ultrafine PM from motor vehicles endangers people who live or work in close proximity to freeways, ports, and goods movement corridors and facilities. Reducing PM emissions from diesel engines is essential, but we also need to decrease fine PM of all types, including wood smoke, in order to protect public health.

Diminishing returns: Aggressive efforts to reduce emissions from all sources have greatly reduced pollution levels. But we have picked the "low-hanging fruit" – it is becoming harder and harder to find regulations and other control measures that provide significant reductions in criteria pollutants. To make further progress, we will need to pursue new approaches.

Land Use Challenges

Our land use patterns and transportation infrastructure have a profound impact on air quality and population exposure to pollution. In the long run, where and how the Bay Area chooses to develop is likely to have as great or greater an impact on air quality, public health, and climate change than any rules or regulations that the Air District adopts.

Despite current economic challenges, the Bay Area will experience population growth and economic growth in the coming decades. If existing land use development patterns continue, this will result in a major increase in the number of motor vehicles competing for space on our roads, and additional pressure to build housing and commercial property on the periphery of the region, thus complicating our efforts to attain air quality standards and the State's climate protection goals. We need to find a way to accommodate growth through sustainable land use patterns.

Promoting focused development to create vibrant communities in core areas of the region is essential in order to reduce motor vehicle emissions and achieve our air quality and climate protection goals. However, *we must pursue focused development in a way that does not put people at risk from exposure to existing and/or new sources of pollution.*

Climate Protection / Greenhouse Gas Challenges

Climate change is the greatest environmental challenge of the 21st century. We need to radically reduce greenhouse gas emissions to attain the state's ambitious GHG reduction goals for the year 2050. Can the Bay Area find a way to slash greenhouse gas emissions per capita, while still maintaining a strong economy and high quality of life?

Climate change will exacerbate air pollution, and complicate our efforts to attain and maintain air quality standards. Higher temperatures may increase emissions of ozone precursors and ozone formation, eroding the progress that the region has made over the past 50 years of regulatory action.

Climate change has been implicated in increasing the number and severity of summer wildfires in California. Some of these fires have impacted the Bay Area, producing fine particle concentrations that exceed air pollution standards.

Emissions of carbon dioxide (CO2), the primary greenhouse gas, are a direct product of fossil fuel combustion. To protect our climate and avoid global warming, we must reduce combustion of fossil fuels (coal, petroleum products, natural gas, etc.). Recent research indicates that particulate matter from fires and vehicle exhaust contributes directly to global climate change in the form of black carbon, a soot-like substance that both absorbs radiation and diminishes the ability of snow and icepack to reflect radiation away from the earth's surface.

Opportunities

In responding to the challenges described above, the Bay Area has an opportunity to show the world that a diverse region can marshal its economic, political, and social assets to build a sustainable economy and communities that protect our environment and climate. Some of the key ways to achieve this are summarized below.

Attack root causes: To date, emission control strategies have often focused on the tail end of processes, for example by installing scrubbers on smoke stacks or catalytic converters on motor vehicle tail pipes. But we need to tackle the root causes of our air quality and climate challenges by pursuing greater efficiency in all sectors of our society and economy: industrial processes, power generation, motor vehicles and transportation, and design of our buildings and communities.

Promote focused development: We need to change the way in which we live, work, play, and get around. Linking land use, transportation, and air quality planning is a key long-term strategy to reduce emissions of criteria air pollutants, air toxics, and greenhouse gases. We must build public support for a robust Sustainable Communities Strategy [9] for the Bay Area (in response to SB 375) to promote land use, transportation and lifestyle changes that decrease motor vehicle travel and encourage less energy-intensive modes of transportation.

Reduce emissions from goods movement: Goods movement (trucking, rail, ports, etc.) is a major source of air pollution and greenhouse gases. Reducing emissions from the

[9] See discussion of SB 375 and Sustainable Communities Strategy in Chapter 4.

goods movement sector will provide benefits in reducing population exposure to air toxics in impacted communities.

Protect impacted communities: Improving air quality in impacted communities will require a comprehensive strategy and sustained collaboration between the Air District, local governments, health departments, community groups, industry, and other stakeholders.

Take personal responsibility: Each of us makes decisions every day that have a direct impact on our environment and our climate: how we travel, what we buy (or don't buy), the type of vehicle we drive, whether to light a fire in our fireplace. Taken together, these individual decisions have powerful impacts. In the final analysis, each of us has both a direct stake and a direct responsibility in protecting our environment and our climate.

Organization of the CAP

The CAP includes two volumes, plus appendices. Volume I consists of five chapters which present the overall framework of the plan. Chapter 1 explains the goals of the plan and innovative directions that the CAP pursues to address the challenges described above. Chapter 2 lays out the technical foundation for the plan, including air quality standards, Bay Area attainment status, emissions inventory data, trends in emissions and population exposure, and air quality modeling, and also provides a profile of each pollutant addressed in the CAP. Chapter 3 describes the context for this plan, summarizing existing Air District programs that provide the foundation for the CAP, as well as external plans and programs that complement the CAP. Chapter 4 provides an overview of the CAP control strategy and its rationale, and describes key policy issues that informed the development of the control strategy. Chapter 5 briefly summarizes key findings and outcomes of the CAP.

Volume I also includes the following appendices:

- Appendix A: Bay Area Health Burden from Air Pollution: Past & Present
- Appendix B: Public Outreach for the 2010 CAP
- Appendix C: State Air Quality Planning Requirements
- Appendix D: Ecosystem impacts of Air Pollution
- Appendix E: Photochemical Modeling
- Appendix F: Evaluation of Potential Control Measures
- Appendix G: Progress Toward 2010 CAP Performance Objectives

Volume II provides detailed descriptions of the 55 control measures that comprise the CAP control strategy, as well as Further Study Measures and the CAP Leadership Platform.

Chapter 1 – Scope & Purpose of 2010 CAP

The Bay Area 2010 Clean Air Plan (CAP) provides a comprehensive plan to improve air quality, protect public health, and protect the climate. The plan proposes a control strategy to reduce four types of air pollutants – ozone, particulate matter (PM), air toxics, and greenhouse gases – in a multi-pollutant framework. Chapter 1 describes the key goals and objectives of this plan, and the innovative approaches that the Air District employed in developing the 2010 CAP.

The 2010 CAP has been prepared in collaboration with the Air District's regional agency partners: the Association of Bay Area Governments (ABAG), the Bay Conservation and Development Commission (BCDC) and the Metropolitan Transportation Commission (MTC).

In developing the CAP, the Air District performed extensive outreach to the public and interested stakeholders, as described in Appendix B, including multiple rounds of public workshops in various locations throughout the Bay Area. The input provided by interested parties helped to inform the development of the CAP and the CAP control measures.

Update to State Ozone Plan

The legal impetus for the 2010 CAP is to update our most recent state ozone plan,[10] the Bay Area 2005 Ozone Strategy, in order to fulfill the requirements of the California Clean Air Act (CCAA) as codified in the California Health & Safety Code. The CCAA planning requirements, and how the 2010 CAP fulfills these requirements, are described in Appendix C. The key requirements can be summarized as follows:

- Report on progress in implementing the region's most recent plan to address state ozone standards, the *Bay Area 2005 Ozone Strategy;*
- Propose a control strategy that includes all feasible measures to reduce emissions of ozone precursors: reactive organic gases (ROG) and nitrogen oxides (NOx); and
- Reduce transport of ozone and ozone precursors to neighboring air basins.

Section 40914 of the Health & Safety Code requires that air district plans shall either be designed to achieve a reduction in emissions of 5% or more per year for each non attainment pollutant or its precursors, <u>or</u> the plan shall provide an alternative emission reduction strategy that includes all feasible control measures. To date, no air district in

[10] The 2010 CAP responds to planning requirements pursuant to state law only. The CAP does not address federal air quality planning requirements, and is not part of a SIP (State Implementation Plan) for federal air quality planning purposes.

the state has been able to demonstrate a 5% reduction in ozone precursors each year. As in the case of previous Bay Area ozone plans that address state air quality planning requirements, the control strategy for the 2010 CAP is based on the "all feasible measures" alternative.

2010 CAP Goals and Performance Objectives

The 2010 CAP is focused on three related goals of fundamental importance, namely to:

- Protect air quality;
- Protect public health; and
- Protect the climate.

To better define these goals and to measure progress toward their achievement, several performance objectives have been identified for the 2010 CAP.

Air Quality: For air quality performance objectives, the CAP seeks to attain the ambient air quality standards established by the California Air Resources Board (CARB) and the US Environmental Protection Agency (EPA), as summarized in Table 2-1.

Public Health: Two public health objectives have been identified for the CAP:

- Reduce PM2.5 exposure by 10% by 2015;[11] and
- Reduce diesel PM exposure by 85% by 2020

Climate Protection: The CAP performance objectives, consistent with the State of California's climate protection goals, are to:

- Reduce emissions of greenhouse gases (GHGs) to 1990 levels by 2020 and 40% below 1990 levels by 2035.[12]

The rationale for the CAP performance objectives is described in Chapter 5. Appendix G presents an analysis as to how well the CAP control strategy and other measures will achieve the CAP performance objectives.

New Directions in Air Quality Planning

To pursue the goals defined above, the 2010 CAP employs an integrated, multi-pollutant planning framework. This represents a departure from the traditional approach to air

[11] Since it is difficult to measure population exposure to PM, our analysis of progress in meeting the PM2.5 and diesel PM performance objectives uses emissions reductions as a surrogate for reducing population exposure.

[12] The goal of reducing GHG emissions to 1990 levels by 2020, established in AB 32, will require reducing 2009 emissions by 15%. The 2035 goal is a prorated target based upon the goal in the Governor's 2005 Executive Order S-3-05 to reduce GHGs emissions to 80% below 1990 levels by year 2050. The 2035 goal is the same as the goal expressed in MTC's *Transportation 2035* plan and ABAG's *Projections 2009*.

quality planning, embodied in state and federal guidelines, whereby plans are prepared to address a single pollutant, such as ozone or particulate matter (PM). Although the single-pollutant approach has been successful in reducing ambient ozone concentrations in the Bay Area and elsewhere, it suffers from several limitations. In particular, it does not directly consider:

- The co-benefits or trade-offs for control strategies that affect multiple pollutants;
- The range and severity of health effects of different pollutants (e.g. air toxics), and the potential health benefits of reducing the various pollutants; or
- The effects that control measures designed to reduce criteria pollutants may have in increasing or decreasing emissions of CO2 and other greenhouse gases that contribute to climate change.

Considering the limitations of the single-pollutant approach, there is growing recognition of the need to move in the direction of integrated, multi-pollutant air quality planning. The conceptual rationale for multi-pollutant planning was initially set forth in recommendations issued by the National Research Council (NRC), an arm of the National Academy of Sciences, in January 2004.[13] The NRC report advocated that air quality planning should employ a risk-based, multi-pollutant approach to address the major goals of the Federal Clean Air Act, including:

- Reduce concentrations of the six "criteria" pollutants: ozone, PM, SO2, PM, lead, NO2;
- Reduce exposure to air toxics; and
- Address ecosystem impacts related to criteria air pollutants, including acid deposition and stratospheric ozone depletion.[14]

In response to the NRC report, the US EPA Office of Air Quality Planning and Standards (OAQPS) has been investigating the multi-pollutant planning concept in recent years.[15] In May 2007, US EPA issued a call for states or regions interested in pursuing multi-pollutant pilot projects. Multi-pollutant pilot projects under the aegis of US EPA are currently under way in four areas: New York State, North Carolina, Detroit, and the St. Louis MO/IL metro area.

Although the NRC has provided the conceptual basis for multi-pollutant planning, there are currently no laws or regulations that require, or even directly encourage, the preparation of multi-pollutant plans. Nor are there any detailed guidelines available as to how to prepare such a plan.

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[13] *Air Quality Management in the United States*, National Research Council, January 2004.

[14] In terms of ecosystem impacts, the CAP focuses on the link between air quality and climate change. There are, however, a range of ecosystem impacts related to criteria pollutants, such as nitrogen deposition, acid rain, etc. An overview of these other ecosystems impacts is provided in Appendix D. The NRC report also notes that, ideally, multi-pollutant planning should address multiple media, including air quality, water quality, soil, etc.

[15] *The Multi-Pollutant Report: Technical Concepts & Examples,* U.S. EPA, July 2008.

The CAP as a Multi-Pollutant Plan

The Air District has chosen to develop the 2010 CAP as an integrated, multi-pollutant air quality plan in the belief that this is the best way to address the Bay Area's air quality and climate protection challenges. The sections below describe the rationale for multi-pollutant planning, the potential benefits of this concept, and how the Air District approached multi-pollutant planning for the CAP. Key findings from the Air District's multi-pollutant analysis are also discussed.

Scientific Rationale for Multi-Pollutant Planning

The scientific rationale for multi-pollutant planning is summarized below.

Shared chemistry and meteorology: Air pollutants share common precursor chemicals and interact with one another in the atmosphere in response to meteorology in complex ways. Similar atmospheric processes create, remove or transform multiple pollutants. A few examples of the complex interactions among air pollutants include the following:

- ROG and NOx act as precursors to formation of both ozone and PM, but the processes are different.[16]
- Benzene, 1-3 butadiene, acetaldehyde, and formaldehyde are air toxics with direct health effects, but they are also components of ROG and thus act as precursors to ozone and PM formation.
- Climate change and ozone are intertwined: higher temperatures related to climate change are expected to increase ozone formation; ozone, in turn, acts as a potent, albeit short-lived, greenhouse gas.
- PM has a complex role in terms of global warming. Black (elemental) carbon, also referred to as soot, is a component of PM that appears to accelerate the effects of climate change, such as melting of the polar ice caps. But other aerosol forms of PM such as organic carbon, sulfates and nitrates scatter light, and thus have a cooling effect. Dust particles (e.g. dust from agriculture and construction activities) that contribute to PM also have a cooling effect.
- Emissions of methane, one of the top GHGs, also contribute to increasing background levels of ozone at the global scale.[17] Thus, reducing methane

[16] In the Bay Area, where ozone formation is limited by the availability of ROG, air quality modeling suggests that reducing NOx may actually increase ozone levels, at least under certain conditions in the short term.

emissions can help to reduce both climate change and ground-level ozone concentrations.

Pollutants may have common emission sources: Many emission sources produce multiple air pollutants. For example, combustion of fossil fuels in motor vehicle engines emits ROG and NOx, which act as precursors to formation of ozone and PM; direct emissions of PM; air toxics such as diesel PM, benzene, 1-3 butadiene, and ammonia; as well as greenhouse gases, including significant quantities of CO2, and small amounts of methane. Thus, control measures to reduce emissions from these sources may provide reductions in multiple pollutants.

Multiple pollutants can interact in terms of health effects: From the standpoint of health effects, the interaction among pollutants can be *additive* (the simple sum of the individual effects of each pollutant, *synergistic* (whereby the combined effect is greater than the sum of the effect of each individual pollutant), or *antagonistic* (where the combined effect is less than the sum of the effect of each individual pollutant). Although more research is needed, there is evidence[18] that interaction among multiple pollutants can produce a combined effect that is greater than the simple additive outcome of each individual pollutant.

Policy Rationale for Multi-Pollutant Planning

Multi-pollutant planning also makes sense from the policy perspective. Since available resources are finite both for air quality regulators and for the regulated community, it is important to maximize the cost-effectiveness of pollution control programs. Developing an integrated control strategy that addresses multiple pollutants can optimize the cost-effectiveness of air quality regulations and plans. Multi-pollutant planning can also help to:

- Provide stakeholders and the public with a comprehensive analysis of key air quality issues, build support for strategies to address these issues, and help target resources where they will yield the greatest benefit;
- Maximize co-benefits and avoid trade-offs between the different pollutants;
- Analyze pollutants on the basis of their health risks, and design a control strategy to maximize reductions in health risks;
- Provide better justification for new control measures by analyzing the full range of pollutants reduced and the potential health benefit for proposed measures; and
- Integrate climate protection into air quality planning.

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[17] Seinfeld J.H. and S. N. Pandis, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, p. 246-249, John Wiley & Sons, Inc, New York, 1998. Also, Fiore et al, Linking ozone pollution and climate change: the case for controlling methane, Geophysical Research Letters, Vol. 29, No. 19, 2002.
[18] *Is There Evidence for Synergy Among Air Pollutants in Causing Health Effects?* Joe L. Mauderly and Jonathan M. Samet, Environmental Health Perspectives vol. 117, Number 1, January 2009.

A key rationale for multi-pollutant planning is to maximize co-benefits in reducing multiple pollutants and minimize any potential trade-offs. Control measures that reduce multiple pollutants provide desirable co-benefits. However, in some cases, a particular control measure or technology may reduce one or more pollutants, but at a cost of increasing emissions of some other pollutant(s). Analyzing control measures on a multi-pollutant basis provides a means to evaluate and minimize any potential trade-offs, and to determine whether a trade-off, if unavoidable, may nevertheless still provide a net air quality benefit.

Multi-Pollutant Issues and Challenges

Although multi-pollutant planning makes sense conceptually, it is inherently more complex than single-pollutant planning, especially in the absence of state or federal guidelines. Therefore, it presents a range of challenges from both the policy and technical perspective. These challenges include:

- The scope of multi-pollutant planning is not yet well-defined. In developing a multi-pollutant plan, where should one draw the line in terms of the range of pollutants, health effects, and ecosystem impacts to address?
- Do we have adequate technical knowledge and tools to allow us to plan on a multi-pollutant basis? (See Chapter 2)
- What does the science and health data tell us about the relative harmfulness of the different pollutants?
- How to develop an effective multi-pollutant control strategy?

Although multi-pollutant planning has conceptual appeal and practical value, it should not be seen as a panacea. In the final analysis, the effectiveness of any air quality plan depends upon identifying and implementing effective emission control measures. Multi-pollutant planning provides a broader lens through which to evaluate control measures, but the universe of potential control measures is not necessarily greatly expanded. Finding viable control measures that provide significant emission reductions remains a major challenge.

Air Pollutants Addressed in CAP

There are hundreds of air pollutants, with a multitude of known and suspected health effects. It would be neither technically or practically feasible to address every air pollutant in the CAP, so the Air District has chosen to focus on a manageable subset of pollutants, namely:

- Ground-level ozone and ozone precursors: ROG and NOx
- Particulate matter (PM): both directly-emitted PM and secondary PM
- Key air toxics, such as diesel PM and benzene, and
- The “Kyoto 6” greenhouse gases (GHGs)

The choice of pollutants to include was based primarily on which pollutants pose the greatest risk to public health and to the climate.[19] Ozone and PM were chosen because they are the two criteria air pollutants for which the Bay Area continues to exceed state and national air quality standards. PM was also chosen because it has been identified as a major cause of serious health effects.

The California Air Resources Board (CARB) has identified 191 air toxics. In addressing air toxics in the CAP, we focus on a small set of carcinogenic air toxics – benzene, 1,3-butadiene, formaldehyde, acetaldehyde, and diesel PM. Although just a small subset of the full spectrum of toxics, these toxic compounds were chosen because they account for approximately 95% of the estimated cancer risk from air toxics in the Bay Area.[20] Diesel PM is both a component of PM2.5 and also the Bay Area's leading airborne carcinogen.[21]

Greenhouse gases are included because they are the agents of climate change. There are many GHGs, but the CAP focuses on the "Kyoto 6" greenhouse gases. Three of these gases - CO_2, methane, and nitrous oxide – represent 99% of the known GHG potential of the Bay Area.[22]

Although they may share characteristics and interact in the atmosphere, the pollutants addressed in the CAP differ in fundamental ways. One of the differences relates to how pollutants are emitted or formed. For example, some pollutants, including many air toxics, are directly emitted. Others, such as ozone, are formed via photochemical processes in the atmosphere. And some, such as PM, are both directly emitted, as well as formed via secondary processes. As summarized in Table 1-1, the pollutants addressed in the 2010 CAP differ in terms of:

- Chemical composition and formation
- Time of year when highest concentrations occur
- Geographic scale (local, regional, global)
- Range and severity of health effects they cause
- Climate and ecosystem impacts

[19] For additional discussion regarding how the pollutants addressed in this plan were selected, see Section 1.3.1 of the MPEM Technical Document.

[20] In addition to carcinogenic risks, air toxics may have both acute (short-term) and chronic (long-term) non-cancer health effects. However, for purposes of this methodology, we have chosen to focus on toxic cancer risks only.

[21] See CARE *Phase I Findings and Policy Recommendations Related to Toxic Air Contaminants in the San Francisco Bay Area*, BAAQMD, September 2006, at www.baaqmd.gov/Divisions/Planning-and-Research/Planning-Programs-and-Initiatives/CARE-Program.aspx

[22] The other Kyoto 6 GHGs are hydroflourocarbons (HFCs), perflourocarbons (PFCs), and sulfur hexafluoride (SF_6). See additional discussion re: GHGs in Chapter 2.

Table 1-1 provides an overview of the key characteristics and impacts of the air pollutants addressed in the 2010 CAP.

Table 1-1. Pollutant summary table.

Pollutant	Constituents/ Precursors	Key Anthropogenic Sources	Scale of Impact	Peak Levels	Health Impacts	Other Impacts
Ozone	ROG	Mobile sources (cars) Evaporation of petroleum & solvents Consumer products	Regional & beyond	Summer	Aggravated asthma Acute bronchitis Chronic bronchitis Respiratory symptoms Decreased lung function Heart attacks Premature mortality	Property damage: tires, paints, building surfaces Damage to crops Nitrogen deposition to land & waterways
	NOx	Mobile sources (cars & trucks) Other combustion				
PM2.5	Direct emissions from combustion	Wood-burning Diesel engines Gasoline engines Burning natural gas Commercial cooking	Local & Regional	Winter	Aggravated asthma Respiratory symptoms Increase blood pressure Decreased lung function Heart disease Stroke Premature mortality	Regional haze Acid deposition Water pollution
	ROG	See ROG above				
	NOx	See NOx above				
	Ammonia (NH3)	Landfills, livestock, wastewater treatment, refineries				
	SO2	Petroleum refining Ships				
Air Toxics	Diesel PM Benzene 1,3 Butadiene Formaldehyde Acetaldehyde	Diesel engines Gasoline engines Construction equipment Ships & boats	Local	Year-Round	Acute non-cancer Chronic non-cancer Lung cancer Leukemia Premature mortality	Water pollution
Green House Gases	Carbon dioxide:CO2 Methane (CH4) Nitrous oxide (N2O) Hydroflourocarbons Perflourocarbons Sulfur hexafluoride	Fossil fuel combustion Mobile sources Industrial/commercial Electricity generation	Global	Year-Round	Potentially increase ozone levels Disease vectors Effects from prolonged heat waves	Climate change Rising sea levels Acidification of oceans Species extinction Drought Wildfires

Linking Air Pollution to Health Effects

Protecting public health is one of the key goals of the 2010 CAP. The fundamental linkage between reducing emissions of air pollutants and protecting public health is based on four key steps described below.

Emissions: Many different sources, both stationary (factories, refineries, etc.) and mobile (cars, trucks, locomotives, marine vessels, and farm and construction equipment) emit a wide variety of air pollutants. Identifying the key emission sources and developing strategies to reduce emissions of harmful pollutants (or their chemical precursors) from man-made or "anthropogenic" sources[23] is the first and most fundamental step to improve air quality.

Ambient Concentrations: This term refers to the level of pollutants that are measured in the air. Air quality standards for criteria pollutants are generally defined in terms of ambient concentration, as expressed in terms of either a *parts per million* ratio (e.g., the state 8-hour ozone standard is 0.070 parts per million) or a *mass per volume* basis (e.g., the national 24-hour PM2.5 standard is 35 $\mu g/m^3$). The relationship between emissions and ambient concentrations is complex and depends upon many factors, including meteorological conditions (temperature, wind speed and direction, vertical mixing, etc.) the ratio of precursor pollutants (e.g., the ROG to NOx ratio, in the case of ozone), and regional topography. Some pollutants, such as ozone, are regional in scale. In other cases, such as PM and air toxics, ambient concentrations can vary greatly within a small geographic area. The Air District performs sophisticated photochemical modeling to better understand the complex relationship between emissions and ambient concentrations. These emissions-concentrations relationships or "sensitivities" were quantified and used in the multi-pollutant evaluation method (MPEM) described below.

Population Exposure: Population exposure refers to the type and magnitude of exposure to pollution for a given individual or population cohort.[24] From the public health perspective, the key issue is not how much pollution is present in the air, but rather how many people are actually exposed to the pollution, and how much is taken into the body (dosage). Individual exposure to air pollution varies greatly depending upon where people live, work, and play. Activity patterns and lifestyle, such as how much time people are outside, or how much time they spend driving on busy roadways, vary greatly from person to person. The magnitude, frequency, duration, and route of exposure are all key factors in determining total exposure.

[23] In addition to anthropogenic sources, there are also natural or "biogenic" sources of some pollutants. For example, some species of trees and vegetation emit volatile organic compounds (VOC) that contribute to formation of ozone in the atmosphere.
[24] Inhalation is the primary means of population exposure. Other pathways of indirect exposure to air pollution include absorption through the skin and ingestion.

Just as individual exposure differs, so does the ability of our bodies to tolerate exposure to pollutants. From the standpoint of protecting public health, we are especially concerned about reducing population exposure for the most susceptible people, also called "sensitive populations," including children, pregnant women, seniors, and people with existing cardiovascular or respiratory conditions. Activity levels and body weight are also factors; when people, especially children, are exercising, they receive higher dosages relative to exposure.

Health Effects: Air pollution can cause or contribute to a wide range of health effects and illnesses, depending upon individual exposure to and tolerance for air pollution. Key health effects related to the air pollutants addressed in the 2010 CAP are summarized in Table 1-1.

Multi-Pollutant Evaluation Method

Because pollutants differ in terms of their emission sources, formation, health effects, and other factors, evaluating the benefit of potential control measures on a multi-pollutant basis is a challenging task. To address this issue, the Air District developed a multi-pollutant evaluation method (MPEM) for the 2010 CAP.[25]

The MPEM is based on the four links in the emissions to public health chain described above. For each control measure, the MPEM analyzes how the reduction (or increase) in emissions of each pollutant will affect ambient concentrations, population exposure, and changes in health effects related to each pollutant. The MPEM then monetizes the value of the health and climate protection benefits of each control measure in dollar terms in order to compare the relative benefits of the various control measures. The MPEM thus provides a tool that integrates the CAP goals of improving air quality, protecting public health, and protecting the climate.

For purposes of the 2010 CAP, the MPEM has been used to:

- Estimate the health and climate protection benefits, expressed in dollar terms, for individual control measures;
- Analyze trade-offs in the case of control measures that would increase one or more pollutants while reducing others;
- Estimate the aggregate benefit for the proposed CAP control strategy as a whole; and
- Evaluate the health burden associated with pollution levels in years past and compare that to the health burden in more recent years, as described in Appendix A.

[25] A more detailed description is provided in the *MPEM Technical Document* which is available on the District's website at www.baaqmd.gov/Divisions/Planning-and-Research/Plans/Clean-Air-Plans/Resources.aspx.

MPEM Caveats and Limitations

Although it includes key health effects, the MPEM does not fully consider all pollutants or all the benefits related to improving air quality. The MPEM excludes many air toxics, as well as criteria pollutants for which the Bay Area currently attains applicable standards: i.e., carbon monoxide (CO) and lead.[26] Nor does the MPEM include all potential health effects related to air pollution; only well-documented health effects are included. In addition, the MPEM, as currently designed, does not consider:

- Benefits of improvements in air quality beyond the boundaries of the Air District due to reduction in transport of Bay Area emissions to neighboring air basins;
- Economic benefits in terms of reduced damage to crops and other property (ozone damages tires, building surfaces, etc.), benefits in attracting tourism, the potential increase in property values due to improved air quality, etc.;
- How reducing emissions of air pollutants may provide other environmental benefits such as improving water quality or protecting ecosystems; or
- Co-benefits from control measures that provide enhanced transportation options, improved travel time, improvements in safety for bicyclists and pedestrians, reduced traffic accidents, reduced fuel or energy consumption, etc.

It is important to note that the MPEM provides a means of estimating the benefits of protecting public health and our climate *at this particular point in time*, based on our current understanding of pollutants and their health effects, the current Bay Area emission inventory, and current ambient concentrations. Had the Air District devised a version of the MPEM back in the 1970's or 1980's, when levels of ozone, carbon monoxide and air toxics were much higher than they are today, and the dangers of PM were little understood, the comparative values of different pollutants for purposes of a multi-pollutant comparison would likely have been different than what the MPEM tells us today. Similarly, looking forward, it is likely that the results of a multi-pollutant comparison two or three decades in the future will also tell a different story, in response to evolving science, progress in reducing the different pollutants in the intervening years, and other factors.

The MPEM by necessity incorporates many assumptions and approximations; these are described in the MPEM Technical Document. For example, for purposes of estimating population exposure to pollutants, the MPEM assumes "backyard" exposure; i.e., that people are at home and outside in their yards 24 hours a day, 7 days a week. Because the MPEM is a complex methodology, the estimates of social benefits that it generates are subject to considerable uncertainty. To address this uncertainty, Air District staff

[26] The Bay Area also attains State and national standards for NO2 and SO2. However, these pollutants are included in the MPEM because they act as precursors in secondary formation of PM.

performed a probability analysis of MPEM results.[27] The MPEM is intended primarily for purposes of comparing the relative dollar value of benefits across control measures. Although the methodology is a useful tool to help inform our decision-making, it should not be used as the sole arbiter of air quality rule-making or policy. With these caveats, key MPEM findings are presented below.

Valuation of Health Effects

Negative health effects related to air pollution impose direct costs to treat illness and disease, as well as indirect costs such as lost work days and diminished productivity. For the MPEM, the following values were used for key health endpoints.[28]

- Mortality: $6,900,000
- New cancer case: $1,750,000
- New chronic bronchitis case: $ 410,000
- Non-fatal heart attack: $ 84,100
- Hospitalization for respiratory/cardiovascular illness: $33,000-$44,000 per admission
- Asthma emergency room visits: $468 per incident
- Acute bronchitis episodes: $534, for a 6-day illness period
- Upper respiratory symptom days: $35 per day
- Lower respiratory symptom days: $22 per day
- Work loss days: daily median wage by county
- School absence days: $91 per day
- Minor restricted activity days: $61 per day

Valuation of Greenhouse Gas Reductions

The MPEM also considers the value of reducing greenhouse gas emissions. Assigning a value to GHG reductions is problematic, given that 1) climate change will have impacts both locally and at the global scale, 2) potential climate change impacts are very broad, including a wide array of health, ecosystem, social, and economic impacts, and 3) the full range and force of climate change impacts from GHGs emitted today will not be experienced until decades, or even centuries, into the future. To develop a credible estimate for the value of reducing GHGs, the Air District performed a literature review and selected the value of $28 per metric ton of GHG reduced (expressed in CO2-equivalent), as described in Section 5.3 of the *MPEM Technical Document*.

[27] District staff performed an uncertainty analysis based upon the Monte Carlo method to evaluate the MPEM calculations for each control measure, as described in the MPEM Probability Analysis which is posted on the 2010 CAP page on the District website: www.BAAQMD.gov.
[28] Valuations of health effects are explained in Section 5 in the MPEM Technical Document. See: www.baaqmd.gov/Divisions/Planning-and-Research/Plans/Clean-Air-Plans/Resources.aspx.

Relative Value of Emission Reductions Based on MPEM

The MPEM can be used to compare the benefit of reducing the various air pollutants, as shown in Table 1-2. For this exercise, the MPEM was used to calculate the value of reducing one ton of each pollutant or precursor that is included in the methodology. The relative weight for each pollutant was then determined, using ROG as the unit of comparison. Since studies show that PM is the predominant cause of air pollution-related mortality, as discussed below, and mortality has by far the highest value ($6.9 million) among the health endpoints used in the MPEM, it is not surprising that the MPEM-derived weighting factor for PM reductions is much higher than for the other pollutants analyzed. These weighting factors are instructive for purposes of comparing the value of reducing the various pollutants. They can also be used to calculate the weighted tons of emissions reduced by various control measures for purposes of comparing their overall air quality and climate protection benefit.

Table 1-2. Dollar value of reducing one ton per year of each pollutant using MPEM.

Pollutant	$$ Benefit: Reducing One Ton Per Year	Weighting Factor *
ROG	$4,800	1.0
NOx	$7,300	1.5
Diesel PM2.5	$459,300	96.1
Direct PM2.5 (no diesel)	$456,400	95.5
SO2	$37,900	7.9
Ammonia	$53,500	11.2
Acetaldehyde	$5,300 ($500 plus $4,800 as ROG)	1.1
Benzene	$ 12,000 ($7,200 plus $4,800 as ROG)	2.5
1,3-Butadiene	$30,200 ($25,400 plus $4,800 as ROG)	6.3
Formaldehyde	$ 6,000 ($1,100 plus $4,800 as ROG)	1.2
CO2 equivalent	$28	0.03

**Weighting factor: ROG = 1.0. The $ benefit/ton is divided by the ROG value of $4,800/ton to calculate weighting factor for each pollutant. For example, the value of SO2 reductions is $37,900; dividing this by $4,800 yields a weighting factor of 7.9 for SO2. The weighting for benzene, butadiene, formaldehyde, and acetaldehyde includes their effects both as air toxics, as well as components of ROG that contribute to formation of ozone and PM.*

Another way to assess the relative weight of the different pollutants is to compare the monetary benefit of reducing ambient concentrations of the various pollutants covered by the MPEM by 1%, as shown in Figure 1-1.[29]

[29] It should be noted that the relatively low value for (non-diesel) air toxics in Figure 1-1 is due in large part to our success in reducing air toxics over the past 25 years. Also, the greenhouse gas slice of the pie would be larger if a value higher than $28 per ton was ascribed to the value of reducing one reducing GHGs in the MPEM.

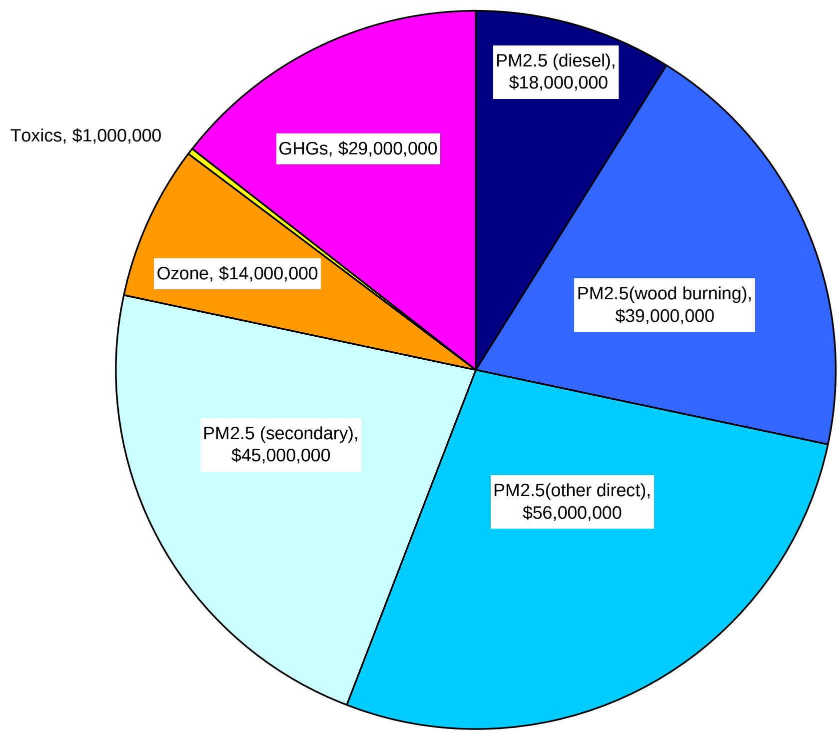

Figure 1-1. Social benefits of a 1% reduction of air pollutants in the Bay Area. The estimated social benefits are based on reductions of 1% of anthropogenic emissions, except for ozone. For ozone, the estimated benefit is based on a 1% reduction in exposures above 0.50 ppm.

Two key points about this pie chart are that (1) reducing PM accounts for roughly 80% of the total benefit and (2) diesel PM accounts for only about 20% of the total PM benefit.[30] The take-away message from Figure 1-1 is that, while reducing diesel PM is very important, we also need to continue, and strengthen, our efforts to reduce PM from wood smoke and other sources such as commercial cooking, and combustion of non-diesel fossil fuels, including gasoline and natural gas.

Protecting Public Health

Protecting public health is one of the core objectives of the 2010 CAP. The CAP is concerned with reducing pollution exposure throughout the region, but we place special

[30] Emissions of diesel PM are expected to decline significantly over the next decade in response to stringent CARB rules to control emissions from both on-road and off-road heavy-duty diesel engines.

emphasis on reducing population exposure and health impacts in the Bay Area communities that are most heavily impacted by air pollution.

From the standpoint of public health, air pollutants only become a problem when someone inhales or ingests the pollutant. The greatest risk occurs when a dense population is exposed to elevated concentrations of harmful pollutants, especially among the most sensitive members of that group: children, seniors, or people with pre-existing cardiac or respiratory problems.

Exposure to air pollution can cause a wide range of health effects, as summarized in Table 1-1, including short-term (acute) effects and long-term (chronic) effects, including asthma, bronchitis, cancer, heart attacks, and strokes. To protect public health, it is important to:

- Determine which pollutants are most harmful to public health;
- Identify where the greatest concentrations of people are exposed to the most harmful pollutants; and
- Develop and implement effective strategies to reduce population exposure to the most harmful pollutants.

Defining and documenting the relationship between air pollution and public health is a complex endeavor. It is very difficult to prove a direct causal relationship between pollution and any specific illness or health impact in a given individual. Even if it were possible to accurately measure exposure and dosage to various pollutants at the individual level, the body's response (or lack of response) can vary greatly depending upon the individual. In general, sensitive populations – children, elderly, and people with pre-existing heart or lung conditions – are at greatest risk from air pollution. Because the relationship between air pollution and illness is difficult to prove or measure on an individual level, researchers rely on epidemiological studies of various population groups to tease out the effects of air pollution on public health. Clarifying the link between air quality and public health is also difficult for the following reasons.

- There may be health effects associated with some pollutants (e.g., PM2.5) even at levels below the established air quality standards.
- The Air District's air quality monitoring network is designed primarily to measure ambient concentrations of criteria air pollutants for purposes of determining compliance with state and national ambient standards on a regional basis. However, ambient concentrations for pollutants such as PM2.5 and air toxics can vary significantly at a local scale.[31]

[31] Although the existing Bay Area monitoring network fully complies with all state and federal requirements, it does not provide accurate measurement of PM and air toxics at a fine-grained scale. The Air District conducts special local measurement studies to augment the regional monitoring network. Control measure LUM 6 in Volume II provides a discussion of how the Air District plans to further enhance air monitoring.

- It is difficult to measure population exposure to pollution, due to variation in personal activity patterns and ambient concentrations of pollution at a local scale, and in micro-environments such as vehicles, homes, schools, offices, and other buildings.
- There is still great uncertainty as to how different pollutants may interact (or not) in terms of their health effects. Depending on the specific combination of pollutants, they may interact in ways that are additive, synergistic, or antagonistic in terms of their health effects.
- It is difficult to separate the impact of air pollution from the many other factors that influence health, including lifestyle (diet, exercise habits, smoking, drinking), socio-economic variables, etc.

Nonetheless, a great deal of research has been performed to analyze the public health impacts of air pollution, and the analysis presented in this plan draws upon the best available studies, information, and methodologies.

Which Pollutants Pose the Greatest Risk?

As discussed in Appendix A, the Air District estimates that air pollution is associated with nearly 3,000 premature deaths per year in the Bay Area. Table 1-3 shows the estimated reduction in annual deaths in the Bay Area that would be achieved if all anthropogenic emissions of PM2.5 and air toxics, including diesel PM2.5, were eliminated,[32] and if ozone concentrations were reduced to 0.05 parts per million. The table divides diesel PM in two parts: mortality caused by diesel PM as a component of PM2.5, and mortality from diesel PM in its role as the leading carcinogenic toxic air contaminant in the region. The point estimate for annual deaths that would be avoided is 2,840 per year, with an 80% chance that the number is within the range of 1,140 to 5,060.

Table 1-3. Estimated reduction in annual deaths from elimination of anthropogenic PM2.5, ozone, and selected toxics.

	PM2.5		Ozone	Toxics (lung cancer)		Total
	Diesel (non-cancer)	Non-diesel		Diesel	Non-diesel	
Point estimate	325	2,370	60	75	10	2,840
Lower bound*	130	950	25	30	5	1,140
Upper bound*	600	4,200	105	135	20	5,060

[32] Reducing all anthropogenic $PM_{2.5}$ would mean reducing average annual Bay Area $PM_{2.5}$ concentrations from about 10.0 $\mu g/m^3$ to 3.5 $\mu g/m^3$.

* The probabilities of deaths being fewer than the lower bound or more than the upper bound are each 10%.

The data in Table 1-3 suggest several important points regarding the impact of air pollution, and the role of PM2.5 and diesel PM, on premature mortality.

The vast majority of premature deaths associated with air pollution - more than 90% - are related to exposure to fine particulate matter (PM2.5). Most of the deaths associated with PM2.5 are related to cardiovascular and respiratory problems.

Although PM emitted by diesel engines is the leading air toxic in the Bay Area, only 10-20% of PM-related deaths in the Bay Area are linked to diesel exhaust. Other types of PM, from sources such as wood smoke, cooking, burning other fossil fuels, and secondary formation of PM from precursors such as NOx, SO2, and ammonia, collectively account for most of the PM – and PM-related deaths - in the Bay Area.

To the extent that diesel PM does contribute to premature mortality, it is primarily due to its role as a component of PM2.5, in which it contributes to mortality related to heart attacks, emphysema and chronic bronchitis. Diesel PM appears to be associated with 4-5 times more deaths in its role as PM2.5 than in its role as a carcinogenic air toxin.

Lung cancer caused by exposure to air toxics appears to account for only a modest portion, on the order of 3%, of the total deaths related to air pollution in the Bay Area; and only a tiny fraction, on the order of one in a thousand, of overall cancer cases in the Bay Area. The estimated lifetime cancer risk from air toxics in the Bay Area is on the order of 400 cases per million.[33] This compares to the total lifetime cancer risk of approximately 400,000 cases per million from all causes.

The information presented above highlights the importance of reducing PM emissions and concentrations, because PM has been identified as the leading cause of mortality from air pollution, and a high cost is ascribed to premature mortality. However, it should be emphasized that there are also significant negative health and economic impacts related to ozone and air toxics. Although ozone and air toxics are not leading causes of premature mortality, a wide range of acute and chronic health effects are associated with exposure to elevated levels of these pollutants, causing very real impacts to thousands of Bay Area residents. Therefore, it is essential to continue our efforts to reduce ozone and air toxics in response to both public health imperatives and legal requirements.

[33] Estimate is based on concentrations of air toxics measured at Bay Area monitoring stations in 2008, multiplied by OEHHA cancer risk factors.

How the CAP Addresses Public Health

As described in Chapters 3, 4, and 5, the 2010 CAP addresses public health in many ways, including:

- Identifying public health protection as one of its three primary goals;
- Establishing numerical performance objectives for reducing population exposure to diesel PM and PM2.5;
- Developing the Multi-Pollutant Evaluation Method to estimate the health benefits of proposed control measures and express these benefits in dollar terms;
- Using the MPEM to determine which pollutants pose greatest health risk;
- Developing potential control measures to maximize the reduction in population exposure to air pollutants, both at the regional scale and in local communities;
- Building on the Air District's current programs to reduce population exposure in impacted communities, such as CARE and the Clean Air Communities Initiative, and proposing to strengthen and enhance these efforts in the CAP control strategy; and
- Including a new category entitled Land Use and Local Impacts Measures (LUMs) in the CAP control strategy. The key objective of the six LUMs is to address localized impacts of air pollution, and in particular to help local jurisdictions to pursue transit-oriented infill development in priority areas, while simultaneously protecting people from exposure to air pollution in these areas.

Protecting the Climate

The third key goal of the 2010 CAP is to reduce emissions of greenhouse gases (GHGs) to protect the climate within the multi-pollutant plan framework. Addressing GHGs in an air quality plan is a challenge because GHGs differ in major ways compared to traditional air pollutants.

- Climate change is global in scale, with an enormous range of impacts and a long time frame before the impacts of today's emissions will be fully experienced.
- GHG emissions dwarf the criteria pollutants and air toxics; emissions of GHGs typically outweigh the other pollutants on a mass basis by a factor of 1000 or more.
- The regulatory framework for GHGs is still a work in progress at the national and international level.

Despite these differences, there are compelling reasons from both the policy and the scientific perspective to address climate protection and GHGs in the CAP. The same emission sources are the primary contributors of both traditional air pollutants and GHGs; this provides a good opportunity to achieve co-benefits from control measures. Higher temperatures related to climate change can increase emissions of ozone precursors and intensify ozone formation, as discussed below. Also, reductions in some criteria pollutants, such as black carbon (a component of PM), ROG, and carbon monoxide will help to decrease the "radiative forcing" that drives global warming. Conversely, some technologies to reduce emissions of traditional pollutants increase energy use or decrease fuel economy and thus generate additional CO2 emissions; therefore, it is important to identify, analyze, and attempt to mitigate trade-offs of this nature.

The Air District officially established a climate protection program in June 2005. Since then, the District has made climate protection a key element in its mission and moved aggressively to integrate climate protection into its core programs and plans, as discussed in Chapter 3. In September 2006 the State of California enacted ground-breaking climate protection legislation, the Global Warming Solutions Act (AB 32). In December 2008, CARB adopted a wide-ranging climate scoping plan pursuant to AB 32. The Air District is committed to using the full scope of its resources and authority to take actions within the Bay Area to help implement and complement the ARB scoping plan.

The range of impacts due to climate change is staggering, and most are beyond the direct scope of this plan. Nonetheless, it is essential that we address global warming in order to prevent, or at least reduce, potential negative impacts on air quality. Although it is difficult to predict how climate change at the global scale will impact air quality in the Bay Area, climate change has the potential to greatly exacerbate our air quality problems and undermine decades of progress in reducing criteria pollutants.

Impacts of Climate Change on Ozone Levels

There is irrefutable scientific evidence that the earth's atmosphere is getting hotter, that man-made emissions of carbon dioxide and other greenhouse gases are the primary cause of global warming, and that the effects of climate change are already being experienced in California and throughout the world.

Climate change is expected to have a direct and significant impact on ozone levels in the Bay Area and throughout the state. Simply stated, high temperatures lead to high ozone levels.

Bay Area emissions of CO2 and other GHGs contribute to climate change on the global scale; conversely, the Bay Area is impacted by emissions of GHGs from all parts of the world. Research suggests that global warming caused by world-wide emissions of GHGs could impact ozone levels through any and all of the following:

- higher temperatures;
- longer and more frequent heat waves;
- more frequent severe temperature spikes;
- increased length of the ozone season;
- increased VOC emissions from trees and other biogenic sources of VOCs, such as isoprene, and monoterpenes, due to higher temperatures;

- increased evaporative emissions of VOCs from storage tanks, solvents, motor vehicles, etc.
- change in ratio of VOC to NOx;
- increased atmospheric water vapor, higher humidity; and
- reduction in wind and vertical mixing that disperse pollutants

Potential Impacts on Bay Area Ozone Levels

Ozone monitoring data and the Air District's air quality modeling both show a strong correlation between extreme heat days and ozone exceedances. Air quality modeling by Air District staff suggests that an anticipated 2 degree Celsius increase in average temperatures predicted from climate change would set back progress in reducing ozone by a decade.[34] A separate study by UC Berkeley researchers using computer modeling to simulate the impact of higher temperatures on ozone levels in central California found that within the study domain, Bay Area ozone levels may be the most impacted by higher temperatures, and that parts of the Bay Area could experience an increase in ozone concentrations of nearly 10%.[35] An increase of this magnitude could cripple efforts to attain ozone standards in the Bay Area. As shown in Figure 1-2, the years in which the Bay Area has greater numbers of ozone exceedances correlate very closely with the years when the region experiences higher temperatures.

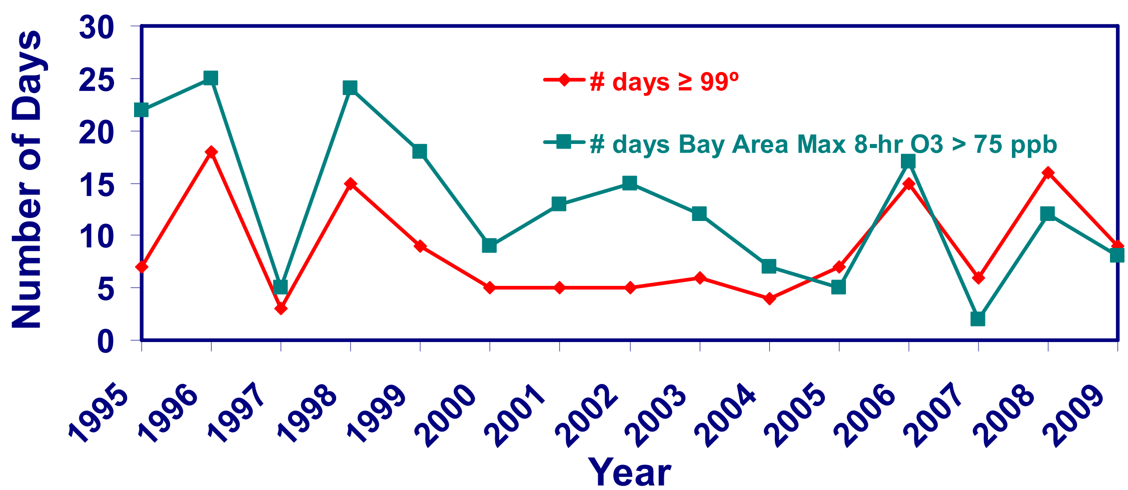

Figure 1-2. Correlation between # of high heat days and # of ozone exceedances in the Bay Area.

[34] See "The effects of climate change on emissions and ozone in Central California" by Su-Tzai Soong, Cuong Tran, David Fairley, Yiqin Jia, and Saffet Tanrikulu. Paper #590 presented in the 101st Annual Meeting, Air and Waste Management Association, June 24-26, 2008 Portland OR.

[35] Steiner, Allison et al. "Influence of future climate and emissions on regional air quality in California." Journal of Geophysical Research, Vol. 111. D183303, September 21, 2006.

The correlation between high heat and increased air pollution is at the heart of the Air District's commitment to climate protection. Figure 1-3 shows several potential scenarios for the number of high heat days per year in coming decades, representing anywhere from a 3-fold to a 10-fold increase over current levels. All these scenarios, even the "low-warming" scenario, would mean a great increase in the number of ozone exceedance days in the Bay Area.

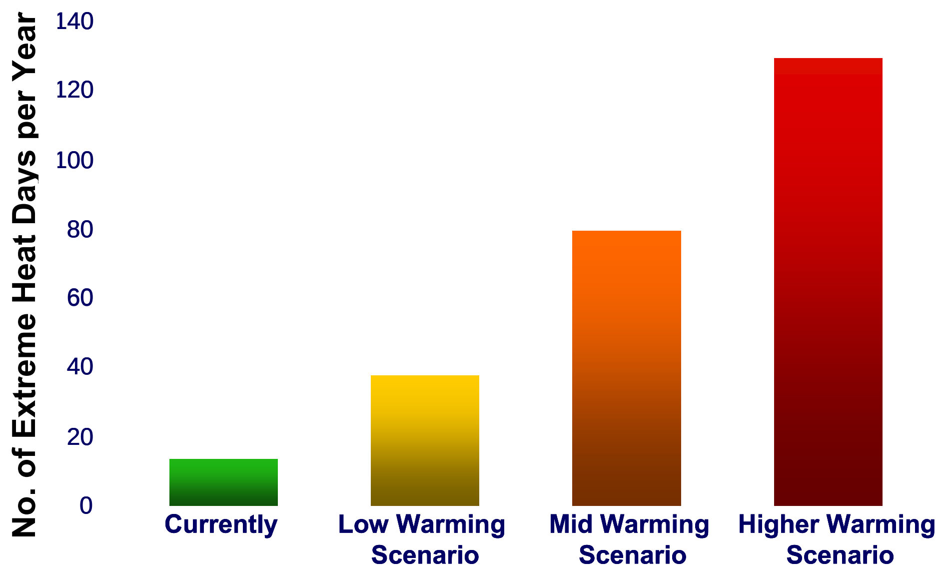

Figure 1-3. Number of extreme heat days per year projected for the San Francisco Bay Area: 2070-2099. (Source: Union of Concerned Scientists, 2006)

Impacts of Climate Change on PM and Air Toxics

Since benzene, 1,3-butadiene and some other air toxics are components of many VOCs, to the extent that those VOCs increase, so will these toxics. The potential impact of GHG emissions and climate change on other pollutants is still under investigation. However, climate change is likely to increase PM and other pollutants as well. For example, increased demand for air conditioning in buildings and vehicles may cause higher emissions of direct PM and PM precursors such as NOx and SO2 from power plants and vehicle engines.

Health Impacts Related to Climate Change

If climate change does, in fact, increase air pollution and impede efforts to attain ozone and PM standards in the Bay Area, this will have negative impacts on public health in years to come. But evidence suggests that climate change may already be degrading air quality and impacting public health in California and other western states due to an increase in the number and severity of wildfires, as a result of changes in the timing and quantity of precipitation, and reduction in mountain snowpack.[36]

Increased wildfires, although episodic in nature, could prove to be one of the most dramatic impacts of global warming on air quality and public health, since large-scale fires can greatly increase population exposure to PM and other harmful pollutants. The outbreak of wildfires that swept across California in late June 2008 caused ambient concentrations of ozone and PM to soar to unprecedented levels.[37] A recent study found that the PM concentrations not only reached high levels, but that the PM released by these fires was much more toxic than the PM more typically present in the California atmosphere.[38] Acute episodes that combine high levels of PM with much more toxic PM could be especially dangerous to sensitive individuals with pre-existing lung conditions. In addition to these health effects, wildfires also release immense quantities of CO2 stored in trees and vegetation; thus, in an example of a negative feedback loop, fires provoked by global warming create yet more of the gases that exacerbate the problem.

Other impacts of climate change are also likely to have a negative effect on public health, including an increase in vector-borne diseases, and mortality directly caused by longer and more severe heat waves.

Addressing Climate Protection in the CAP

Although reducing greenhouse gas emissions to protect the climate is a key goal for this plan, the CAP is not intended to serve as a comprehensive regional climate protection plan. Instead, the CAP focuses on integrating climate protection into the control strategy to reduce criteria pollutants and air toxics. The CAP control strategy also proposes several new Energy & Climate Measures to reduce emissions of GHGs and mitigate the impacts of climate change.

Greenhouse gas emission inventory data and an analysis of GHG trends are provided in Chapter 2. Existing state, regional, and local efforts to protect the climate are briefly described in Chapter 3. The new Energy & Climate control measures, and other measures that help to reduce GHGs, are presented in Chapter 4. Chapter 5 summarizes how climate protection is addressed in the CAP.

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[36] Westerling, A. L., H. Hidalgo, D.R. Cayan, and T. Swetnam, 2006: Warming and Earlier Spring Increases Western US Forest Wildfire Activity, *Science*, 313: 940-943. This study found that large wildfire activity increased suddenly and markedly in the mid-1980s, with greater frequency of large wildfires, longer wildfire durations, and longer wildfire seasons. The study concluded that this is strongly associated with increased spring and summer temperatures and an earlier spring snowmelt.

[37] During the final week of June 2008, PM2.5 levels increased five or ten-fold compared to normal readings at several Bay Area monitoring stations.

[38] Wegesser et al. "California Wildfires of 2008: Coarse and Fine Particulate Matter Toxicity." *Environmental Health Perspectives* Volume 117, June 2009

Chapter 2 – Technical Foundation

Overview

Sound air quality planning requires a solid technical foundation. This chapter provides the technical underpinnings for the 2010 CAP. The first part of this chapter describes air quality standards and Bay Area attainment status for the various criteria pollutants, and provides an overview of the Air District's emissions inventories, as well as photo-chemical air quality modeling that has informed this plan. Profiles of each of the four major categories of air pollutants addressed in the CAP are provided in the remainder of this chapter. The profiles describe health impacts, emissions inventories, trends in ambient concentrations, and air quality modeling results, as appropriate, for:

- Ground-level ozone and ozone precursors: ROG [77] and NOx:
- Particulate matter (PM), both directly emitted and secondary PM
- Key air toxics, such as diesel PM and benzene
- The "Kyoto 6" greenhouse gases

Ambient Air Quality Standards and Bay Area Attainment Status

The federal Clean Air Act of 1970 directed US EPA to establish national ambient air quality standards (NAAQS), at a level to provide an adequate margin of safety to protect public health, for six air pollutants: ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, lead, and particulate matter. These six pollutants are commonly referred to as criteria pollutants because, in setting the NAAQS, US EPA develops a "Criteria Document" that summarizes the scientific evidence on the sources, concentrations, atmospheric dynamics, and health effects of a pollutant. After considering recommendations from an independent committee of experts – the Clean Air Science Advisory Committee (CASAC) - EPA staff presents a range of values for the standard, from which the EPA administrator selects the final standard. EPA is required to review and potentially revise the NAAQS every five years, in light of new scientific evidence.

The State of California also establishes air quality standards, referred to as "state standards" in this plan. State standards are determined by the California Air Resources Board (CARB), based on technical input from the Office of Environmental Health Hazard Assessment (OEHHA). In many cases, state standards are more stringent than national standards.

[77] The term ROG (reactive organic gases) is used interchangeably with the term VOC (volatile organic compounds). ROG / VOC include hundreds of reactive hydrocarbon compounds.

Air quality standards may be set for different time intervals, ranging from hourly averaged measurements to annual averages. There are multiple standards that apply to some pollutants, such as ozone and PM. Determining whether an air basin attains a given standard requires comparing monitored pollutant values, such as an hourly peak or annual average, with the standard. For purposes of determining whether an air basin attains a given air quality standard, a metric called the *design value* is calculated for each monitoring station. The way the design value is calculated depends upon how the standard is defined; i.e. the "form of the standard." An air basin (e.g., the Bay Area) generally meets the standard for a given pollutant only if the design values for all monitoring sites do not exceed the standard.

Ambient concentrations of all six of the criteria pollutants have been greatly reduced in the Bay Area over the past four decades. The Bay Area attains all national and state standards for four of the six criteria pollutants - lead, carbon monoxide, sulfur dioxide, and nitrogen dioxide. In fact, as shown by the design values in Table 2-1, Bay Area concentrations are well below (i.e., much cleaner than) current standards for these four pollutants. However, the Bay Area does not yet attain standards for ozone and PM.

The national 8-hour ozone standard was lowered to 0.075 ppm in March 2008. US EPA is currently reviewing this standard and considering reducing it to somewhere in the range of 0.060 to 0.070 ppm. It is likely that the Bay Area will be designated as non-attainment when US EPA sets the revised national 8-hour ozone standard and completes the process to designate the attainment status for each air basin under the new standard. The Bay Area does not yet attain the 0.070 ppm State 8-hour ozone standard.

There are national and state standards for both fine PM (PM2.5) and coarse PM (PM10). There are separate standards for annual average PM and for maximum 24-hour concentrations. In 2002, California adopted an annual PM2.5 standard, but the State has yet to adopt a short-term 24-hour PM standard. Recent monitoring data indicates that the Bay Area meets the state annual PM2.5 standard,[78] but the region does not attain the state annual and 24-hour standards for PM10.

The Bay Area attains the national 24-hour PM10 standard and the national annual PM2.5 standard, but violates the national 24-hour PM2.5 standard. The national 24-hour PM2.5 standard was tightened to 35 $\mu g/m^3$ in 2006. The Bay Area was designated as non-attainment for this standard on November 13, 2009. The Air District will be required to prepare a PM2.5 State Implementation Plan (SIP) by December 2012.

[78] Monitoring data shows that the Bay Area now complies with the State annual PM2.5 standard. However, because the region has not yet been re-designated as attainment for the State annual PM2.5 standard by CARB, the Bay Area is shown as non-attainment for this standard in Table 2-1.

Although there are national and state ambient air quality standards (AAQS) for the criteria pollutants, there are no AAQS for air toxics or greenhouse gases. Air toxics are regulated differently, as explained in the Air Toxics section below. Greenhouse gases are pollutants of a global nature. Although the State of California adopted the Global Warming Solutions Act (commonly referred to as AB 32) in 2006 to reduce emissions of greenhouse gases, the regulatory framework to address GHGs at the national and international level is still under development.

Table 2-1 summarizes current national and state standards, Bay Area attainment status, and Bay Area design values for the national standards for the six criteria pollutants.

Table 2-1. Standards for criteria pollutants, attainment status, and design values[a].

Pollutant	Averaging Time	California Standard[b]	Attainment Status	National Standard	Attainment Status	National Design Value[c] (2008)
Ozone	1-hour	0.09 ppm	N			
Ozone	8-hour	0.070 ppm	N	0.075 ppm – 3-yr average of 4th highest value	N[d]	0.081 ppm[e]
CO	1-hour	20 ppm	A	35 ppm – not to be exceeded > once per year	A	3.8 ppm
CO	8-hour	9 ppm	A	9 ppm – not to be exceeded > once per year	A	2.2 ppm
$PM_{2.5}$	24-hour			35 $\mu g/m^3$ – 3-year 98th percentile	N[f]	36 $\mu g/m^3$
$PM_{2.5}$	Annual	12 $\mu g/m^3$ – 3-year max	N	15 $\mu g/m^3$ – 3-year average	A	11.0 $\mu g/m^3$
PM_{10}	24-hour	50 $\mu g/m^3$	N	150 $\mu g/m^3$ [g]	U	78 $\mu g/m^3$
PM_{10}	Annual	20 $\mu g/m^3$	N			26 $\mu g/m^3$
SO2	1-hour	0.25 ppm	A			
SO2	24-hour	0.04 ppm	A	0.14 ppm – not to be exceeded > once per year	A	0.0101 ppm
SO2	Annual			0.030 ppm		0.0017 ppm
NO2	Annual	0.030 ppm	A	0.053 ppm	A	0.017 ppm
NO2	1-hour	0.18 ppm	A			0.073 ppm
Lead	Quarterly			1.5 $\mu g/m^3$	A	< 0.01 $\mu g/m^3$

* A = Attainment N = Non-Attainment U = Unclassified

[a] Design values are computed on a site-by-site basis. District design value is the highest design value at any individual monitoring site.

[b] California standards are nominally "not to be exceeded," but, other than for annual standards, in practice allow approximately 1 exceedance per year.

[c] The national design value is a statistic based on the monitored concentrations that can be compared with the corresponding standard. The standard is violated if the design value exceeds the standard.

[d] In June 2004, the Bay Area was designated as a marginal nonattainment area of the national 8-hour ozone standard. US EPA lowered the national 8-hour ozone standard from 0.080 to 0.075 PPM (or 75 ppb) in March 2008. US EPA is currently reviewing the 8-hour ozone standard, with a decision expected in July 2011.

[e] Preliminary data show the District's 2009 ozone design value as 0.078 ppm.

[f] US EPA tightened the national 24-hour PM2.5 standard from 65 to 35 μg/m^3 in 2006. The designation of the Bay Area as non-attainment for the 24-hr national PM2.5 standard became effective on December 14, 2009.
[g] The national 24-hour PM10 standard allows one exceedance per year over 3 years with every-day sampling. Because PM10 is sampled on a 1-in-6 day schedule, this means that, in practice, any exceedance would violate the standard.

BAAQMD Monitoring Network

The Air District's air monitoring program operates a network of 28 air monitoring stations to measure air quality levels in the Bay Area, as shown in Table 2-2. The monitoring network is designed to (1) provide the data required to determine the Bay Area's attainment status for both national and state ambient air quality standards; (2) provide air quality data to the public in a timely manner; and (3) support air pollution research and modeling studies. The monitoring network is evaluated and updated on a regular basis in response to changes in monitoring requirements, shifts in population, and other factors. The Air District revises its *Air Monitoring Network Plan* annually to describe changes and improvements to the monitoring network; this plan is available on the District web site. Table 2-2 shows the list of monitoring stations operated by the Air District in 2009.

Table 2-2. Bay Area monitoring stations and pollutants monitored in 2009.

Site	Location	Monitoring Objective *	Pollutants Monitored
1	Berkeley	Population Oriented, Source Impact	O_3, NO_2, SO_2, CO, HC, PM_{10}, $PM_{2.5cont}$, Toxics
2	Bethel Island	Regional Transport	O_3, NO_2, SO_2, CO, PM_{10}, Toxics
3	Concord	Population Oriented & Highest Concentration	O_3, NO_2, SO_2, CO, HC, PM_{10}, $PM_{2.5}$, Toxics
4	Crockett	Source Impact	SO_2, Toxics
5	Cupertino	Population Oriented & Source Impact	PM_{10cont}
6	Fairfield	Regional Transport	O_3
7	Fort Cronkhite	Background	Toxics
8	Fremont	Population Oriented	O_3, NO_2, CO, HC, PM_{10}, $PM_{2.5cont}$, Toxics
9	Gilroy	Population Oriented, Highest Concentration, & Regional Transport	O_3, $PM_{2.5cont}$
10	Hayward	Population Oriented & Regional Transport	O_3
11	Livermore	Highest Concentration	O_3, NO_2, CO, HC, PM_{10}, $PM_{2.5}$, $PM_{2.5cont}$, Speciated $PM_{2.5}$, Toxics
12	Los Gatos	Highest Concentration	O_3
13	Martinez	Source Impact	SO_2, Toxics
14	Napa	Population Oriented	O_3, NO_2, CO, PM_{10}, $PM_{2.5cont}$, Toxics

Table 2-2 (continued). Bay Area monitoring stations and pollutants monitored in 2009

Site	Location	Monitoring Objective *	Pollutants Monitored
15	Oakland	Population Oriented	O_3, NO_2, CO, $PM_{2.5cont}$, Toxics
16	Oakland West	Population Oriented	NO_2, SO_2, CO, $PM_{2.5cont}$, Toxics, Black Carbon
17	Pt Reyes	General Background	$PM_{2.5cont}$
18	Pt Richmond	Source Impact	H_2S
19	Redwood City	Population Oriented	O_3, NO_2, CO, PM_{10}, $PM_{2.5}$, $PM_{2.5cont}$, Toxics
20	Richmond 7th	Source Impact	SO_2, H_2S, Toxics
21	Rodeo	Source Impact	H_2S
22	San Francisco	Population Oriented	O_3, NO_2, SO_2, CO, HC, PM_{10}, $PM_{2.5cont}$, $PM_{2.5}$, Toxics
23	San Jose	Population Oriented & Highest Concentration	O_3, NO_2, CO, HC, PM_{10}, $PM_{2.5}$, $PM_{2.5cont}$, Speciated $PM_{2.5}$, Toxics, Black Carbon
24	San Martin	Highest Concentration	O_3
25	San Pablo	Population Oriented	O_3, NO_2, SO_2, CO, PM_{10}, Toxics
26	San Rafael	Population Oriented	O_3, NO_2, CO, PM_{10}, $PM_{2.5cont}$, Toxics
27	Santa Rosa	Population Oriented	O_3, NO_2, CO, PM_{10}, $PM_{2.5}$, Toxics
28	Vallejo	Population Oriented	O_3, NO_2, SO_2, CO, PM_{10}, $PM_{2.5}$, $PM_{2.5cont}$, Speciated $PM_{2.5}$, Toxics

* Explanation of Monitoring Objectives in Table 2-2:
Population Oriented: Monitor in areas with high population density.
Highest Concentration: Monitor in areas expected to have the highest concentrations.
Source Impact: Monitor downwind of major stationary sources, such as the five Bay Area oil refineries: Chevron, Shell, Tesoro, Conoco-Phillips, and Valero.
General Background: Monitor in area with no significant emissions from mobile, area, or industrial sources, in order to establish background concentrations.
Regional Transport: Monitor along boundaries with other air districts to measure concentrations of pollutants transported into and out of the Bay Area.

A map showing the 2009 Bay Area monitoring network is shown in Figure 2-1.

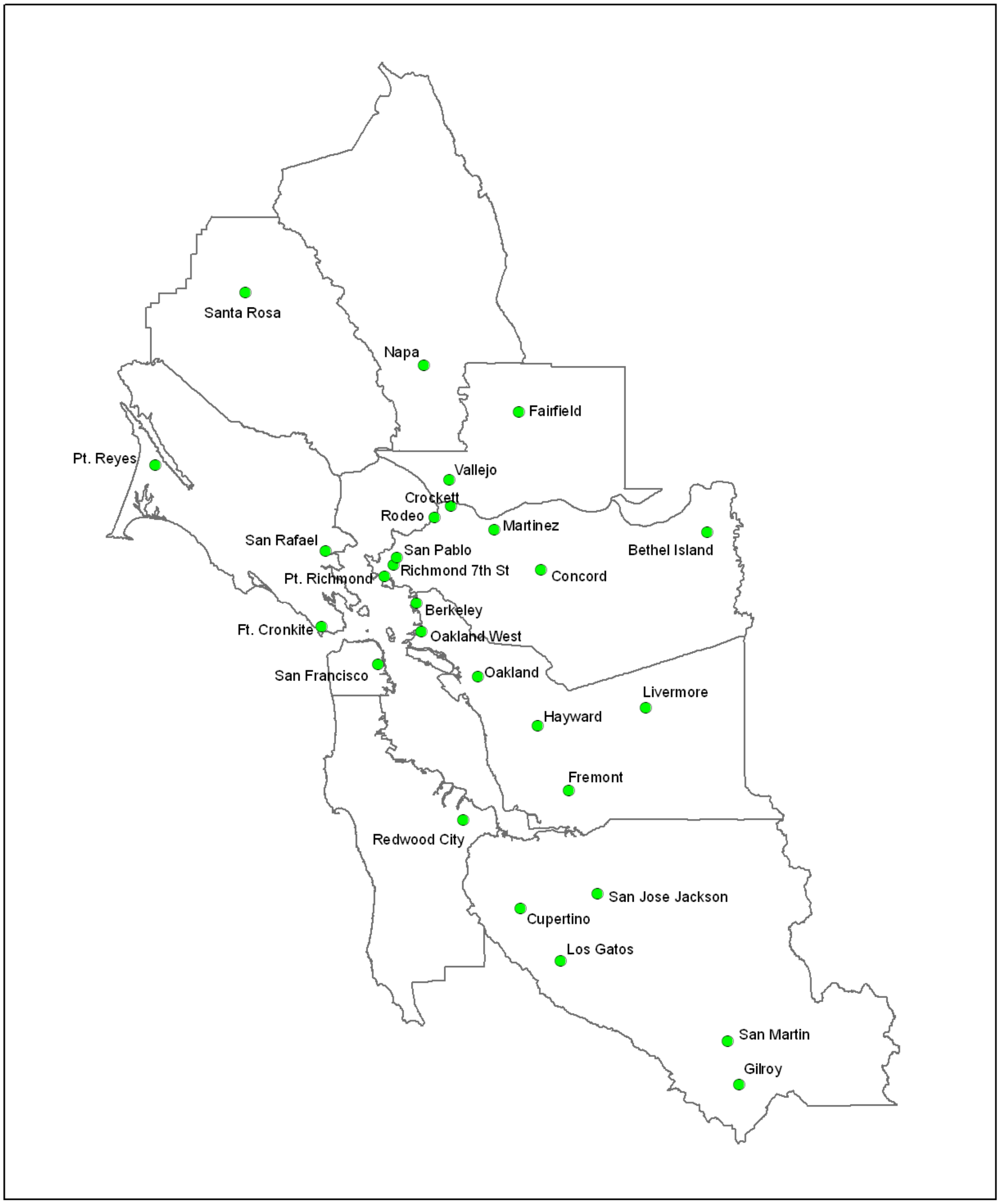

Figure 2-1. 2009 BAAQMD Air Monitoring Network.

Emission Sources

The major categories of emission sources are described in this section. For some pollutants, such as ROG, there are biogenic (natural) sources of emissions, as well as anthropogenic (man-made) sources. However, emissions inventories and control strategies focus on anthropogenic emissions, since these are most readily subject to control.

The two most basic emission source categories of anthropogenic emissions are stationary sources and mobile sources. Stationary sources include both point sources and area sources. Point sources are those that are identified on an individual facility or source basis, such as refineries and manufacturing plants. For point sources, the District's inventories are based on a computer data base with detailed information on operations and emissions characteristics for nearly 4,000 facilities, with roughly 20,000 different sources, throughout the Bay Area. Data on the activity, seasonal variations, and hours of operation are collected at the process level from each facility. Parameters that affect the quantities of emissions are updated regularly. The emissions from general processes, such as combustion, are computed using generalized or specific emission factors.

Area sources are stationary sources that are individually small, but collectively make a significant contribution to the inventory. Many area sources do not require permits from the Air District, such as residential furnaces and water heaters, and consumer products including paints, solvents, and cleaners. However, some facilities considered to be area sources, such as gas stations, do require permits from the Air District. Emissions estimates for area sources may come from the Air District's data base, from CARB calculations based on statewide data, or from calculations based on surrogate variables such as population.

Mobile sources include on-road motor vehicles such as automobiles, trucks and buses, as well as off-road sources such as construction equipment; boats, ships, trains and aircraft; and small non-road engines including lawn and garden equipment. Estimates of on-road motor vehicle emissions include consideration of the number of vehicles and the fleet mix (vehicle type, model year, and accumulated mileage); miles traveled; ambient temperatures; vehicle speeds; and vehicle emission factors, as developed from Smog Check data, Caltrans vehicle counts, and CARB testing programs.

On-road motor vehicle emissions estimates are based on CARB's latest available emission factor model (EMFAC 2007, Version 2.3, November 2006). Bay Area emission factors incorporate projected growth in vehicle miles of travel (VMT) for the Bay Area developed by the Metropolitan Transportation Commission (MTC) from its travel demand model for the Transportation Air Quality Conformity Analysis of the Regional Transportation Plan 2030 (RTP 2030). MTC's travel demand model utilizes regional demographic forecasts from ABAG's socio-economic and population projections, in this case, Projections 2007.

Off-road mobile sources include boats, ships, trains, and aircraft, as well as garden, farm and construction equipment. Various methodologies are used for compilation of emissions for these mobile sources. Emission factors and methodologies for off-road mobile sources are calculated from information provided by CARB and EPA. Aircraft mix and activity data specific to each Bay Area airport are used in estimating airport emissions.

Emissions Subject to Air District Control

The Air District has direct regulatory authority over stationary and certain area sources, which account for only a relatively small portion of the sources that comprise the Bay Area emissions inventory. This is especially true in the case of ROG and NOx, which are precursors to the formation of both ozone and secondary PM. In California, CARB establishes emissions standards for on-road and off-road vehicles, as well as vehicles fuels and consumer products. US EPA is responsible for establishing emission standards for ships, aircraft, and locomotives. Therefore, progress in reducing both emissions and concentrations in the Bay Area will depend to a great extent upon actions at the State and federal levels to reduce emissions from sources under their control.

In Figures 2-2 through 2-4 "District jurisdiction" includes stationary and area sources, such as factories, refineries, gas stations, commercial cooking, and wood-burning; "CARB jurisdiction" refers to on-road and off-road vehicles and equipment; and "Federal jurisdiction" includes ships, locomotives, and aircraft. In Figure 2-4, "Non-Regulated" emissions of PM2.5 include dust from construction and farming operations, dust from paved and unpaved roads, other geologic dust, and PM from wildfires.

Although it has no direct authority over motor vehicle emissions, the Air District does work, in partnership with MTC, ABAG, and other agencies, to implement programs to reduce motor vehicle travel and promote the use of clean vehicle technologies, as described in the Mobile Source Measures and the Transportation Control Measures components of the CAP control strategy.

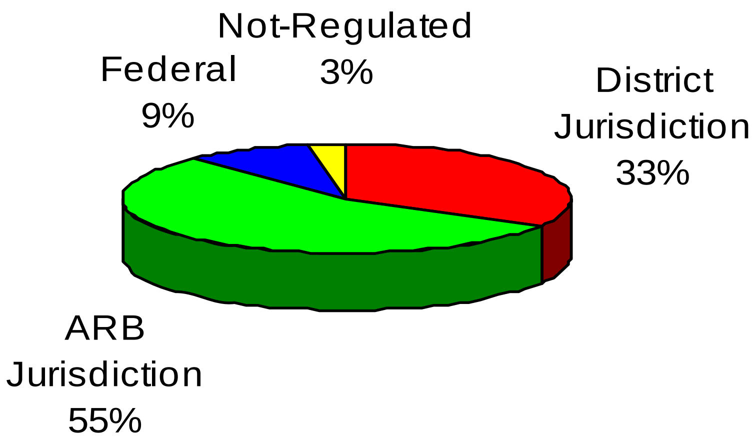

Figure 2-2. Reactive organic gases (ROG), 2009 annual average emissions (344 tons/day).

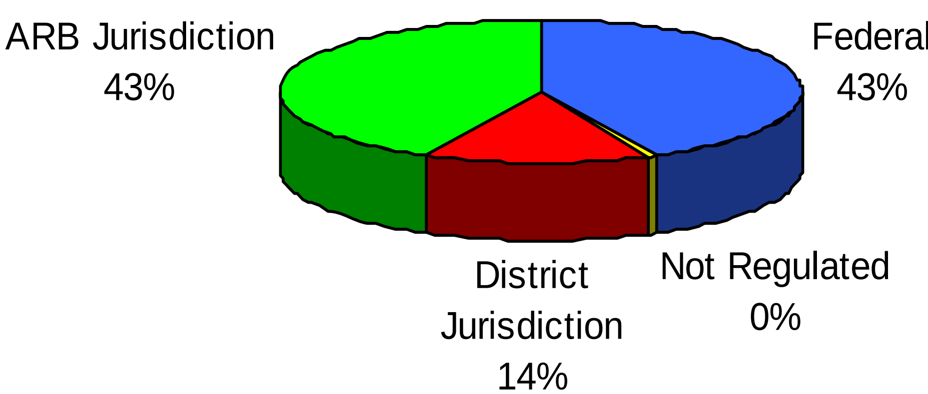

Figure 2-3. Oxides of nitrogen (NOx), 2009 annual average emissions (460 tons/day).

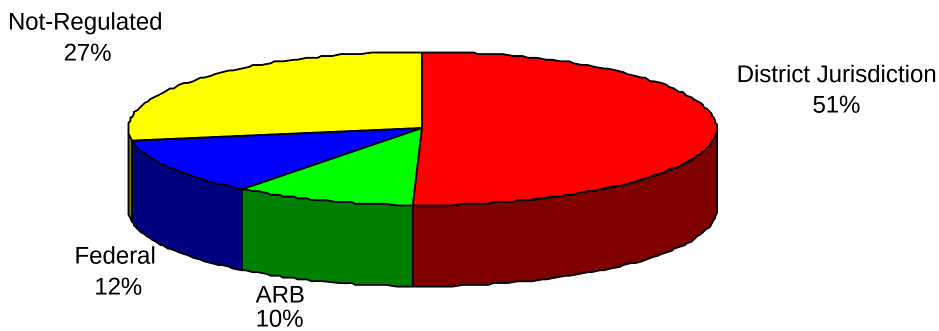

Figure 2-4. Directly emitted $PM_{2.5}$, 2009 annual average emissions (87 tons/day).

Emissions Inventories

Emissions inventories are essential tools for air quality planning. Inventories identify source categories and provide estimates of emissions from each source. Emissions inventories undergo constant refinement in order to reflect changes in emission factors (such as turnover in the vehicle fleet), economic and demographic trends, and rule-making activity. Emissions inventories are used to perform air quality modeling, to identify source categories where there may be opportunities for additional emission reductions, and to estimate potential emission reductions for control measures under consideration. Developing inventories and emission factors for all the pollutants addressed is one of the key technical prerequisites needed to prepare a multi-pollutant air quality plan.

The Air District develops and maintains detailed emissions inventories for a variety of pollutants, including ROG, NOx, PM2.5, and PM10. In recent years, the Air District has also developed an air toxics inventory, as well as an ammonia inventory (ammonia is a key precursor to secondary formation of PM). In November 2006, the Air District became the first air quality agency in the nation to develop a detailed regional greenhouse gas inventory; the GHG inventory was updated in December 2008.

Emissions inventories can be prepared for different seasons (summer or winter) or based on annual average emissions. For purposes of ozone planning, it is customary to use the summer emissions inventory, since this is when ozone exceedances normally occur. For PM planning, the winter emissions inventory is normally used, because PM exceedances typically occur during winter months. Since the 2010 CAP addresses both ozone and PM, Air District staff decided, after consulting with CARB air quality planning staff, to use the annual average inventory in order to avoid potential confusion related to differences between the summer and winter inventories.

Emissions inventories for the various pollutants are described in detail in the profiles of ozone, PM, air toxics, and greenhouse gases provided below. Overall, the emission inventories for criteria pollutants and air toxics have shown a steady downward trend in recent decades. This reflects the combined effect of state and regional programs to reduce emissions, including the Air District's regulations to reduce emissions from stationary sources, CARB programs to reduce emissions from mobile sources, and turnover in the motor vehicle fleet whereby older, high-emitting vehicles are replaced by new vehicles that meet stringent CARB emissions standards. Looking forward, emissions from motor vehicles will continue to decline on a per-mile basis, primarily due to turnover in the vehicle fleet, in combination with CARB regulations to reduce emissions from heavy-duty vehicles, as described in Chapter 3. However, this progress will be offset, at least in part, by continued growth in total vehicle travel in the region.

Whereas emissions of criteria pollutants and air toxics have been decreasing, emissions of CO2 and other greenhouse gases have been increasing, and would be projected to continue to increase under a "business as usual" scenario.

Photochemical Modeling

The Air District has extensive in-house photochemical modeling capabilities. The Air District applies photochemical models to simulate ozone, air toxics, and PM. Ozone modeling started in 1989, air toxics modeling in 2005, and PM modeling in 2008. Model applications and types of models used depend on a number of factors, including Air District needs, U.S. EPA and CARB requirements, staff expertise, availability of appropriate models, and the nature of the problems being investigated.

Although no air quality modeling was required to be performed for the 2010 CAP, results of the Air District's recent modeling work were used in developing the 2010 CAP. In particular, results of photochemical modeling were used for the first time to help evaluate the air quality and health impacts of emission control measures on a multi-pollutant basis. Modeling to show how changes in emissions of ozone precursors, PM, and toxics affect ambient concentrations of these pollutants was essential to the development of the Multi-Pollutant Evaluation Method (MPEM) described in Chapter 1.

In coming years, the Air District intends to develop the capacity to perform integrated "one atmosphere" air quality modeling for ozone, PM, toxics, and greenhouse gases. This will improve our multi-pollutant planning capabilities. Integrated modeling will require a modeling platform based upon unified, full-year, multi-pollutant emission inventories; a single modeling system; and full-year meteorological fields.[79]

Results of modeling performed for ozone, PM, wood smoke, and air toxics are briefly summarized in the respective pollutant profile sections below. A more detailed description of the Air District's modeling work is provided in Appendix E.

Profiles of Pollutants Addressed in the CAP

A profile of each of the four pollutant categories addressed in the CAP is provided below.

Ozone

Ozone (O3), a powerful oxidant, is harmful to public health at high concentrations near ground level.[80] Ozone can damage the tissues of the lungs and respiratory tract. High concentrations of ozone irritate the nose, throat, and respiratory system and constrict the airways. Ozone also can aggravate other respiratory conditions such as asthma, bronchitis, and emphysema, causing increased hospital admissions. Repeated exposure to high ozone levels can make people more susceptible to respiratory infection and lung inflammation and permanently damage lung tissue. Ozone can also have negative cardiovascular impacts, including chronic hardening of the arteries and acute triggering of heart attacks. Children are most at risk, as they tend to be active and outdoors in the summer, when ozone levels are highest. Seniors and people with respiratory illnesses are also especially sensitive to ozone's effects. Even healthy adults, working or exercising outdoors during high ozone levels, can be affected.

Ozone also damages leaf tissue in trees and other plants, and reduces yields of agricultural crops. [81] This reduces the ability of trees and plants to photosynthesize and produce their own food. Ozone can also cause substantial damage to a variety of materials such as rubber, plastics, fabrics, paint, and metals. Exposure to ozone

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[79] The availability of modeling results that cover an entire year would eliminate the need to extrapolate episodic modeling results to the full year (as was done for the MPEM used in the 2010 CAP).

[80] While ground-level ozone is a harmful air pollutant, ozone in the upper atmosphere is beneficial because it blocks the sun's harmful ultraviolet rays. The 2010 Clean Air Plan addresses ground-level ozone only.

[81] In fact, the need to reduce damage to orchards in the Santa Clara Valley was a major factor in the creation of the Bay Area AQMD in 1955, when agriculture was still the backbone of the economy in the South Bay.

progressively damages both the functional and aesthetic qualities of materials and products, and shortens their life spans. Damage from ozone exposure can result in significant economic losses as a result of the increased costs of maintenance, upkeep, and replacement of these materials.

Ozone Dynamics

Ozone is not emitted directly from pollution sources. Instead, ozone is formed in the atmosphere through complex chemical reactions in the presence of sunlight between two types of precursor chemicals: hydrocarbons, often referred to as "reactive organic gases" (ROG), and nitrogen oxides (NOx). As air temperatures rise, the formation of ground-level ozone increases at an accelerated pace. Ozone levels are usually highest on hot, windless summer afternoons, especially in inland valleys.

Ozone is a regional pollutant. Emissions of ROG and NOx throughout the Bay Area contribute to ozone formation. Because emissions in one part of the region can impact air quality miles away, efforts to reduce ozone levels focus on reducing emissions of ROG and NOx throughout the region.

The relationship between ROG and NOx in ozone formation is complex; the ratio between the precursor pollutants influences how ozone forms. The Air District's ozone modeling indicates that the Bay Area is "ROG-limited" for ozone formation. This means that reducing ROG emissions will be more productive in reducing ozone, at least in the near term. However, modeling also suggests that large reductions in NOx emissions will be needed to achieve the steep ozone reductions required to attain the very stringent ozone standards.

A certain amount of ozone formation occurs naturally, even in the absence of anthropogenic emissions of ROG and NOx. This natural ozone is referred to as the "background level." Locally, background ozone appears to have increased, perhaps due to reductions in other pollutants: some air pollutants react with and eliminate ozone, sometimes reducing ambient concentrations.[82] Also, as discussed in Chapter 1, increasing emissions of methane at the global scale may be increasing background levels of ozone. In the recent past, ozone standards were roughly three times higher than background levels. Because ozone standards have been tightened, the standards are now less than twice the estimated background level, and may be reduced to even more stringent levels in the future.

Ozone formation in the Bay Area is strongly influenced by the location and strength of the Eastern Pacific High Pressure System. During the summer months, this system normally develops over the Pacific Ocean and travels towards the east. From time to time, depending upon its strength and route of travel, it blocks westerly airflow exiting

[82] For example, NO combines with O3 (ozone) to produce NO2 and O2.

the Bay Area into the Central Valley and develops meteorological conditions conducive to ozone production: light winds, high temperatures, sunny and clear sky conditions, and a shallow mixing layer. When these conditions occur in mid-summer, typically airflow from the core Bay Area penetrates into the Livermore Valley through the I-680 corridor from the north and various gaps along the East Bay ridge from the west, carrying polluted air and causing ozone exceedances. At other times, especially in early or late summer, airflow with a weaker westerly push that is unable to cross the East Bay ridge flows southward, causing ozone exceedances in the Santa Clara Valley. San Martin is frequently the exceedance site in the Santa Clara Valley under these conditions.

Sources of Ozone Precursors – Emissions Inventory

There are literally millions of sources of ozone precursors in the Bay Area, including industrial and commercial facilities, motor vehicles, and consumer products such as household cleaners and paints. Even trees and plants produce ozone precursors. Sources of ozone precursors produced by human activity are called “anthropogenic” while natural sources, produced by plants and animals, are called “biogenic”. In the Bay Area, emissions from anthropogenic sources are higher than from biogenic sources.

The main sources of ROG emissions in the Bay Area are motor vehicles and evaporation of solvents, fuels and other petroleum products, as shown in Figure 2-5. The main sources of NOx are motor vehicles and combustion at industrial and other facilities, as shown in Figure 2-6.

The Bay Area annual average emission inventory for ozone precursors, ROG and NO_X is presented in Table 2-3.[83] The inventory is based upon CARB EMFAC 2007, Version 2.3 and reflects the effect of regulations adopted as of December 31, 2006. The inventories do not include additional emissions reductions from State or federal measures adopted since 2007 or CARB’s “Pavley regulations” to reduce greenhouse gases from motor vehicles. Estimated emission reductions of ROG, NOx, and PM from CARB regulations not reflected in the current inventory are shown in Table 3-10.

[83] Summer and winter emissions inventories are provided in the “Base Year 2005 Emissions Inventory Summary Report” issued by BAAQMD in December 2008. See www.BAAQMD.gov

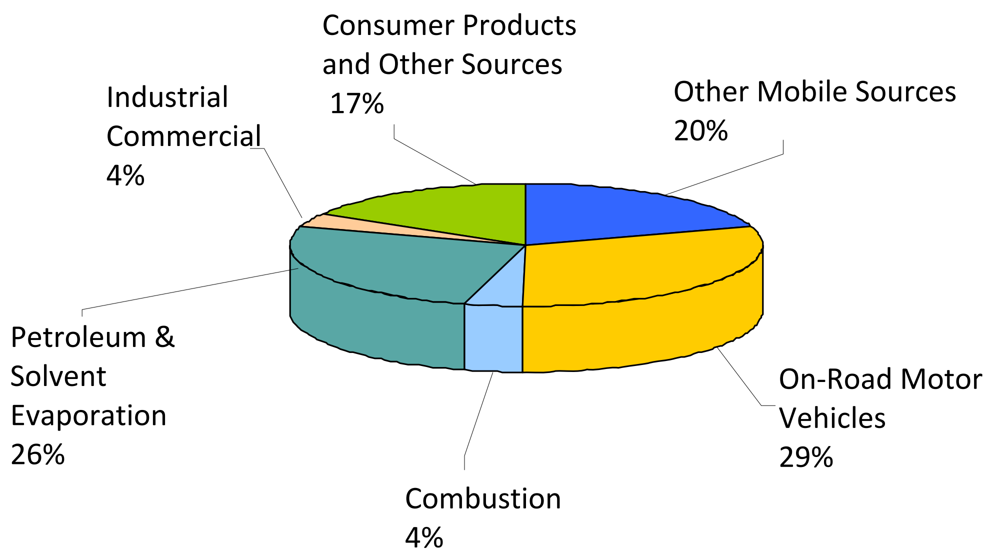

Figure 2-5. ROG anthropogenic emissions by source, 2009.

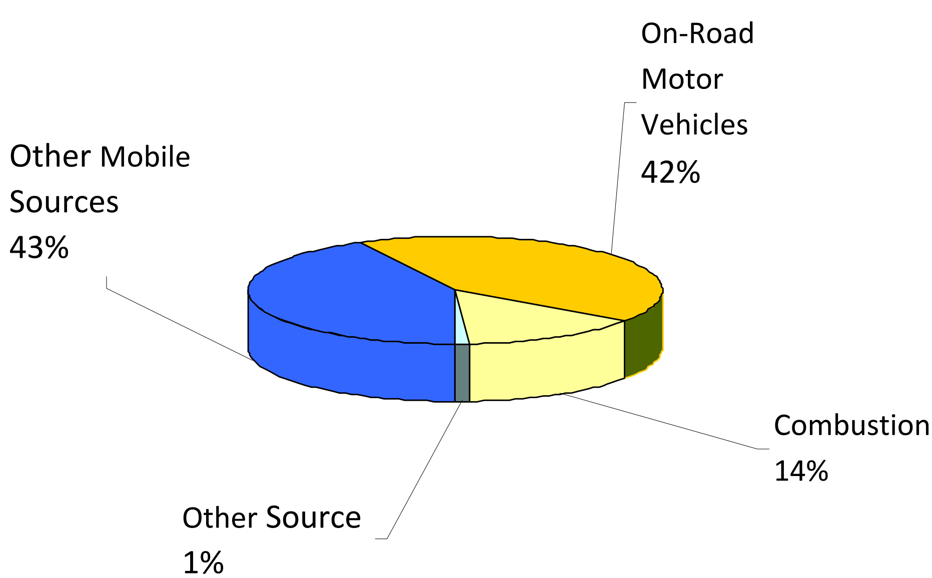

Figure 2-6. NOx emissions by source, 2009.

Table 2-3. Bay Area inventory 2005-2020, ROG & NO_x.

Bay Area Baseline [1] Emission Inventory Projections: 2005 - 2020										
Annual Average Inventory [2] (Tons/Day) [3]										
	Reactive Organic Gases [4]					Oxides of Nitrogen [5]				
SOURCE CATEGORY	**2005**	**2009**	**2012**	**2015**	**2020**	**2005**	**2009**	**2012**	**2015**	**2020**
INDUSTRIAL/COMMERCIAL PROCESSES										
PETROLEUM REFINING FACILITIES										
Basic Refining Processes	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3
Wastewater (Oil-Water) Separators	1.9	0.9	0.9	0.9	1.0	--	--	--	--	--
Wastewater Treatment Facilities	0.1	0.1	0.1	0.1	0.1	--	--	--	--	--
Cooling Towers	2.2	2.2	2.3	2.4	2.5	--	--	--	--	--
Flares & Blowdown Systems	0.8	0.8	0.8	0.9	0.9	0.2	0.2	0.2	0.2	0.3
Other Refining Processes	0.1	0.2	0.2	0.2	0.2	--	--	--	--	--
Fugitives	0.6	0.6	0.7	0.7	0.7	--	--	--	--	--
Subtotal	**5.8**	**5.0**	**5.1**	**5.3**	**5.5**	**0.5**	**0.5**	**0.6**	**0.6**	**0.6**
CHEMICAL MANUFACTURING FACILITIES										
Coating, Inks, Resins & Other Facilities	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1
Pharmaceuticals & Cosmetics	0.7	0.7	0.7	0.7	0.7	1.5	1.6	1.7	1.7	1.9
Fugitives – Valves & Flanges	0.7	0.7	0.7	0.8	0.8	--	--	--	--	--
Subtotal	**1.6**	**1.6**	**1.7**	**1.7**	**1.9**	**1.6**	**1.7**	**1.7**	**1.8**	**2.0**
OTHER INDUSTRIAL/COMMERCIAL PROCESSES										
Bakeries	0.9	1.0	1.0	1.0	1.1	--	--	--	--	--
Cooking	1.3	1.2	1.3	1.3	1.3	--	--	--	--	--
Wineries & Other Food & Agr. Processes	1.5	1.5	1.6	1.7	1.9	--	--	--	--	--
Metallurical & Minerals Manufacturing	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2
Waste Management	5.6	5.8	5.8	5.9	6.0	--	--	--	--	--
Semiconductor Manufacturing	0.3	0.3	0.3	0.3	0.3	--	--	--	--	--
Fiberglass Products Manufacturing	0.3	0.3	0.3	0.3	0.4	--	--	--	--	--
Rubber & Plastic Products Manufacturing	0.3	0.3	0.3	0.4	0.4	--	--	--	--	--
Contaminated Soil Aeration	0.1	0.1	0.1	0.1	0.1	--	--	--	--	--
Other Industrial Commercial	0.8	0.8	0.9	0.9	1.0	--	--	--	--	--
Subtotal	**11.2**	**11.5**	**11.8**	**12.1**	**12.6**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**

Table 2-3 (continued). Bay Area inventory 2005-2020, ROG & NO_x.

	Reactive Organic Gases [4]					Oxides of Nitrogen [5]				
SOURCE CATEGORY	**2005**	**2009**	**2012**	**2015**	**2020**	**2005**	**2009**	**2012**	**2015**	**2020**
COMBUSTION - STATIONARY SOURCES										
FUELS COMBUSTION										
Domestic	9	9.3	9.6	9.8	10.3	14.4	14.9	15.2	15.6	16.2
Cogeneration	1.4	1.4	1.5	1.5	1.6	4.1	4.2	4.2	4.3	4.6
Power Plants	--	0.1	0.1	0.1	0.1	1.7	2.2	2.2	2.3	2.5
Oil Refineries External Combustion	0.5	0.5	0.5	0.5	0.6	13.7	14.2	14.7	15.1	15.9
Glass Melting Furnaces - Natural Gas	--	--	--	--	--	1.4	1.4	1.5	1.6	1.7
Reciprocating Engines	0.8	0.7	0.6	0.5	0.4	7.7	7.1	6.8	6.5	5.9
Turbines	0.1	0.1	0.1	0.1	0.1	1.6	1.6	1.6	1.7	1.8
Landfill/Cement Plant Combustion	1.2	1.3	1.3	1.4	1.4	16.7	15.3	15.8	16.3	17.1
Subtotal	**13**	**13.3**	**13.6**	**13.9**	**14.5**	**61.2**	**60.9**	**61.9**	**63.2**	**65.6**
BURNING OF WASTE MATERIALS										
Incineration	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.3
Planned Fires	0.3	0.3	0.3	0.3	0.4	0.2	0.2	0.2	0.2	0.2
Subtotal	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.5**	**0.5**
Banked Emissions 6	**0**	**9.5**	**9.5**	**9.5**	**9.5**	**0**	**7.2**	**7.2**	**7.2**	**7.2**
Alternative Compliance Allowance 7	**0**	**0**	**0**	**0**	**0**	**0**	**4.9**	**4.9**	**4.9**	**4.9**
Subtotal (District Jurisdiction)	**120.2**	**124.4**	**125.3**	**127.1**	**130.5**	**63.8**	**75.8**	**77**	**78.4**	**80.9**
COMBUSTION-MOBILE SOURCES										
ON-ROAD MOTOR VEHICLES										
Passenger Cars	66.3	45.1	33.2	25.6	18.6	52.4	35.4	26	19.3	12.5
Light Duty Trucks<6000lbs	41.3	33.6	29.2	25.4	20.5	50.4	36.9	29.8	23.9	16.5
Medium Duty Trucks 6001-8500 lbs	6	5	4.7	4.5	4.1	11.7	8.7	7.3	6.1	4.4
Light Heavy Duty Trucks 8501-14000lbs	5.2	4	3.4	3	2.5	12	10.2	8.8	7.9	6.6
Medium Heavy Duty Trucks 14001-33000lbs	4.4	3.2	2.4	1.9	1.3	31.7	26.3	20.8	15.9	10.1
Heavy Heavy Duty Trucks>33000 lbs	5.3	4.2	3.3	2.6	1.8	56.1	45.7	34.8	26	16.9
School/Urban Buses	1.2	1.1	1.1	1.1	1.1	16.4	16	15.8	15	14.1
Motor-Homes	0.4	0.3	0.2	0.2	0.1	1.3	1.1	1	0.8	0.5
Motorcycles	8.4	7.5	7	6.9	6.9	1.9	2	2	2.1	2.1
Subtotal	**138.5**	**103.9**	**84.6**	**71.0**	**56.6**	**233.7**	**182.3**	**146.3**	**116.9**	**83.7**

Table 2-3 (continued). Bay Area inventory 2005-2020, ROG & NO_x.

	Reactive Organic Gases [4]					Oxides of Nitrogen [5]				
SOURCE CATEGORY	**2005**	**2009**	**2012**	**2015**	**2020**	**2005**	**2009**	**2012**	**2015**	**2020**
OFF-HIGHWAY MOBILE SOURCES										
Lawn and Garden Equipment	19.5	16.5	15.1	14	12.9	2.9	2.4	2.3	2.2	2.2
Transportation Refrigeration Units	2.4	1.7	1.1	0.8	0.8	4.6	5.1	5.7	5.6	5.6
Agricultural Equipment	1.6	1.3	1	0.8	0.5	7.4	6.2	5.2	4.2	2.7
Construction and Mining Equipment	12.2	9.8	8.4	7.3	5.7	72.9	62.9	54.5	45.1	30.7
Industrial Equipment	3.7	2.6	2.1	1.8	1.6	20.7	15.6	12.8	10.6	8.3
Light Duty Commercial Equipment	7	5.7	4.8	4	3.3	7.9	7.1	6.5	5.6	4.4
Trains	1.1	1	1	1	1.1	13.8	11.9	12.8	13.1	13.8
Off Road Recreational Vehicles	1	0.8	0.8	0.9	1	0.1	--	--	--	0.1
Ships [8]	1.8	2.1	2.3	2.5	2.9	41.3	47	51.8	57.1	67.2
Commercial Boats	3	2.8	2.5	2.2	2.1	24.7	22.1	20	17.2	16.2
Recreational Boats	18.3	16.7	15.8	15.3	15.1	3.6	4.1	4.1	4.1	4.3
Subtotal	**71.6**	**60.8**	**54.9**	**50.5**	**47.1**	**199.8**	**184.4**	**175.7**	**164.9**	**155.4**
AIRCRAFT										
Commercial Aircraft	1.9	2.9	3.6	4.2	5.1	12.1	18.9	21.3	22.3	24.3
General Aviation	0.7	0.7	0.7	0.8	0.8	0.2	0.4	0.4	0.5	0.5
Military Aircraft	3.3	3.3	3.4	3.4	3.4	4.9	4.9	5	5	5.1
Airport Ground Support Equipment	0.9	1	1	1.1	1.2	3.8	4.1	4.3	4.5	4.9
MISCELLANEOUS OTHER SOURCES										
Construction Operations	--	--	--	--	--	--	--	--	--	--
Farming Operations	--	--	--	--	--	--	--	--	--	--
Entrained Road Dust-Paved Roads	--	--	--	--	--	--	--	--	--	--
Entrained Road Dust-Unpaved Roads	--	--	--	--	--	--	--	--	--	--
Wind Blown Dust	--	--	--	--	--	--	--	--	--	--
Animal Waste	5.5	5.5	5.5	5.5	5.5	--	--	--	--	--
Agricultural Pesticides	0.8	0.8	0.8	0.8	0.8	--	--	--	--	--
Non-Agricultural Pesticides	0.2	0.2	0.2	0.2	0.2	--	--	--	--	--
Consumer Products(Excluding Pesticides)	45.2	46.7	47.9	49.1	51.2	--	--	--	--	--
Other Sources	4	3.6	3.6	3.7	3.7	2.2	2	2	2	2
Subtotal	**55.6**	**56.8**	**58**	**59.2**	**61.3**	**2.2**	**2**	**2**	**2**	**2**
GRAND TOTAL EMISSIONS	**393**	**354**	**331**	**317**	**306**	**521**	**473**	**432**	**394**	**357**

Notes for Table 2-3

1. Inventory and projections are based upon CARB EMFAC 2007, Version 2.3 and assume implementation of all control measures adopted as of December 31, 2006, including Smog Check II for the Bay Area.
2. The annual average inventory represents average day emissions. ABAG Projections 2007 were used to project future emissions from on-road motor vehicles and for the regional population projections used for the planning inventory.
3. Entries are rounded to nearest whole number, totals may not equal to sums of column entries.
4. A photochemically reactive organic compound excludes methane and other non-reactives and roughly 160 tpd of ROG emissions from natural sources.
5. Oxides of nitrogen (nitric oxide and/or nitrogen dioxide), NOx as NO2.
6. Banked Emissions show the total current deposits in the District's emissions banking program as allowed by BAAQMD Regulation 2, Rules 2 and 4. These emissions were reduced (beyond regulations) and banked, but may be withdrawn from the bank and emitted in future years.
7. Surplus emissions, voluntarily reduced, available for alternative compliance with BARCT requirements of selected rules, as prescribed by State law and BAAQMD Regulation 2, Rule 9.
8. California Air Resources Board (CARB) has recently developed statewide emissions estimates for ocean-going vessels (OGVs) occurring within 100 nautical miles of the California coastline. As a result, these emissions are substantially higher than those reported in the previous version of the inventory published in the 2005 Ozone Strategy, which accounted for ship activities within three miles of the Golden Gate Bridge.

Trends in ROG and NOx Emissions

Emissions of ROG and NOx have both been greatly reduced in recent decades. However, ROG emissions have been reduced much faster than NOx. Since the early 1980's, ROG emissions have been reduced by about 75%, compared to about 50% for NOx. This reflects the fact that in the 1970-2000 period CARB focused on reducing emissions from light-duty vehicles; light-duty vehicles are a major source of ROG emissions, whereas heavy-duty vehicles are the primary source of NOx emissions. Since diesel engines currently account for more than half (57%) of total NOx emissions in the Bay Area, CARB regulations to reduce emissions of NOx (and PM) from heavy-duty diesel engines, as described in Chapter 3, will be very beneficial in reducing ozone levels.

As shown in Figures 2-7 and 2-8, emissions of ROG and NOx in the Bay Area are projected to continue to decline in future years. These projections reflect the impact of regulations in place as of December 31, 2006. More recent regulations, as well as control measures identified in this CAP, will further reduce emissions in the future.

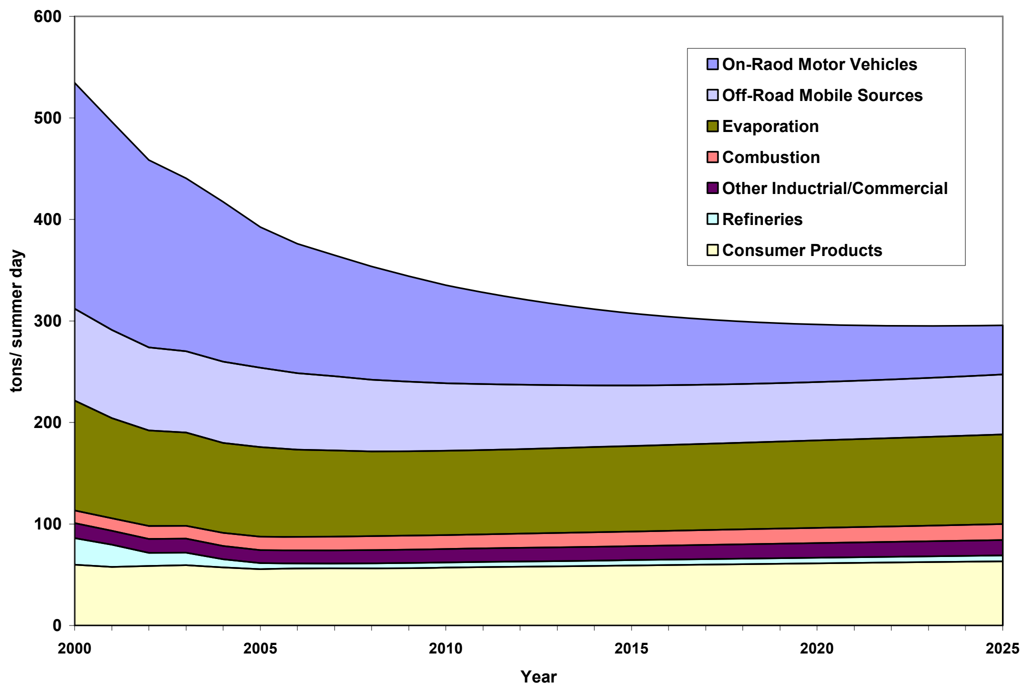

Figure 2-7. Annual average ROG emissions trend: 2000-2025.

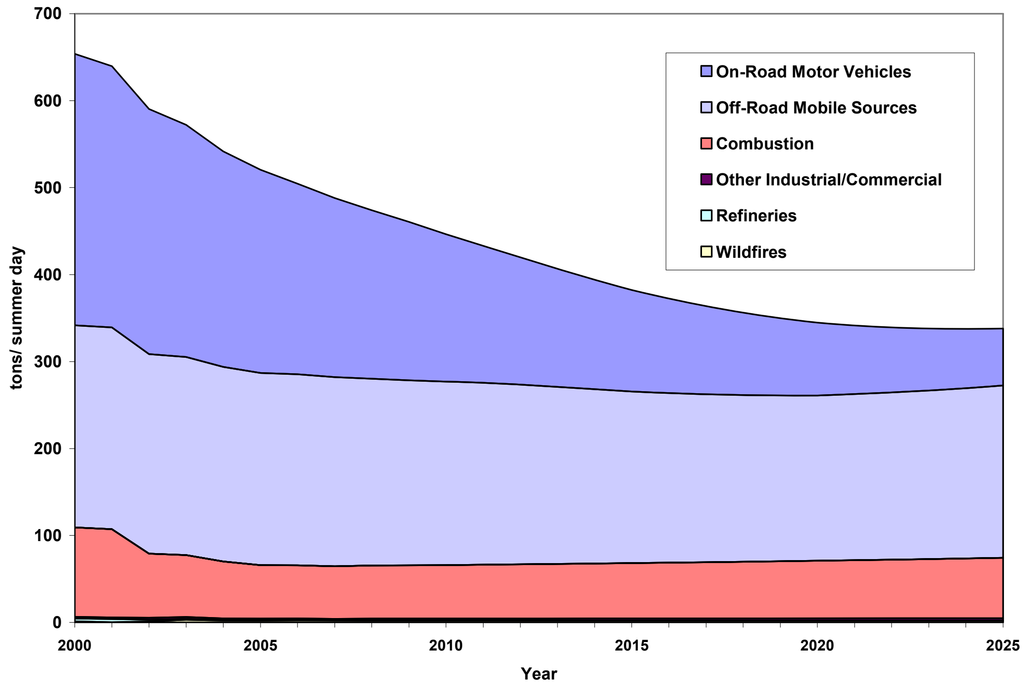

Figure 2-8. Annual average NOx emissions trend: 2000-2025.

In addition to anthropogenic sources of ozone precursors, there are significant quantities of biogenic emissions of ROG from natural sources like plants and animals. Vegetation emits large amounts of isoprene, terpenes, and other organic compounds that act as ozone precursors. Emission rates depend upon species, season, biomass density, time of day, local temperature, moisture and other factors. Total ROG emissions from natural sources in the Bay Area amounts to roughly 105 tons per day on an annual average basis (160 tpd in the summer inventory). Biogenic emissions are not included in the planning emissions inventory because they are generally not subject to control, but these emissions do contribute to ozone formation, and are therefore included in ozone modeling. As discussed in the section on climate change in Chapter 1, higher temperatures due to global warming are likely in increase biogenic emissions of ROG, which will contribute to increased ozone formation.

Trends in Ozone Concentrations

Health and Safety Code Section 40924(b)(1) requires the Air District to assess its progress toward attainment of the California ambient air quality standard for ozone during the most recent triennial period. The analysis in this section examines progress made in the period 2006-08 from the base years 1986-88 and from 1997-99.

Monitoring Data

A basic indicator of air quality trends is the number of days that the region exceeded air quality standards. Table 2-4 shows the annual number of exceedances of the current 0.09 ppm California 1-hour ozone standard at each ozone monitoring station for the 1987-2009 period.

Figure 2-9 shows the annual number of days over the standard at any station during the same period. The figure shows large fluctuations in the numbers of exceedances from year to year. Note, for example, that between 1996 and 1998 the number of exceedances drops from 45 to 10 and then rises to 29. Most of this short-term variation is weather-related. Ozone exceedances only occur on hot, relatively stagnant days, the number of which can vary dramatically from one summer to the next. Variations in the weather can obscure trends in exceedances resulting from changes in emissions of ozone precursors.

Averaging across several years reduces the weather-related “noise.” The 3-year moving average in Figure 2-9 shows a relatively steady downtrend in exceedances, from an average of 20 or more exceedance days per year prior to 1990 to about 10 days in the past few years.

Table 2-4. Number of days exceeding the California 1-hour ozone standard by monitoring site 1987-2008.

Stations by Sub-Region	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09
Northern																							
Benicia																					0	2	
Napa	6	1	2	0	3	0	2	0	4	0	0	3	4	0	1	1	2	0	0	1	0	1	1
San Rafael	1	1	0	0	0	0	0	0	0	2	1	0	2	0	0	0	0	0	0	0	0	0	0
Santa Rosa	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Vallejo	6	5	2	2	2	1	3	2	4	5	1	3	4	0	0	1	2	1	0	0	0	1	2
Central																							
Hayward	12	9	1	0	2	1	0	1	7	2	2	4	4	1	2	0	3	0	0	2	0	1	4
Oakland	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0			0	0
Redwood City	2	2	1	0	0	0	1	0	5	1	0	0	0	0	1	0	1	1	0	0	0	0	0
San Francisco	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Leandro	0	0	0	0	2	2	3	0	6	2	3	2	3	1	0	1	2	1	1	0	0	0	
Richmond/San Pablo	0	2	1	0	0	0	2	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0
Eastern																							
Bethel Island	14	7	11	5	3	7	3	5	6	6	1	10	5	1	3	5	0	1	0	9	0	4	2
Concord	20	10	6	3	4	3	7	4	9	11	2	13	8	2	6	5	5	1	1	7	1	3	2
Fairfield	9	3	4	1	3	3	3	2	10	5	0	9	9	1	3	3	0	1	0	3	0	2	2
Livermore	26	21	9	8	17	14	7	5	20	22	3	21	14	5	9	10	10	5	6	13	2	5	8
Pittsburg	14	8	5	4	0	3	4	3	8	5	0	4	2	1	2	4	0	0	0	2	1	1	

Table 2-4 (continued). Number of days exceeding the California 1-hour ozone standard by monitoring site 1987-2008.

Stations by Sub-Region	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09
Southern																							
Fremont	17	7	11	3	6	5	5	4	10	2	2	7	3	2	3	3	4	0	1	4	0	1	4
Los Gatos	25	12	1	5	7	3	8	2	13	10	1	5	4	0	2	4	7	0	3	7	0	2	3
Mt View/ Sunnyvale	16	13	6	1	2	1	2	0	2	3	1	2	7		0	0	4	1	1	3	0	0	
San Jose	23	12	10	4	6	3	3	2	14	5	0	4	3	0	2	0	4	0	1	5	0	1	0
San Jose - East	22	13	9	1		5	5	3	15	5	1	5	2	1	0	0	2	0	1				
Gilroy	19	23	10	5	5	11	6	3	10	15	1	10	3		3	6	6	0	0	4	0	1	1
San Martin					7	17	9	5	14	18	0	15	7	4	7	8	9	0	2	7	1	2	4
Total Days	**47**	**41**	**22**	**14**	**23**	**29**	**24**	**13**	**30**	**45**	**10**	**29**	**20**	**12**	**15**	**16**	**19**	**7**	**9**	**18**	**4**	**9**	**11**

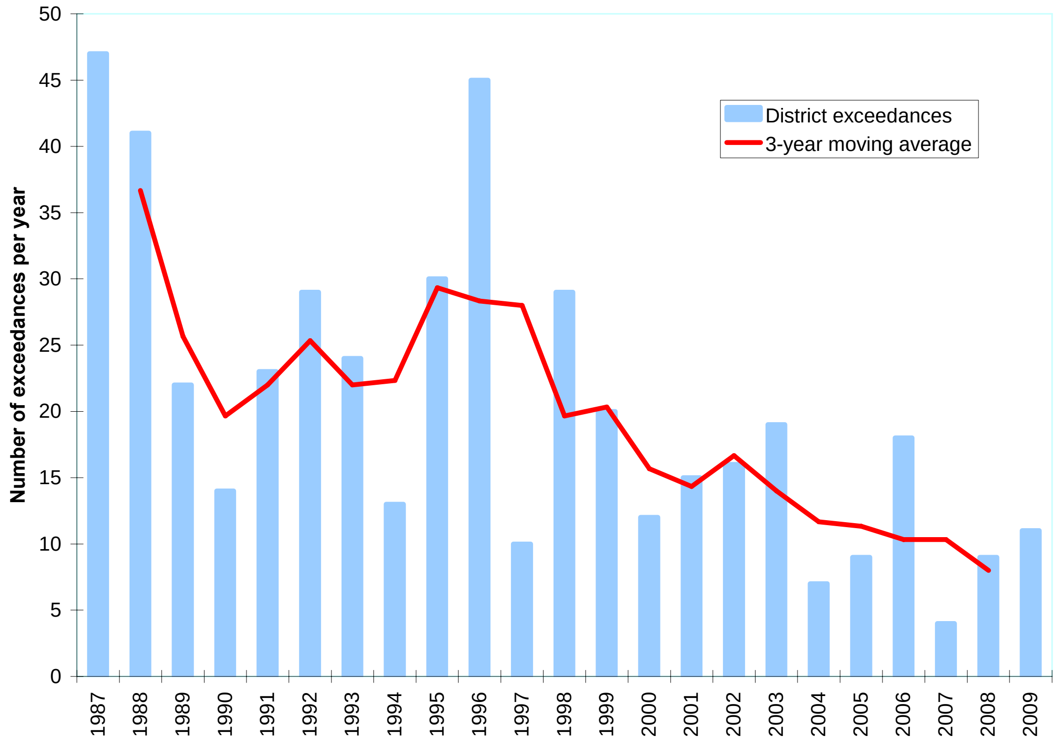

Figure 2-9. Annual Bay Area days exceeding the 0.09 ppm state 1-hour ozone standard at any monitoring station: 1987-2009.

Figure 2-10 shows Bay Area trends relative to the current State 8-hour standard (0.70 ppm), with reductions in exceedances similar to those seen in Figure 2-9 above.

Peak Ozone Concentrations and Exposure

CARB guidance requires the calculation of three air quality indicators to assess the extent of air quality improvements within an air basin: (1) Expected Peak Day Concentration (EPDC), which is an estimate of the ozone concentration that would be exceeded once per year on average, (2) population-weighted exposure to ozone levels that exceed the state standard, and (3) area-weighted exposure to levels that exceed the state standard.

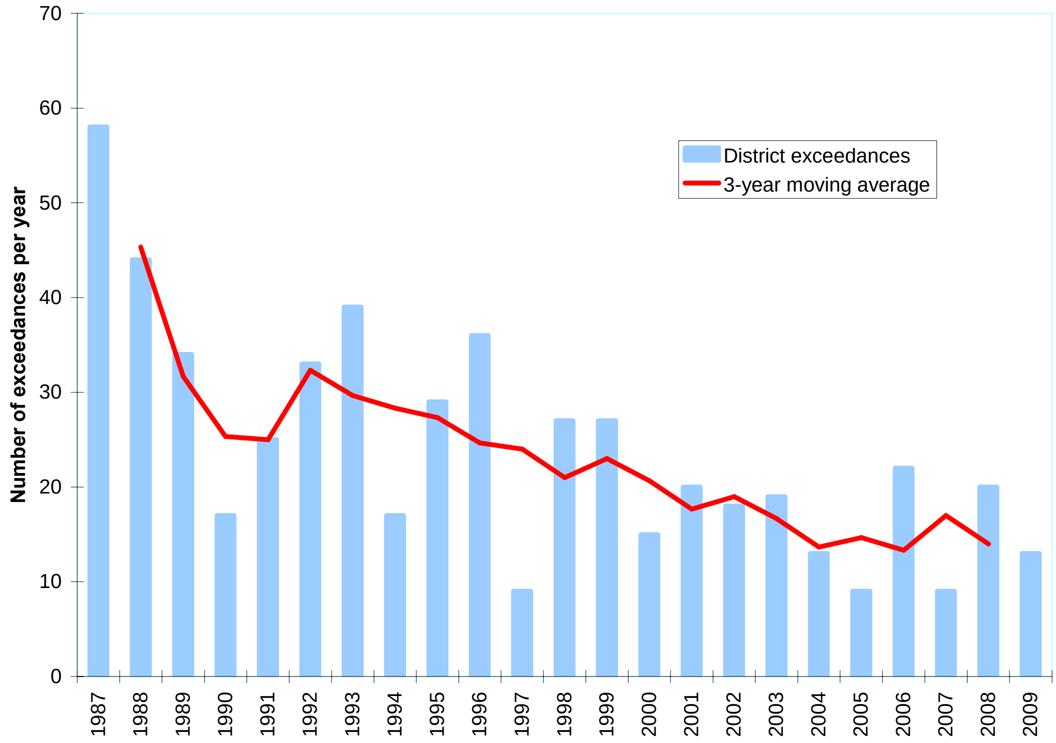

Figure 2-10. Annual Bay Area days exceeding the 0.070 ppm state 8-hour ozone standard at any monitoring station: 1987-2008.

Expected Peak Day Ozone Concentrations

The EPDC for the State 1-hour ozone standard at Bay Area monitoring sites are listed in Table 2-5 for 1986-88, 1997-99, and 2006-08. Also shown are annual percentage reductions. Table 2-6 presents this data for the 8-hour ozone standard. There was an average annual reduction in 1-hour ozone of 1.1% per year across all Bay Area sites between 1986-88 and 2006-08, and a reduction of 1.0% per year in 8-hour ozone, with total reductions of 19% and 18% respectively. No site shows an increase in ozone over this period, indicating that progress is region-wide. During the period from 1997 through 2008, the reduction was 1.0% per year for 1-hour ozone and 0.8% per year for 8-hour ozone, indicating that progress has continued in recent years.

The progress has not been uniform, however. As the tables show, there were substantial reductions in the southern areas, including Los Gatos and Gilroy, sites that once registered some of the District's highest values. There was progress in the north also. In the central area, the progress is mixed, but at locations where there has been little reduction since the late 1990s, ozone values actually meet the standard. In the eastern areas there have also been reductions, but long-term progress has been slower. At the Air District's design value site in Livermore reductions have averaged 0.8% per year, which is on the order of 1 ppb per year, since the late 1990s.

State ozone standards in essence require that there be no more than one exceedance per year at any monitoring site. Since the EPDC is an estimate of the ozone concentration that would be exceeded once per year, a site whose EPDC is less than 95 ppb could be considered to meet the 1-hour standard, and a site whose EPDC is less than 71 ppb could be considered to meet the State 8-hour standard. Between 1986-88 and 2006-08, the number of sites meeting the 1-hour standard increased from 4 to 9, and the number meeting the 8-hour standard increased from 4 to 8.

Table 2-5. Expected peak day concentrations for 1-hour max ozone at Bay Area sites: 1986-2008.

	Expected Peak Day Concentration (ppb)			Annual Percentage Change in EPDC*	
Monitoring Site:	**1986-88**	**1997-99**	**2006-08**	**97-99 to 06-08**	**86-88 to 06-08**
Northern					
Napa	107	106	88	-2.1	-1.0
San Rafael	93	85	74	-1.5	-1.2
Santa Rosa	87	86	72	-1.9	-0.9
Vallejo	109	98	83	-1.8	-1.4
Central					
Hayward	129	112	96	-1.7	-1.4
Redwood City	97	71	74	0.4	-1.3
Richmond/ San Pablo**	83	80	68	-1.8	-1.0
San Francisco	74	59	59	0.0	-1.1
Eastern					
Bethel Island	111	117	108	-0.9	-0.2
Concord	128	127	109	-1.7	-0.8
Fairfield	111	122	103	-1.8	-0.4
Livermore	145	143	123	-1.7	-0.8
Pittsburg	117	95	96	0.1	-1.0
Southern					
Fremont	132	107	93	-1.5	-1.7
Los Gatos	139	113	106	-0.7	-1.4
Mt View/ Sunnyvale***	140	106	94	-1.4	-2.0
San Jose	131	107	100	-0.7	-1.3
Gilroy	142	113	101	-1.2	-1.7
San Martin Airport		125	110	-1.4	
Average	**117**	**104**	**95**	**-1.0**	**-1.1**

* Percentage change results shown may differ slightly from those calculated using displayed data points because of rounding for display purposes.
** Monitoring site moved from Richmond to San Pablo in 1997.
*** Site moved from Mountain View to Sunnyvale in 2000.

Table 2-6. Expected peak day concentrations for 8-hr max ozone at Bay Area sites 1986-2008.

	Expected Peak Day Concentration (ppb)			Annual Percentage Change in EPDC*	
Monitoring Site:	**1986-88**	**1997-99**	**2006-08**	**97-99 to 06-08**	**86-88 to 06-08**
Northern					
Napa	85	80	70	-1.4%	-1.0%
San Rafael	69	60	58	-0.3%	-0.9%
Santa Rosa	68	63	58	-0.9%	-0.7%
Vallejo	85	72	67	-0.8%	-1.2%
Central					
Hayward	102	88	78	-1.3%	-1.3%
Redwood City	71	56	61	1.0%	-0.8%
Richmond/ San Pablo**	65	63	56	-1.4%	-0.8%
San Francisco	59	50	51	0.3%	-0.7%
Eastern					
Bethel Island	103	101	92	-1.1%	-0.6%
Concord	101	102	91	-1.2%	-0.6%
Fairfield	99	101	84	-2.1%	-0.9%
Livermore	112	111	95	-1.8%	-0.8%
Pittsburg	99	81	82	0.1%	-0.9%
Southern					
Fremont	98	73	69	-0.7%	-1.7%
Los Gatos	111	91	86	-0.6%	-1.2%
Mt View/ Sunnyvale***	104	74	71	-0.5%	-1.9%
San Jose	107	77	76	-0.1%	-1.7%
Gilroy	113	91	87	-0.6%	-1.3%
San Martin Airport		100	90	-1.1%	
Average	92	81	75	-0.8%	-1.0%

* Percentage change results shown may differ slightly from those calculated using displayed data points because of rounding for display purposes.
** Monitoring site moved from Richmond to San Pablo in 1997.
*** Site moved from Mountain View to Sunnyvale in 2000.

Population-Weighted Exposure to Ozone

Peak ozone concentrations reflect potential population exposure in areas with the highest ozone levels, but not the exposure of the Bay Area's population as a whole. Therefore, population-weighted exposure to high ozone concentrations is another indicator used to assess progress in reducing public exposure to ozone on a per-capita region-wide basis.

Population-weighted exposure is computed by estimating hourly ozone concentrations for each census tract in the Bay Area based on the hourly values actually measured at Air District monitoring sites. Concentrations are estimated by averaging ozone from nearby monitors inversely weighted by distance to the tract. For each census tract, for each hour where its estimated ozone exceeds the standard, the estimated amount by which the ozone level exceeds the standard is multiplied by the population of the tract. These values are summed across all hours for a year for each tract, and then for all tracts in each county. The result is divided by the population of the county. The result is per capita exposure, specifically person-ppm-hours above the standard.[84]

Table 2-7 shows population-weighted exposures for 1986-88, 1997-99 and 2004-06 for Bay Area counties in relation to the state 1-hour ozone standard. Also shown are the total decreases in exposure between these periods. Population exposure decreased from an average of 19 to 2 person-ppm-hours above the standard per year from 1986-88 to 2006-2008, for an overall reduction of 88%. Today, no county experiences an average of more than 4 person-ppm-hours above the standard per year.

Table 2-7. Population-weighted exposure to ozone exceeding the state one-hour standard in the Bay Area.

	Per Capita Exposure (person-ppm-hours above 95 ppb/total population)			Percent Decrease*	
County	86-88	97-99	06-08	86-88 to 06-08	97-99 to 06-08
Alameda	18	7	2	87	64
Contra Costa	22	17	4	80	75
Marin	0	1	0	NA	100
Napa	3	6	1	73	88
San Francisco	0	0	0	NA	NA
San Mateo	3	0	0	98	79
Santa Clara	46	7	4	91	42
Solano	8	9	2	78	80
Sonoma	1	1	0	88	88
Bay Area	**19**	**6**	**2**	**88**	**64**

* Values for per capita exposure are rounded to the nearest whole number. Percentage decrease is based on unrounded data.

Figure 2-11 shows the Bay Area per-capita population exposure to ozone by year, and also a 3-year moving average. Exposures vary dramatically from year to year, but the 3-year average shows progress toward reduced exposure.

[84] This is sometimes termed "backyard" exposure because it assumes that everyone is at home and outside every hour that ozone exceeds the standard. While there are obvious limitations to this measure, it may be reasonable for children, who are often at or near home, and frequently outside, at times when ozone exceeds the standard.

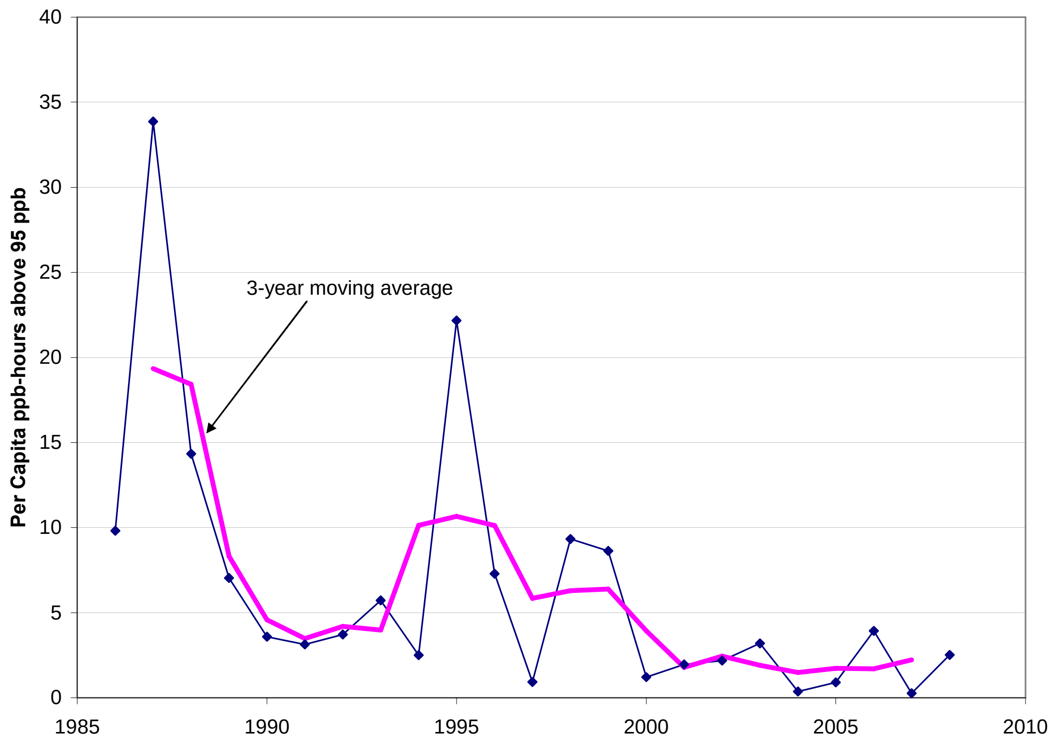

Figure 2-11. Average per-capita population exposure to ozone levels exceeding the 0.09 ppm state 1-hour standard in the Bay Area, 1986-2008.

Area-Weighted Exposure to Ozone

The third indicator used in assessing progress in reducing exposure to ozone is area-weighted exposure. This is calculated similarly to population-weighted exposure, except with census tract area replacing census tract population.

Reductions in area-weighted exposure are important because high ozone levels harm not only humans but also vegetation, other animals, and most surfaces with which it comes in contact, such as architectural finishes, tires, and plastics. Table 2-8 shows the average km^2-ppm-hours above the state standard for each county and the District as a whole. The trends and exposure patterns among counties are quite similar to population-weighted exposures. The table shows reductions similar to those in Table 2-7, with area-weighted exposure dropping 84% since 1986-88 and 64% since 1997-99.

Table 2-8. Area-weighted exposure to ozone in the Bay Area, 1986-2008.

	Area-Weighted Exposure (km^2-ppm-hours above 95 ppb/total km^2)			Percent Decrease*	
County	86-88	97-99	04-06	86-88 to 06-08	97-99 to 06-08
Alameda	40	19	8	80	58
Contra Costa	27	20	6	77	69
Marin	1	1	0	100	100
Napa	3	6	1	72	85
San Francisco	0	0	0	NA	NA
San Mateo	12	1	1	93	45
Santa Clara	52	13	6	88	51
Solano	12	11	2	79	77
Sonoma	1	2	0	85	88
Bay Area	**20**	**9**	**3**	**84**	**64**

* Values for area-weighted exposure are rounded to the nearest whole number. Percentage decrease is based on unrounded data.

Summary of Key Ozone Modeling Findings

Photochemical modeling, as described in Appendix E, was used to estimate the impacts of NOx and VOC emissions reductions on ozone concentration for the Bay Area and its neighboring ozone non-attainment regions. Reducing Bay Area emissions of NOx and VOC by 40% resulted in significant reductions of up to 15 ppb for Bay Area 8-hour ozone levels. The impacts of reductions in precursor emissions transported from the Bay Area were much smaller than the local impacts of the Bay Area emissions. Reducing the Bay Area emissions by 40% benefited the downwind Sacramento and San Joaquin Valley non-attainment areas by only 1-3 ppb reduced relative to the 8-hour ozone level.

Summary of Key Modeling Findings: Impacts of Climate Change on Ozone

Photochemical modeling was used to estimate the impacts of a 2 degree Celsius increase in Bay Area temperatures on regional ozone levels. This increase in global average temperature is estimated by the Intergovernmental Panel on Climate Change (IPCC) to occur by 2050. Higher temperatures related to global warming are expected to promote ozone formation through several mechanisms, including an increase in biogenic emissions of ozone precursors (ROG). The model indicated Bay Area maximum 8-hour ozone levels would increase by about 8 ppb during ozone exceedance days. Assuming the simulated scenario is reasonable, increased ozone levels due to climate change may offset at least 10 years of ozone emissions control efforts in the Bay Area between now and 2050.

Particulate Matter

Particulate matter (PM) is a mixture of suspended particles and liquid droplets (aerosols). PM includes elements such as carbon and metals; compounds such as nitrates, organics, and sulfates; and complex mixtures such as diesel exhaust, wood smoke, and soil. Unlike the other criteria pollutants, which are individual chemical compounds, particulate matter is the total of all particles in the air in a certain size range. PM is both directly emitted (referred to as direct PM or primary PM) and also formed in the atmosphere through reactions among different pollutants (this is referred to as indirect or secondary PM).

As discussed both in Chapter 1 and below, compelling evidence suggests that fine PM is the most harmful of all air pollutants in the Bay Area in terms of its impact on public health. Significant progress has been made to enhance our technical understanding of PM, including improved monitoring and enhanced modeling capabilities. However, because the shift in focus toward PM is relatively recent, efforts to analyze and control PM still lag behind pollutants such as ozone and carbon monoxide.

One of the challenges in devising strategies to reduce PM is that scientists are still working to determine the relative risk associated with the many types and sources of particles that comprise PM. Better information in this regard will help us understand where to focus our efforts in order to get the greatest benefit in reducing health risks associated with PM. Nevertheless, our best knowledge to date suggests that fine particles themselves are harmful, irrespective of composition.

In addition to its negative health effects, PM is also a prime cause of regional haze. Research is still on-going, but PM emissions also have implications for global warming. PM aerosols can help to reduce (or mask) the full effect of global warming by scattering sunlight. But black carbon or soot, a component of PM, appears to contribute significantly to global warming.

PM Health Effects

A large and growing body of scientific evidence indicates that both short-term and long-term exposure to fine particles can cause a wide range of health effects, including: aggravating asthma and bronchitis; causing visits to the hospital for respiratory and cardio-vascular symptoms, and contributing to heart attacks and deaths.

Breathing PM has long been understood as a health hazard.[85] Although PM was designated as one of the criteria pollutants in the original 1970 federal Clean Air Act, in recent years many epidemiological studies have drawn increased attention to the health

[85] The London fogs of the early 1950s that killed thousands of people were primarily caused by PM from coal, which led to the banning of coal burning within the city.

risks associated with PM. In fact, as discussed in Appendix A, the number of deaths in the Bay Area associated with current PM levels likely exceeds the number of deaths from motor vehicle accidents. Reducing PM emissions can reduce mortality and increase average life span.[86]

Although the epidemiological evidence that shows a strong correlation between elevated PM levels and public health effects is very well-documented, scientists are still working to understand the precise biological mechanisms through which PM damages our health. A recent study by researchers at the University of Michigan suggests that PM may harm our bodies by a combination of 1) increasing blood pressure and 2) triggering a response which causes inflammation that can stiffen and damage blood vessels.[87]

PM Standards and Attainment Status

PM is often characterized on the basis of particle size. Ultra-fine PM includes particles less than one micron in diameter. Fine PM consists of particles 2.5 microns or less in diameter. PM10 consists of particles 10 microns or less in diameter. TSP (total suspended particulates) includes suspended particles of any size.

The 1970 Clean Air Act initially established PM standards for TSP only. Subsequently, scientific evidence pointed to small particles as posing the most serious health threat. Therefore, in 1987, the TSP standard was replaced with a PM10 standard – one that regulated particles less than 10 microns in diameter. In 1997, the PM10 standard was augmented by a PM2.5 standard: i.e., particles less than 2.5 microns in diameter.

PM standards and Bay Area attainment status are shown in Table 2-1. Both national and state PM standards have been tightened since 2000. However, to date, researchers have not been able to identify a clear threshold below which there are no health effects from exposure to fine PM. This suggests that PM2.5 standards may be further tightened in the future.

PM Dynamics

PM chemistry and formation is complex and variable. PM concentrations vary considerably both in composition and spatial distribution on a day-to-day basis and on a seasonal basis, due to changes in weather and emissions. The Bay Area experiences its

[86] For example, a recent study of nationwide scope found that reducing fine PM results in significant and measurable improvements in human health and life expectancy. Pope, C. Arden III et al. "Fine Particulate Air Pollution and Life Expectancy in the United States." New England Journal of Medicine, January 22, 2009. Volume 360:376-386. No. 4.

[87] See Robert Brook et al. "Insights into the Mechanism and Mediators of the Effects of Air Pollution Exposure on Blood Pressure and Vascular Function in Healthy Humans" Hypertension: Journal of the American Heart Association, July 29, 2009.

highest PM concentrations in the winter; exceedances of the 24-hour national PM2.5 almost always occur in the November through February period. High PM2.5 episodes are typically regional in scale, impacting multiple Bay Area locations. During other seasons, by contrast, Bay Area PM2.5 tends to be low thanks to the area's natural ventilation system. Thus, on an annual average basis, the Bay Area's PM2.5 levels are among the lowest measured in major U.S. metropolitan areas.

Consecutive stagnant and clear winter days are typically prerequisites for development of PM2.5 episodes. The lower levels of solar radiation (sunlight) in the winter lead to stronger temperature inversions; these inversions are conducive to the buildup of PM in ambient air near ground level, especially ultrafine particles, which can remain airborne for a number of days. Winter is also when the most residential wood burning occurs; in some parts of the Bay Area, wood smoke accounts for the majority of airborne PM2.5 during high PM episodes.

Secondary PM2.5 levels are likewise only elevated during the winter months. Cool weather is conducive to the formation of ammonium nitrate. Ammonium nitrate is the main type of secondary PM2.5 in winter months, contributing an average of about 35% of total PM2.5 under peak PM conditions. This semi-volatile PM2.5 component is stable in its solid form only during the cooler winter months. Although the contribution of ammonium sulfate is relatively low (averaging 1-2 $\mu g/m^3$) it accounts for approximately 10% of total PM2.5 on an annual average basis. In the Bay Area, geological dust contribute only modestly to PM2.5 concentrations, but it accounts for a significant portion of PM10, as shown in Figures 2-12 and 2-13.

Chemical mass balance[88] analysis shows that both fossil fuels and biomass (primarily wood) combustion sources are prevalent PM2.5 contributors for all seasons. The biomass combustion contribution to peak PM2.5 levels is about 3-4 times higher in winter than the other seasons, as confirmed by isotopic carbon (^{14}C) analysis. The increased winter biomass combustion sources reflect increased levels of wood burning during the winter season.

[88] Chemical mass balance (CMB) analysis is a methodology in which a computer model is used to apportion ambient PM2.5 collected on filters over 24-hour periods at monitoring sites around the Bay Area to a set of source categories. Each filter was analyzed for a range of chemical species. The same species were measured in special studies of emissions from various sources, such as motor vehicles and wood burning. The CMB model finds the mix of these source measurements that best matches the ambient sample, chemical species by chemical species.

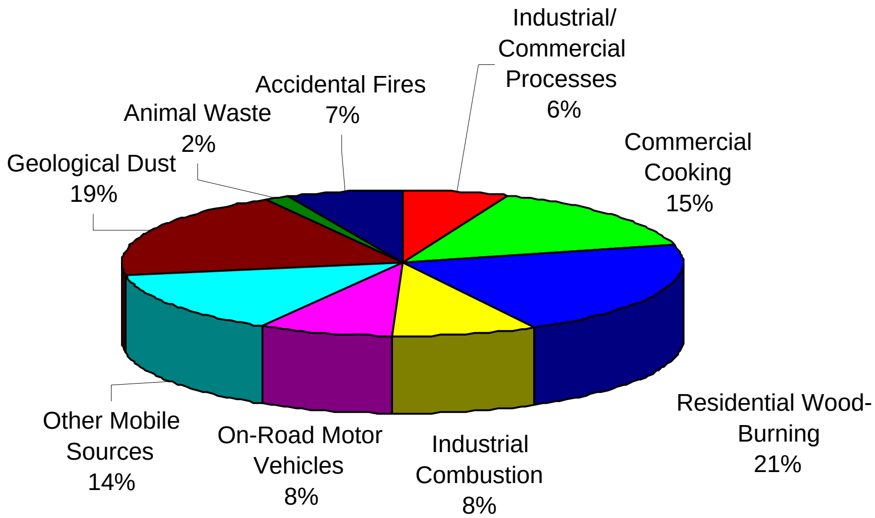

Figure 2-12. Direct PM2.5 emissions by source, annual average, 2009 (87 tons/day).

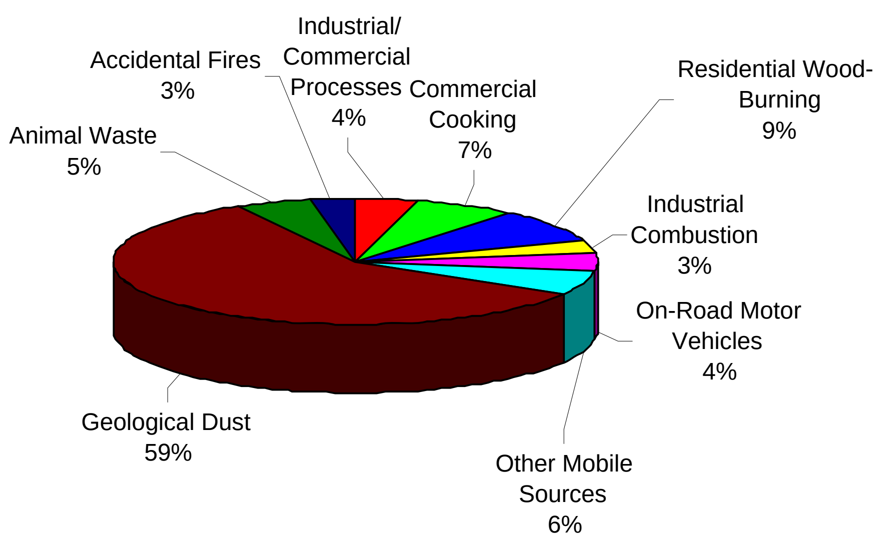

Figure 2-13. Direct PM_{10} emissions by source, annual average, 2009 (214 tons/day).

As in the case of ozone, the PM2.5 levels that occur on a given day are strongly influenced by the prevailing weather. The relationship between the weather and PM2.5 levels was analyzed using a statistical technique known as cluster analysis to find groups of days exhibiting similar conditions. Cluster analysis was applied to 10 years of measurements to determine winter weather patterns associated with elevated Bay Area PM2.5 levels.

Cluster analysis found that a single weather pattern accounted for most 24-hour PM2.5 episodes in the Bay Area. PM2.5 exceedances in the Bay Area usually occurred after 2-4 consecutive days of PM2.5 buildup under a high pressure system. These conditions occur when a high pressure system moves over Central California in winter months, resulting in sunny days and clear, cold nights with little wind. Such conditions are highly conducive to formation of ammonium nitrate, a key component of secondary PM2.5, in the Central Valley. As dense cold air converges on the Central Valley floor, this increases air pressure in the Central Valley, causing air to flow westward through the Carquinez Strait and into the Bay Area, thereby transporting ammonium nitrate PM2.5 from the Central Valley to the Bay Area. When ammonium nitrate transported from the Central Valley to the Bay Area combines with PM2.5 emitted or formed within the Bay Area, this can result in elevated PM levels in the Bay Area, especially in the eastern parts of the region closest to the Central Valley.

Ultra-Fine Particles

The smaller the particle, the more easily it can evade the body's filtration system, penetrate deep into the lungs and enter the bloodstream. Research in recent years suggests that "ultra-fine" particles, those less than 1.0 micron in diameter, may actually pose the most serious threat to public health.[89] Internal combustion engines are a major source of ultrafine PM. Engines powered by gasoline, diesel, and natural gas all emit a large fraction of particles in the ultrafine size range. Studies in southern California have found elevated counts of ultrafine particles near freeways. Numerous studies have shown increased incidence of respiratory and cardiovascular disease near heavily traveled roadways.

Because of their small size, ultrafine particles account for just a small fraction of total PM mass (less than 10%); however, they make up the vast majority of particles by number. In addition, ultrafine particles have a much higher surface area per mass than larger particles; therefore, they act as carriers for other agents such as trace metals and organic compounds that collect on their surface. Despite these concerns, research on the health impacts of ultra-fine particles is still evolving, and no ambient air quality standards for ultra-fine PM have been established as yet. Existing state and national PM standards are based on mass (weight) concentrations in the air, rather than the number of airborne particles.

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[89] See Chapter 11 (Ultrafine Particles) in the 2007 South Coast Air Quality Management Plan.

Diesel Particulate Matter

Diesel engines emit a complex mixture of air pollutants, with a major fraction consisting of fine PM. These emissions include many carbon particles, as well as gases that become PM as they cool and undergo chemical reactions. Diesel emissions account for roughly one-sixth of total emissions of carbonaceous PM2.5 in the Bay Area.

Emissions of diesel PM pose a risk to public health in the Bay Area in two ways: 1) as a component of PM2.5, which has been implicated in increased premature mortality, and 2) as the leading carcinogenic toxic air contaminant. As discussed in the Air Toxics Trends section below, diesel PM emissions are responsible for the majority of cancer risk from air pollution in the Bay Area. However, analysis performed in the course of developing the Air District's multi-pollutant evaluation method shows that the risk of death from diesel particles in their role as a component of PM2.5 is roughly an order of magnitude greater than the risk they pose as carcinogens. In other words, even if diesel particles were not carcinogenic, the risk they pose as PM2.5 would be still be very large.

Sources of PM Emissions

Particulate matter is both directly emitted, as well as formed indirectly from precursor chemicals, such as ROG, NOx, and ammonia (NH3). Direct PM2.5 emissions in the Bay Area are produced by a wide variety of sources, both man-made and natural, but dominated by a few. About half of Bay Area PM2.5 is directly emitted from combustion, i.e., burning fossil fuels, wood, other vegetative matter; or cooking. This PM2.5 is mostly composed of organic carbon compounds, and also soot containing pure carbon. Sea salt from the ocean contributes another 10% on an annual basis.

Combustion of fossil fuels in all types of engines produces direct emissions of PM. In addition to direct PM from engine combustion, motor vehicles also 1) contribute to secondary formation of PM by emitting NOx, and 2) create PM by means of tire and brake wear. Reducing emissions of diesel PM from heavy-duty engines is a priority of CARB and the Air District because diesel PM is a carcinogenic toxic air contaminant.

Light-duty and medium-duty vehicles (8,500 pounds gross vehicle weight or less) emit very little PM on a per-mile basis. However, light and medium-duty vehicles currently account for more than half of the total emissions of both PM2.5 and PM10 from on-road vehicles in the region. PM emissions from heavy-duty vehicles are expected to decrease significantly over the next decade in response to recent CARB regulations pursuant to its Diesel Risk Reduction Program. With emissions from heavy-duty vehicles projected to decline and total vehicle miles of travel (VMT) from light and medium-duty vehicles projected to increase, PM emissions from light and medium-duty vehicles are expected to account for roughly 80% of direct emissions of PM2.5 and PM10 from on-road vehicles in the Bay Area by 2020.

Table 2-9 shows the detailed Bay Area inventory of annual average direct PM2.5 and PM10 emissions, with base year 2005 projected trough 2020.[90] The inventory is based upon CARB EMFAC 2007, Version 2.3 and reflects the effect of regulations adopted as of December 31, 2006. The inventories do not include additional emission reductions from State or federal measures adopted since 2007 or CARB's "Pavley regulations" to reduce greenhouse gases from motor vehicles. Estimated emission reductions of ROG, NOx, and PM from CARB regulations not reflected in the current inventory are shown in Table 3-10.

Major sources of direct PM2.5 and PM10 emissions are shown in Figures 2-12 and 2-13, respectively. Geological dust, which includes road dust, construction dust, and windblown dust, accounts for a relatively modest fraction of PM2.5 (19%), but a very large portion of PM10 (59%). There is still considerable uncertainty regarding the inventory of geological dust. The Air District is working with CARB in a collaborative effort to improve PM emissions inventory estimates statewide and in the Bay Area. Inventory estimates are under review for a variety of sources, including road dust and commercial cooking.

[90] Summer and winter emissions inventories are provided in the "Base Year 2005 Emissions Inventory Summary Report" issued by BAAQMD in December 2008. See www.BAAQMD.gov

Table 2-9. Bay Area inventory 2005-2020, PM10 & $PM_{2.5}$.

Bay Area Baseline Emission Inventory Projections : 2005 – 2020 (1)										
Annual Average Inventory (2) in Tons/Day (3)										
	Particulate Matter< 10 microns (4)					Particulate Matter< 2.5 microns (4)				
SOURCE CATEGORY	**2005**	**2009**	**2012**	**2015**	**2020**	**2005**	**2009**	**2012**	**2015**	**2020**
INDUSTRIAL/COMMERCIAL PROCESSES										
PETROLEUM REFINING FACILITIES										
Basic Refining Processes	0.82	0.85	0.88	0.9	0.95	0.49	0.51	0.53	0.54	0.57
Wastewater (Oil-Water) Separators	--	--	--	--	--	--	--	--	--	--
Wastewater Treatment Facilities	--	--	--	--	--	--	--	--	--	--
Cooling Towers	0.16	0.17	0.17	0.18	0.19	0.15	0.16	0.16	0.17	0.18
Flares & Blowdown Systems	--	--	--	--	--	--	--	--	--	--
Other Refining Processes	0.06	0.06	0.06	0.06	0.07	--	--	--	--	--
Fugitives	--	--	--	--	--	--	--	--	--	--
Subtotal	1.05	1.09	1.12	1.15	1.21	0.69	0.71	0.73	0.76	0.8
CHEMICAL MANUFACTURING FACILITIES										
Coating, Inks, Resins & Other Facilities	0.11	0.12	0.12	0.13	0.14	0.07	0.07	0.08	0.08	0.09
Pharmaceuticals & Cosmetics	0.39	0.41	0.44	0.46	0.49	0.39	0.41	0.43	0.45	0.49
Fugitives - Valves & Flanges	--	--	--	--	--	--	--	--	--	--
Subtotal	0.5	0.53	0.56	0.58	0.63	0.45	0.48	0.51	0.53	0.57
OTHER INDUSTRIAL/COMMERCIAL PROCESSES										
Bakeries	--	--	--	--	--	--	--	--	--	--
Cooking	13.7	13.92	14.24	14.43	15.06	12.8	13	13.3	13.48	14.06
Wineries & Other Food & Agr. Processes	0.5	0.5	0.5	0.51	0.51	0.32	0.32	0.32	0.33	0.33
Metallurgical & Minerals Manufacturing	4.23	4.49	4.69	4.91	5.27	2.86	3.02	3.15	3.29	3.53
Waste Management	1.13	1.19	1.22	1.24	1.28	0.32	0.34	0.35	0.35	0.37
Semiconductor Manufacturing	--	--	--	--	--	--	--	--	--	--
Fiberglass Products Manufacturing	--	--	--	--	--	--	--	--	--	--
Rubber & Plastic Products Manufacturing	--	--	--	--	--	--	--	--	--	--
Contaminated Soil Aeration	--	--	--	--	--	--	--	--	--	--
Other Industrial Commercial	1.12	1.15	1.19	1.23	1.3	0.5	0.51	0.53	0.55	0.58
Subtotal	20.71	21.3	21.89	22.36	23.47	16.83	17.23	17.7	18.04	18.92

Table 2-9 (continued). Bay Area Emissions Inventory 2005-2020, PM10 & PM2.5.

SOURCE CATEGORY	Particulate Matter< 10 microns (4) 2005	2009	2012	2015	2020	Particulate Matter< 2.5 microns (4) 2005	2009	2012	2015	2020
COMBUSTION - STATIONARY SOURCES										
FUELS COMBUSTION										
Domestic	19.73	20.43	21	21.59	22.61	19.04	19.72	20.27	20.84	21.82
Cogeneration	0.82	0.86	0.89	0.92	0.98	0.81	0.85	0.88	0.91	0.97
Power Plants	0.26	0.41	0.42	0.44	0.48	0.26	0.41	0.42	0.43	0.48
Oil Refineries External Combustion	1.7	1.77	1.82	1.88	1.97	1.7	1.77	1.82	1.88	1.97
Glass Melting Furnaces - Natural Gas	--	--	--	--	--	--	--	--	--	--
Reciprocating Engines	0.34	0.3	0.28	0.26	0.22	0.33	0.29	0.27	0.25	0.22
Turbines	0.14	0.15	0.16	0.16	0.17	0.14	0.15	0.15	0.16	0.17
Landfill/Cement Plant Combustion	2.03	2.1	2.17	2.24	2.35	2.03	2.1	2.17	2.23	2.34
Subtotal	25.02	26.02	26.73	27.48	28.78	24.31	25.28	25.98	26.71	27.97
BURNING OF WASTE MATERIAL										
Incineration	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.1
Planned Fires	0.41	0.42	0.43	0.45	0.46	0.38	0.4	0.41	0.42	0.44
Subtotal	0.5	0.52	0.54	0.55	0.57	0.48	0.49	0.51	0.52	0.54
Banked Emissions (5)	0	0.3	0.3	0.3	0.3	0	0.2	0.2	0.2	0.2
Alternative Compliance Allowance (6)	0	0	0	0	0	0	0	0	0	0
Subtotal (District Jurisdiction)	47.78	49.76	51.14	52.42	54.96	42.76	44.39	45.63	46.76	49
COMBUSTION - MOBILE SOURCES										
ON-ROAD MOTOR VEHICLES										
Passenger Cars	3.05	3.22	3.38	3.55	3.82	1.72	1.84	1.93	2.03	2.2
Light Duty Trucks<6000lbs	2.42	2.64	2.83	3.01	3.3	1.53	1.73	1.88	2.02	2.23
Medium Duty Trucks 6001-8500 lbs	0.56	0.62	0.68	0.74	0.82	0.36	0.42	0.47	0.52	0.59
Light Heavy Duty Trucks 8501-14000lbs	0.2	0.18	0.18	0.17	0.18	0.14	0.12	0.11	0.11	0.11
Medium Heavy Duty Trucks 14001-33000lbs	0.82	0.75	0.67	0.6	0.52	0.72	0.65	0.58	0.51	0.43
Heavy Duty Trucks>33000 lbs	2.33	1.73	1.33	1.01	0.68	2.05	1.5	1.12	0.83	0.52
School/Urban Buses	0.33	0.33	0.33	0.33	0.33	0.29	0.29	0.29	0.29	0.29
Motor-Homes	--	--	--	--	--	--	--	--	--	--
Motorcycles	0.08	0.08	0.07	0.06	0.06	--	--	--	--	--
Subtotal	9.81	9.58	9.49	9.5	9.72	6.87	6.6	6.44	6.36	6.42

Table 2-9 (continued). Bay Area Emissions Inventory 2005-2020, PM10 & PM2.5.

SOURCE CATEGORY	Particulate Matter< 10 microns (4)					Particulate Matter< 2.5 microns (4)				
	2005	2009	2012	2015	2020	2005	2009	2012	2015	2020
OFF-HIGHWAY MOBILE SOURCES										
Lawn and Garden Equipment	0.35	0.32	0.31	0.3	0.31	0.34	0.32	0.3	0.3	0.31
Transportation Refrigeration Units	0.51	0.43	0.34	0.21	0.08	0.49	0.42	0.33	0.21	0.08
Agricultural Equipment	0.44	0.36	0.3	0.23	0.13	0.43	0.35	0.29	0.22	0.13
Construction and Mining Equipment	4.4	3.7	3.18	2.52	1.6	4.29	3.62	3.1	2.46	1.57
Industrial Equipment	0.67	0.57	0.48	0.37	0.25	0.66	0.56	0.47	0.37	0.24
Light Duty Commercial Equipment	0.71	0.69	0.67	0.61	0.53	0.7	0.68	0.66	0.61	0.53
Trains	0.32	0.28	0.29	0.3	0.32	0.31	0.27	0.29	0.29	0.31
Off Road Recreational Vehicles	--	--	--	--	--	--	--	--	--	--
Ships (7)	3.12	3.55	3.92	4.32	5.08	3.05	3.47	3.82	4.21	4.96
Commercial Boats	1.11	1.01	0.92	0.8	0.75	1.09	0.99	0.89	0.78	0.74
Recreational Boats	1.04	1.28	1.51	1.77	2.26	1.04	1.28	1.5	1.76	2.26
Subtotal	12.68	12.19	11.91	11.44	11.32	12.42	11.94	11.68	11.22	11.12
AIRCRAFT										
Commercial Aircraft	0.1	0.11	0.11	0.12	0.14	0.09	0.1	0.11	0.12	0.14
General Aviation	--	--	--	--	--	--	--	--	--	--
Military Aircraft	0.27	0.27	0.27	0.28	0.28	0.27	0.27	0.27	0.27	0.28
Airport Ground Support Equipment	0.12	0.13	0.14	0.15	0.16	0.1	0.1	0.11	0.11	0.12
Subtotal	0.5	0.52	0.54	0.56	0.59	0.47	0.49	0.5	0.52	0.55
MISCELLANEOUS OTHER SOURCES										
Construction Operations	26.96	27.32	28.71	30.15	32.62	2.69	2.73	2.87	3.01	3.26
Farming Operations	1.21	1.21	1.21	1.21	1.21	0.18	0.18	0.18	0.18	0.18
Entrained Road Dust-Paved Roads	72.14	76.51	79.82	83.39	89.48	10.82	11.48	11.98	12.51	13.43
Entrained Road Dust-Unpaved Roads	12.57	13.07	13.44	13.82	14.48	1.26	1.31	1.34	1.38	1.45
Wind Blown Dust	6.54	6.54	6.54	6.54	6.54	1.15	1.15	1.15	1.15	1.15
Animal Waste	11.15	11.15	11.15	11.15	11.15	1.39	1.39	1.39	1.39	1.39
Agricultural Pesticides	--	--	--	--	--	--	--	--	--	--
Non-Agricultural Pesticides	--	--	--	--	--	--	--	--	--	--
Consumer Products(Excluding Pesticides)	--	--	--	--	--	--	--	--	--	--
Other Sources	6.95	6.38	6.38	6.38	6.39	6.25	5.74	5.74	5.74	5.75
Subtotal	137.54	142.17	147.26	152.64	161.87	23.75	23.98	24.65	25.37	26.6

Table 2-9 (continued). Bay Area Emissions Inventory 2005-2020, PM10 & PM2.5.

SOURCE CATEGORY	Particulate Matter< 10 microns (4) 2005	2009	2012	2015	2020	Particulate Matter< 2.5 microns (4) 2005	2009	2012	2015	2020
Biogenics	--	--	--	--	--	--	--	--	--	--
Subtotal	--	--	--	--	--	--	--	--	--	--
Total Emissions	208.32	213.92	220.04	226.27	238.16	86.27	87.22	88.7	90.02	93.49
GRAND TOTAL EMISSIONS	208.32	214.22	220.34	226.57	238.46	86.27	87.42	88.9	90.22	93.69

1. Inventory and projections are based upon CARB EMFAC 2007, Version 2.3 and assume implementation of all control measures adopted as of December 31, 2006, including Smog Check II for the Bay Area.
2. The Annual Average inventory represents emissions on an average day. ABAG Projections 2007 were used to project future emissions from on-road motor vehicles and for the regional population projections used for the planning inventory.
3. Entries are rounded to nearest whole number, totals may not equal to sums of column entries.
4. Table shows directly emitted PM only. Figures do not include secondary PM10 such as ammonium nitrate and ammonium sulfate
5. Banked Emissions show the total current deposits in the District's emissions banking program as allowed by BAAQMD Regulation 2, Rules 2 & 4. These emissions were reduced (beyond regulations) and banked, but may be withdrawn from the bank and emitted in future years.
6. Surplus emissions, voluntarily reduced, available for alternative compliance with BARCT requirements of selected rules, as prescribed by State law and BAAQMD Regulation 2, Rule 9.
7. CARB has recently developed statewide emissions estimates for ocean-going vessels occurring within 100 nautical miles of the California coastline. As a result, these emissions are substantially higher than those reported in the previous version of the inventory published in the 2005 Ozone Strategy, which accounted for ship activities within three miles of the Golden Gate Bridge.

Figure 2-14 provides a breakdown of Bay Area ammonia emissions by source. Ammonia is a key precursor to secondary PM, as it combines with NOx to form ammonium nitrate and combines with SOx to form ammonium sulfate.

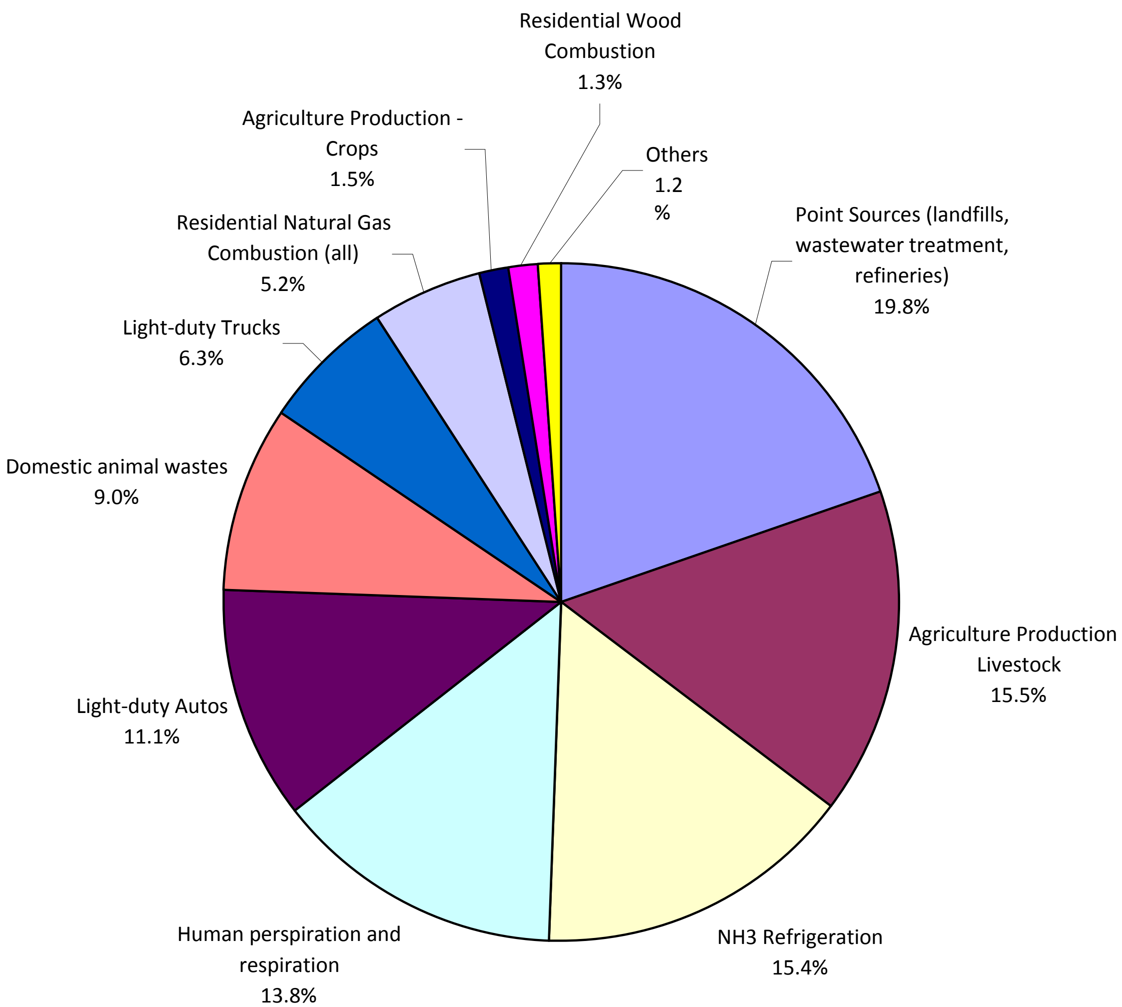

Figure 2-14. Annual average ammonia emissions by source, 2008 (52 tons/day).

Source Contributions to Ambient PM Concentrations

Ambient PM2.5 derives both from direct emissions and secondary compounds created in the atmosphere. Determining the relative contributions of various sources of direct PM2.5 emissions and PM2.5 precursors to total PM concentrations is complex. To estimate the overall contribution of various sources, we combine emissions inventory data with the results of chemical mass balance (CMB) analysis, the latter providing information on the relative contributions from source categories contributing to primary and secondary PM.

In analyzing PM sources there may be discrepancies between the estimated PM emissions inventory and ambient PM concentrations estimated from CMB analysis. For example, the emissions inventory lists road and windblown dust as significant sources, whereas chemical mass balance analysis shows such dust to be a very small contributor on ambient filters. There are several likely reasons, a primary one being that what gets emitted does not necessarily stay airborne to be sampled. Thus, larger PM2.5 particles – those nearly 2.5 microns in diameter such as the bulk of geological dust – tend to settle out relatively quickly, whereas smaller particles – those less than 1 micron in diameter including combustion-related PM2.5 – can stay airborne for days.

Figure 2-15 shows estimated contributions to both primary and secondary annual average PM2.5 by source.[53] The contributions in Figure 2-15 differ from those in Figure 2-12 in a number of respects: Sea salt constitutes about 11% of Bay Area PM2.5, but is not included in the Emissions Inventory. Emissions of NOx from motor vehicles contribute significantly to secondary PM2.5, namely ammonium nitrate; because of this, the overall contribution of motor vehicles to PM2.5 concentrations is considerably larger than their direct emissions alone. Similarly, refineries emit significant amounts of SO2, so that their contribution to ammonium sulfate is significant. A key point is that most Bay Area anthropogenic PM2.5 derives from combustion – either wood (biomass) burning, or combustion of fossil fuels.

[53] See report entitled *Sources of Bay Area Fine Particles*. www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Particulate%20Matter/PM_Report.ashx

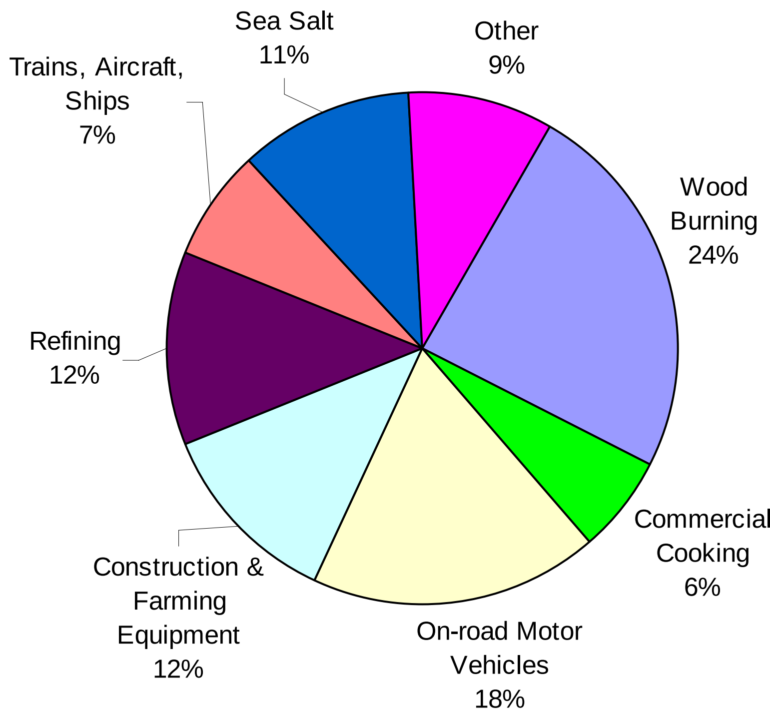

Figure 2-15. Estimated contributions to annual PM2.5 concentrations in the Bay Area.

Figure 2-16 is similar to Figure 2-15, except that it shows the relative contributions to peak PM2.5 concentrations; those relevant for the national 24-hour PM2.5 standard. In the Bay Area, the highest PM2.5 occurs in the wintertime. Wood burning represents a large portion of the total. Wood burning is primarily residential wood fires, but also includes wildfires and prescribed burns. Figure 2-16 shows wood-burning as contributing roughly one-third of peak PM2.5 concentrations. However, on certain days and in certain locations, wood-burning can account for more than half of total ambient PM2.5. Another large portion of winter PM2.5 is ammonium nitrate deriving from NOx and ammonia. Thus, on-road motor vehicles are also a large contributor because they are the principal source of NOx emissions.

In addition to directly emitted PM, emissions of PM precursors such as NOx, ammonia, and sulfur dioxide contribute to the formation of secondary PM. Combustion of fossil fuels produces NOx, which combines with ammonia[54] in the atmosphere to form ammonium nitrate, and sulfur dioxide (SO2), which combines with ammonia to form ammonium sulfate. These secondary compounds constitute another one-third of Bay Area PM2.5 on an annual basis and approximately 40-45% during winter peak periods.

[54] As shown in Figure 2-14, the leading sources of ammonia emissions in the Bay Area include livestock, ommercial refrigeration (wineries, breweries, and cold storage warehouses), human respiration and perspiration, domestic animal waste, and motor vehicles.

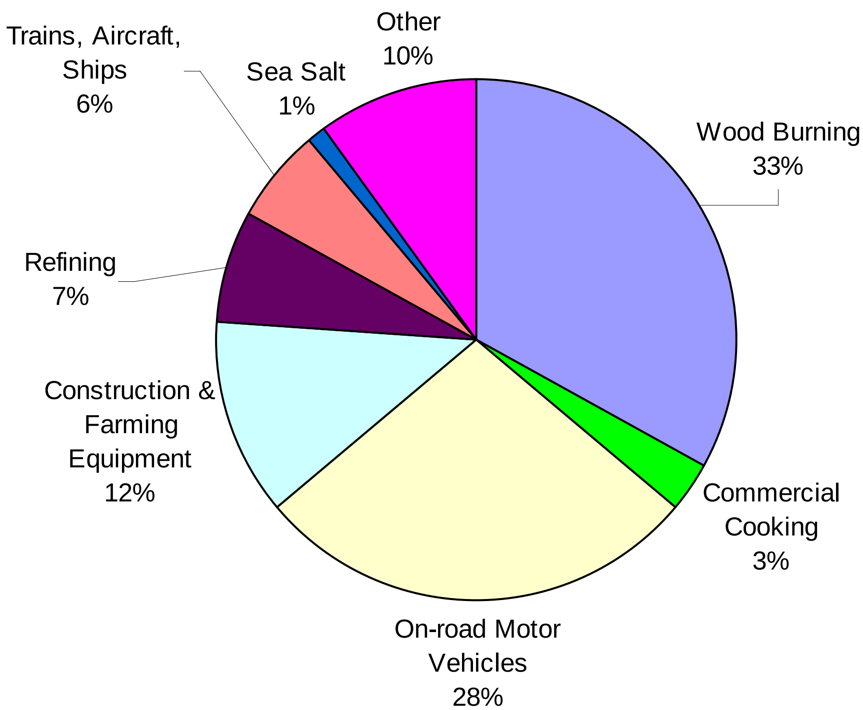

Figure 2-16. Estimated contributions to peak PM2.5 concentrations in the Bay Area

In recent years, as industrial production and air pollution have increased in China and other Asian countries, researchers have been investigating the possible impact of Asian emissions in terms of ambient air quality and deposition in North America. More research is needed in this area. However, preliminary analysis suggests that while there may be substantial transport of PM from Asia, most of it apparently passes far above the Bay Area, continuing eastward where some may be deposited on the slopes of the Sierras.[55]

Trends in Monitored PM Concentrations

The Bay Area has achieved significant reductions in PM concentrations since 1990 but continues to exceed several PM standards. Figure 2-17 shows trends relative to the standards.

[55] Chin, M., Diehl, T., Ginoux, P., Malm, W., 2007. Intercontinental transport of pollution and dust aerosols: implications for regional air quality. Atmos. Chem. Phys. 7, 5501–5517

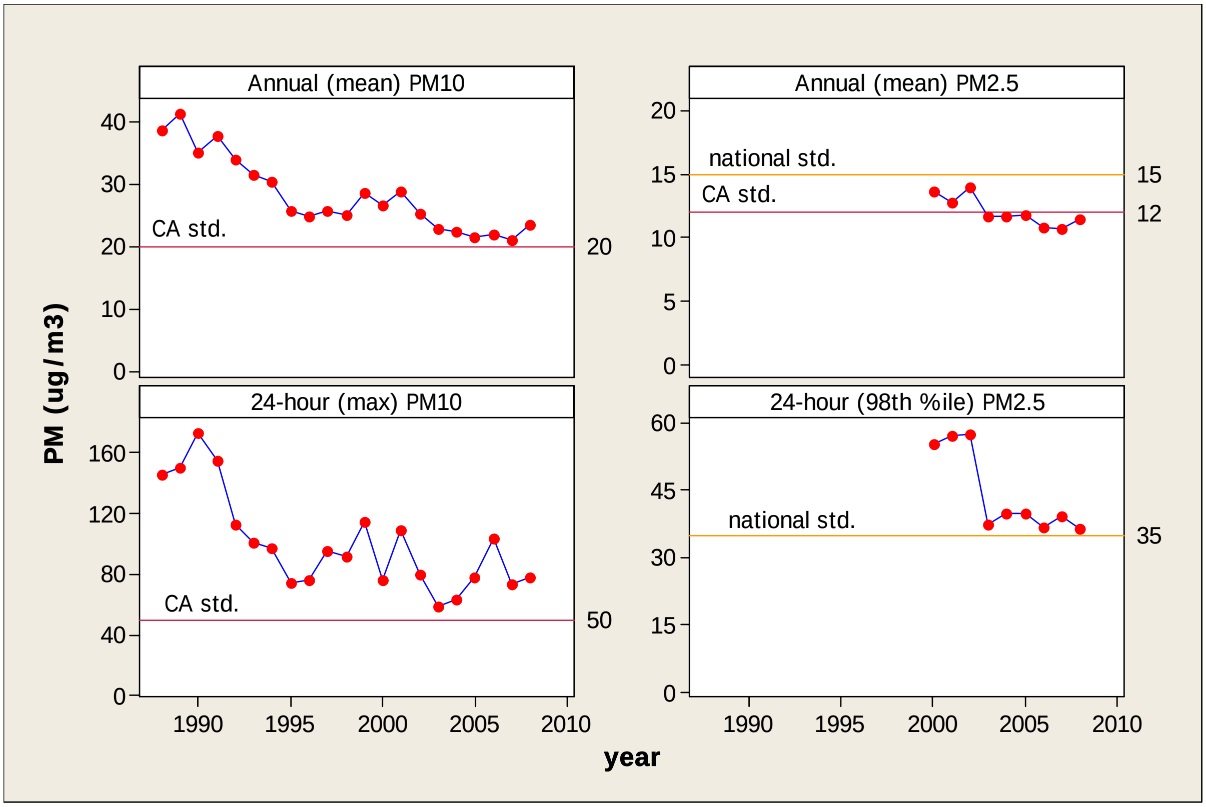

Figure 2-17. Bay Area PM trends relative to national and California standards.

The Bay Area's peak 98th percentile values, which serve as the basis for determining attainment of the national 24-hour $PM_{2.5}$ standard, were just over the national 35 μg/m^3 standard in 2008. Given the continued reductions in emissions of both primary PM2.5 and also its secondary precursors, the standard may be met in a few years. The Bay Area continues to violate state PM10 standards by a considerable margin, however.

The Bay Area has seen significant reductions in PM10 levels since 1990; peak concentrations have declined by approximately half and annual average values have declined by about one-third. PM2.5 has only been measured since 1999, so quantitative trend analysis is currently limited. However, it is likely that PM2.5 has been reduced at least as much as PM10.[56] Analysis of ambient PM10 measurements shows that ammonium nitrate values have dropped faster than PM10 as a whole. This reduction is likely due to reductions in NO_x emissions, which have decreased significantly since 1990; reducing secondary PM represents an additional benefit of reducing NOx as an ozone precursor.

[56] Fine PM is almost completely combustion-related, whereas geological dust, for which emissions appear to be increasing, and marine air, which is trendless, are both more prevalent among the coarse (larger) PM10 particles.

Summary of Key PM Modeling Findings

Photochemical modeling was used to estimate the impacts of reducing PM and its precursor emissions for the Bay Area and its neighboring PM nonattainment regions. Reducing primary (directly-emitted) PM2.5 emissions in the Bay Area provided far greater reductions in ambient Bay Area PM2.5 levels than reducing Bay Area secondary PM2.5 precursor emissions. Of the precursor emissions reductions simulated (ammonia, NOx, VOC, and sulfur-containing compounds), Bay Area ammonia reductions were most effective in reducing PM concentrations. The ammonia emissions reductions lowered Bay Area ammonium nitrate PM2.5 levels only for relatively cold winter days favoring ammonium nitrate buildup. (Ammonium nitrate PM2.5 tends to evaporate faster than it forms at temperatures above around 60 degrees Fahrenheit.) Combined NOx and VOC emissions reductions for the Bay Area were relatively ineffective. NOx emissions reductions were relatively ineffective because ammonium nitrate PM2.5 formation involves the relatively slow and incomplete conversion of NOx to nitric acid. Reducing Bay Area sulfur-containing PM precursor emissions typically had a small impact on Bay Area ambient PM2.5 levels. Under certain conditions, however, reducing Bay Area sulfur-containing emissions did provide around 1 $\mu g/m^3$ reduced Bay Area PM2.5 level.

Photochemical simulations were also performed with zero Bay Area anthropogenic emissions to gauge the impacts of transported PM2.5 and precursors. Significant amounts of both primary and secondary PM2.5 were transported into the Bay Area. On days when the Bay Area exceeded the 24-hour PM2.5 standard, transported primary PM2.5 levels averaged as high as 8 $\mu g/m^3$ and transported secondary PM2.5 levels averaged as high as 13 $\mu g/m^3$. The largest transport impacts for both primary and secondary PM2.5 occurred along the eastern boundary of the Bay Area.

Summary of Modeling Findings: Impact of Wood Smoke Reductions on PM

Locally-emitted wood smoke accounts for approximately one-third of PM2.5 levels on days when Bay Area PM levels exceed the national 24-hr PM2.5 standard. Preliminary wood smoke simulations have suggested that the wood smoke rule may have been effective at reducing ambient wood smoke levels by 50-75 percent at key PM2.5 monitoring locations. This conclusion, however, assumes 100% compliance with the wood smoke rule, which may not have occurred. The largest reductions in wood smoke PM2.5 levels were simulated for the locations having peak wood smoke levels; these locations often were not near any monitor. Therefore, reductions of population exposure to wood smoke resulting from the rule may be significantly greater than indicated by the monitoring data. Multiple, consecutive no-burn days may provide the added benefit of reducing both fresh wood smoke emissions, as well as smoke carried over from prior days.

Air Toxics

Air toxics (often referred to as "toxic air contaminants") are a class of pollutants that include hundreds of individual airborne chemical species hazardous to human health. A number of these are common in urban environments. Reducing emissions of air toxics and population exposure to these chemicals is a key priority for the Air District.

Air Toxics Health Effects

Air toxics can cause or contribute to a wide range of health effects, including acute (short-term) health effects, such as eye and throat irritation; chronic (long-term) non-cancer effects, such as neurological damage, hormone disruption, and developmental defects; and cancer. CARB has identified 191 air toxics, including diesel particulate matter (diesel PM) and environmental tobacco smoke.

Unlike criteria pollutants which are subject to ambient air quality standards, air toxics are primarily regulated at the individual emissions source level based on risk assessment. Human outdoor exposure risk associated with an individual air toxic species is calculated as its ground-level concentration multiplied by an established unit risk factor for that species. Total risk due to air toxics is the sum of the individual risks associated with each species.

The Air District's cancer-risk-weighted emissions inventory, developed based upon OEHHA health risk estimates, shows that a small subset of air toxics account for approximately 95% of the total cancer risk from air pollutants in the Bay Area, as illustrated in Figure 2-18. This cancer risk is estimated at several hundred cases per million in many parts of the Bay Area, and higher in certain communities most impacted by diesel emissions, as discussed in the Air Toxics Trends section below. Diesel PM alone accounts for roughly 85% of this risk.[57]

Diesel particulate matter has been shown to be a lung carcinogen in occupational health studies[58] and is also a respiratory irritant. Mobile sources, especially heavy-duty diesel engines in trucks, construction equipment, locomotives, and ships, account for most of the cancer risk associated with air toxics in the Bay Area, as shown in Figure 2-19.

[57] Unlike most other air toxics, diesel PM cannot be measured directly because no accepted measurement method currently exists. Therefore, the concentration estimates for diesel PM have been made using elemental carbon measurements collected via the IMPROVE method or using a PM-based exposure method.

[58] See "Health Risk Assessment for Diesel Exhaust," Chapter 6.2. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, May 1998.

Benzene, present in gasoline vapors and also a byproduct of combustion, has been classified as a human carcinogen and is associated with leukemia. 1,3-butadiene, produced from motor vehicle exhaust and other combustion sources, has also been associated with leukemia. Reducing 1,3-butadiene also has a co-benefit in reducing the air toxic acrolein.[59]

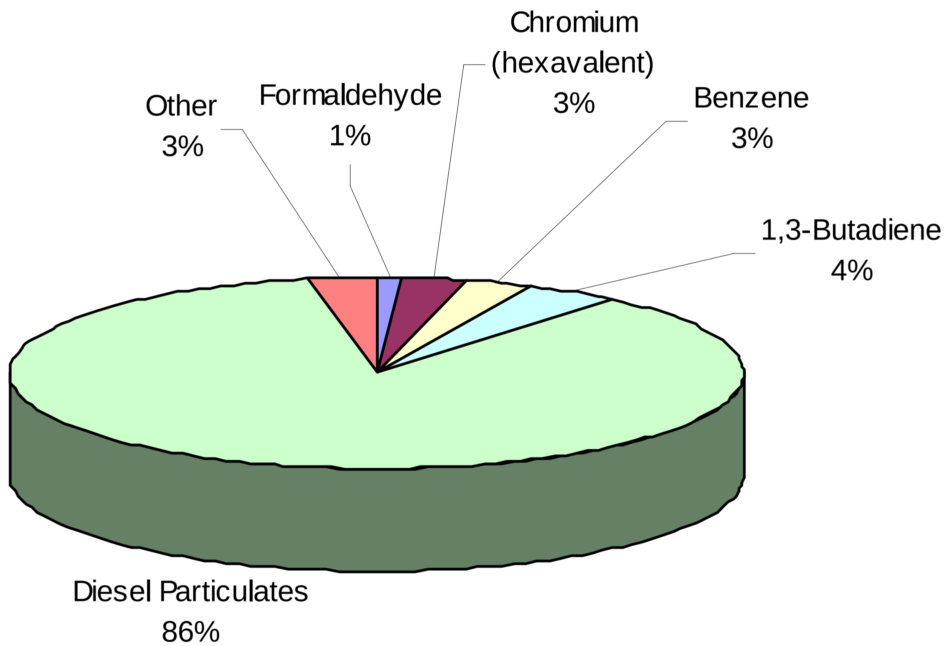

Figure 2-18. Cancer-risk weighted emission estimates for the San Francisco Bay Area.

Acetaldehyde and formaldehyde are emitted from fuel combustion and other sources and formed photo-chemically in the atmosphere from other compounds. Both compounds have been found to cause nasal cancers in animal studies; both are also associated with skin and respiratory irritation. Human studies for carcinogenic effects of acetaldehyde are sparse but, in consideration of animals studies, sufficient to support classification as a probable human carcinogen. Formaldehyde has been associated with nasal sinus cancer and nasopharyngeal cancer, and possibly with leukemia.

Air Toxics Emissions Inventory

[59] Acrolein, which is emitted directly in combustion processes and chemically produced from 1,3-butadiene in the atmosphere, has been associated with both chronic and acute health effects [OEHAA, EPA REF], including respiratory aliments, decreased respiratory function, and eye irritation.

Through the Air District's Community Air Risk Evaluation (CARE) program (described in Chapter 3), estimates of air toxics emissions in 2005 were compiled within the Bay Area for all major source categories: stationary permitted (point); other stationary, non-point; on-road mobile; and off-road mobile sources. The point source category includes industrial emissions from sources such as refineries, power plants and landfills, which are required to provide annual updates to the BAAQMD on their toxic emissions. The non-point area source category includes emissions from sources such as dry-cleaners, gasoline dispensing facilities, and lawn and garden equipment. The on-road mobile source category includes emissions from cars and trucks on freeways and roadways. The off-road mobile source category includes emissions from sources such as ships, trains, and construction equipment.

The air toxics emission inventories for on-road and areas sources were compiled following a "top-down" approach, beginning with total organic gases (TOG) and PM10 emissions estimated at the county level. Air toxics emissions for both on-road and area sources are estimated from chemical speciation of TOG and PM10, using source-specific speciation profiles to transform TOG and PM emissions into emissions of individual air toxics. These estimates were combined with the existing point source inventory of air toxics emissions. The mass-based emissions were converted to toxicity-weighted emissions for cancer, chronic, and acute risks using available cancer unit risk (UR) factors and non-cancer reference concentrations (RfC) for the inhalation exposure pathway.

An inventory showing the major sources of key air toxics is provided in Table 2-10. [60] The emissions shown in this table are raw numbers; that is, the data has not been weighted based upon health risk.

Figure 2-19 shows cancer-risk-weighted air toxics emissions by source category.

[60] The District is in the process of preparing a toxic inventory that will estimate toxics emissions in future years, but the future year inventory was not available in time for inclusion in the Draft CAP.

Table 2-10. Bay Area air toxics inventory for the year 2005.

	Annual Average Emissions in pounds/day (not risk-weighted)					
SOURCE CATEGORY	BENZENE	DPM	1,3-BUTADIENE	FORMALDEHYDE	ACETALDEHYDE	HEXAVALENT CHROMIUM
PETROLEUM REFINING	133.2		3.8	37.4	3.3	0.02
OTHER INDUSTRIAL PROCESSES	50.3		0.04	64.6	8.3	0.06
ORGANIC COMPOUNDS EVAPORATION	316.9		0.00	5.4	14.9	
COMBUSTION – STATIONARY SOURCES	385.6	522.2	3.5	3003.4	1751.2	0.01
OFF-ROAD MOBILE SOURCES	3,072.1	15,441.7	830.8	6,490.3	5,875	0.32
ON-ROAD MOBILE SOURCES	6,310.7	7,465.4	1,321.3	4,741.9	3,505.6	0.29
MISCELLANEOUS			126.3			1.05
TOTAL EMISSIONS	10,269	23,429	2,286	14,343	11,158	1.74

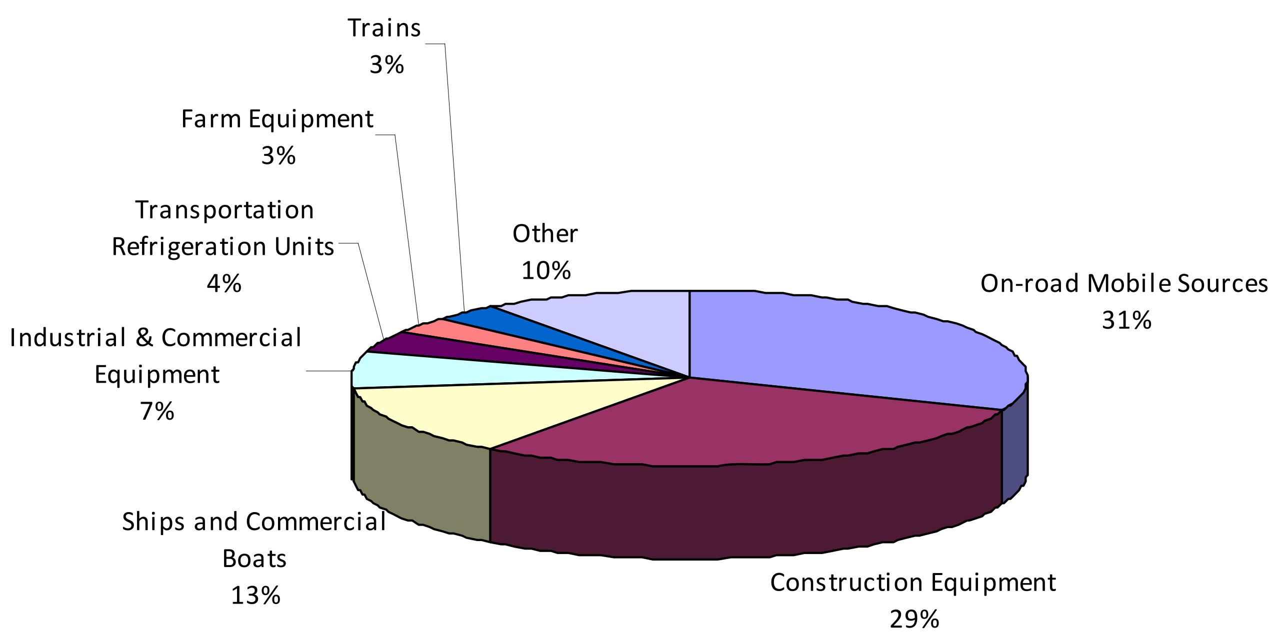

Figure 2-19. Cancer-risk-weighted air toxics emissions by source category.

Air Toxics Trends

The Air District and CARB have monitored selected air toxics in the San Francisco Bay area since the late 1980s. By analyzing trends in the air toxics monitoring data, the Air District estimates that between 1990 and 2005 there was about a 7 percent reduction per year in the cancer risk from air toxics.[61] The health risks of 1,3-butadiene and benzene have been reduced by about 78 percent and 83 percent, respectively, between 1990 and 2005.

As shown in Figure 2-20, using OEHHA cancer risk factors,[62] the estimated lifetime cancer risk (over a 70-year lifespan) from all air toxics combined declined from 1,330 cases per million in 1990 to 405 cases per million people in 2008. This represents a 70 percent drop between 1990 and 2008.

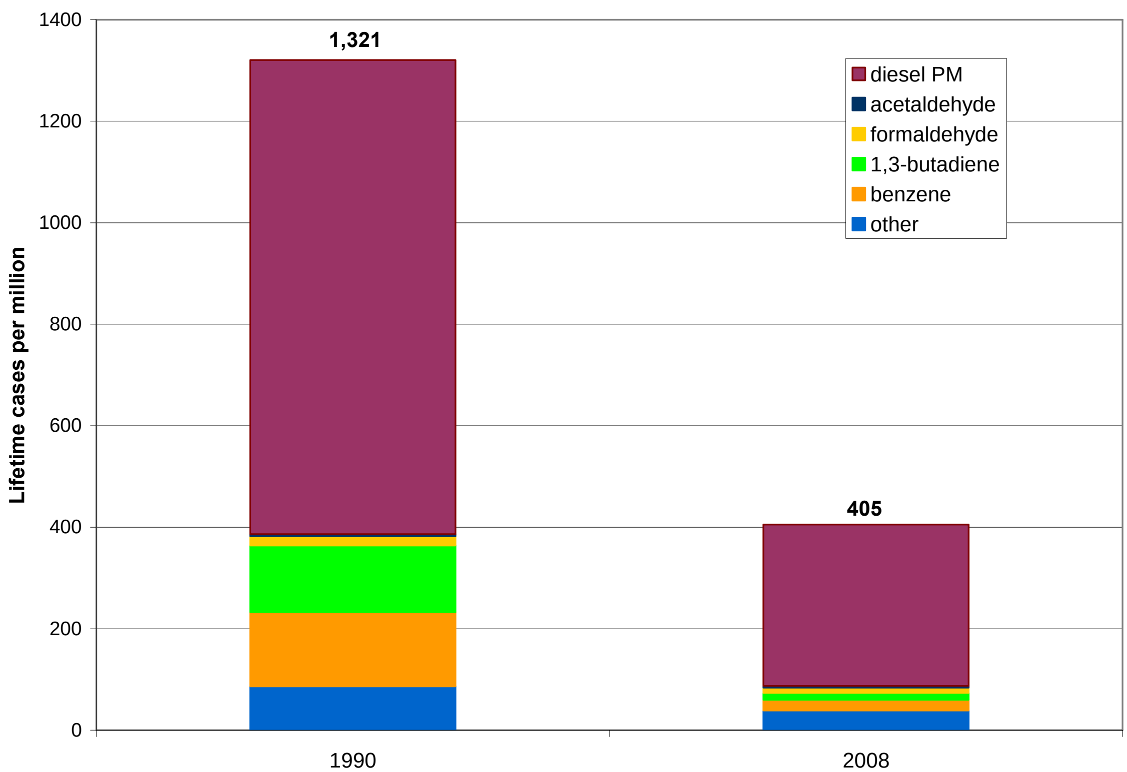

Figure 2-20. Cancer risk-weighted toxics emissions trends.

[61] Similar trends estimates are available from CARB (CARB Almanac, 2009).
[62] See Appendix A of May 2009 OEHHA document: Technical Support Document for Cancer Potency Factors. www.oehha.ca.gov/air/hot_spots/2009/AppendixA.pdf

Summary of Key Air Toxics Modeling Findings

Six air toxics species were simulated over the Bay Area. Five of the species were estimated to account for the bulk of total air toxics cancer risk in the Bay Area: acetaldehyde; benzene; 1,3-butadiene; diesel PM; and formaldehyde. The sixth species, acrolein, was believed to be the ambient toxic with the most serious non-cancer health effects. Over 80% of the Bay Area population-weighted cancer risk derived from diesel PM. The highest simulated annual average diesel PM concentration (10-12 $\mu g/m^3$) was located over West Oakland, extending toward Emeryville and along both sides of the eastern span of the Bay Bridge. The second highest (8-10 $\mu g/m^3$) locations were over an area southeast of downtown Oakland, Alameda, and the Transbay District/Rincon Hill areas in San Francisco. Cancer risk was used to define six impacted communities [63] within the Bay Area: Concord; eastern San Francisco; western Alameda County; Redwood City and East Palo Alto; Richmond and San Pablo; and San Jose. (See impacted communities map in Figure 3-2.) These six impacted communities accounted for nearly half of the total Bay Area population-weighted lifetime cancer risk for sensitive groups (those under 18 or over 64 years of age).

Air Toxics Programs at the National and State Level

There are both national and state programs to regulate air toxics. US EPA regulates air toxics (using the term "hazardous air pollutants" or HAPs) pursuant to Title III, Section 112(b) of the 1990 Clean Air Act Amendments.[64] California's program to reduce exposure to air toxics was established by the Toxic Air Contaminant Identification and Control Act via AB 1807 in 1983, and the Air Toxics "Hot Spots" Information and Assessment Act via AB 2588 in 1987. Under AB 1807, CARB and OEHHA determine if a substance should be formally identified as a toxic air contaminant in California. CARB assesses the potential for human exposure to a substance and OEHHA evaluates the health effects.

The AB 1807 program was amended in 1993 by AB 2728, which required the CARB to identify the 189 federal hazardous air pollutants as air toxics. AB 2588 supplements the AB 1807 program, by requiring a statewide air toxics inventory, notification of people exposed to a significant health risk, and facility plans to reduce these risks. In 1992, the "Hot Spots" Act was amended by Senate Bill 1731 which required facilities that pose a significant health risk to the community to reduce their risk through a risk management plan.

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[63] See *Applied Method for Developing Polygon Boundaries for CARE Impacted Communities* (December 2009) available at www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/CARE-Documents.aspx.

[64] For more details on the 1990 CAAA, see http://www.epa.gov/air/caa/.

District Programs to Reduce Air Toxics

Two programs comprise the backbone of the Air District's air toxics reduction program for stationary sources: New Source Review for Air Toxics and the Air Toxics Hot Spots Program.

New Source Review: Pursuant to Regulation 2, Rule 5, new or modified emissions sources are required to perform health risk screening analysis for air toxics and utilize Best Available Control Technology to reduce emissions of air toxics.

Air Toxics Hot Spots Program: This is a state program implemented by regional air districts in California. Pursuant to Assembly Bill 2588 (1987) and Senate Bill 1731 (1992), facilities are required to provide information about their air toxics emissions, and facilities that pose a significant risk are required to develop and implement site-specific risk reduction plans and audits.

In addition to these core air toxics programs, the Air District seeks to reduce population exposure to air toxics through a variety of rules and programs which are described in Chapter 3, including the CARE program, the Clean Air Communities Initiative, and grant and incentives programs.

Greenhouse Gases

Greenhouse gases that cause climate change are an entirely different type of pollutant than criteria pollutants or air toxics. Climate change and atmospheric warming are global in scale, both in terms of causes and effects. The scientific consensus is clear that climate change poses enormous risks on a worldwide basis. Climate change is expected to have profound impacts on both the natural and man-made systems that sustain us. The range of potential impacts includes reduction in agricultural and forestry productivity, changes in human demographics and migration, reduced water supply, acidification of oceans, changes in natural habitat, extinction of species and loss of biodiversity, more powerful or more frequent hurricanes and cyclones, etc.

As discussed in Chapter 1, climate change poses a direct threat to air quality and public health in the Bay Area. Anticipated impacts include sea level rise (threatening coastal areas, the bay and the delta, as well as key infrastructure), reduced Sierra snowpack (vital to our water supply), increased wildfires, and higher levels of air pollution.

There are dozens of greenhouse gases (GHGs), but a handful of these gases are the primary agents of climate change. For purposes of the CAP, we consider the six GHGs described below, often referred to as the "Kyoto Six."[65] These are the GHGs included in the District's *Source Inventory of Bay Area Greenhouse Gas Emissions* described below, and also included in the CAP *Multi-Pollutant Evaluation Methodology*.

Carbon Dioxide (CO2) is released to the atmosphere when fossil fuels (oil, gasoline, diesel, natural gas, and coal), solid waste, and wood or wood products are burned.

Methane (CH4) is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from the decomposition of organic waste in municipal solid waste landfills and the raising of livestock.

Nitrous oxide (N2O) is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels.

Hydrofluorocarbons (HFCs), ***perfluorocarbons*** (PFCs), and ***sulfur hexafluoride*** (SF6), are generated in a variety of industrial processes. Although these gases are small in terms of their absolute mass, they are potent agents of climate change as expressed by their global warming potential.

Global Warming Potential

Each greenhouse gas differs in its ability to absorb heat in the atmosphere; this is often referred to by the term "radiative forcing" or *global warming potential* (GWP). The GWP of the Kyoto 6 GHGs is shown in Table 2-11. Greenhouse gas emissions are often expressed in terms of carbon dioxide equivalents (CO2e), in which each gas is weighted by its GWP.

Table 2-11. Global warming potentials (GWPs) for greenhouse gases.

Greenhouse Gas	Global Warming Potential
CO2	1
Methane (CH4)	21
N2O	310
HFCs/PFCs	90- 11,700
SF6	23,900

There is great variation in terms of the emissions of each GHG on a mass basis, as well as in their GWP. Even though other GHGs absorb much more heat on a molecule per molecule basis, CO2 emissions dominate the Bay Area GHG inventory, accounting for

[65] These six gases were recognized as the leading GHGs in the Kyoto protocol of 1997. They are considered the primary GHGs by many national and international institutions, including U.S. EPA and the Intergovernmental Panel on Climate Change (IPCC).

91.4% of total GHGs on a GWP-weighted basis, because the amount of CO2 emitted is so enormous.

GHGs Not Addressed in CAP

There are a number of other greenhouse gases or agents that are not addressed in the CAP. The reasons that these GHGs were not included are explained below.

Chloroflourocarbons (CFCs) and **hydrochloroflourocarbons** (HCFCs) are pollutants that deplete stratospheric ozone. Because these emissions are covered under the *Montreal Protocol on Substances that Deplete the Ozone Layer* (1989), they are not included in the Kyoto Protocol.

Water vapor is a naturally occurring greenhouse gas which accounts for a large percentage of the total greenhouse effect. However anthropogenic emissions of water vapor do not contribute significantly to the change of atmospheric water vapor concentration. Therefore, *IPCC Guidelines* do not deal with water vapor as an anthropogenic GHG.

Ozone acts as a greenhouse gas that contributes to climate change, in addition to its role as a criteria air pollutant. Thus, reductions in emissions of ozone precursors (ROG and NOx) will provide an important co-benefit in reducing total GHG emissions.

Carbon Monoxide (CO) has been identified as an important indirect greenhouse gas. An increase in CO emissions alters atmospheric chemistry so as to increase concentrations of methane, which is a potent GHG.

Black Carbon, a key component of fine PM, may also contribute significantly to climate change. The IPCC notes a small effect from fossil fuel–based black carbon, but some researchers have suggested that the impact has been underestimated (Hansen and Nazarenko 2004; Jacobson 2001).[66] In the United States, diesel emissions account for more than half of the black carbon (CARB, 2007). In the Bay Area, combustion of wood and gasoline also contribute significantly to black carbon concentrations. As in the case of ozone, reducing emissions of black carbon may provide an important co-benefit in terms of climate protection.

Bay Area GHG Inventory and GHG Emissions Trends

In November 2006 the BAAQMD became the first air district in the nation to develop a detailed GHG emissions inventory. The Bay Area GHG inventory was updated in

[66] Hansen, J., and L. Nazarenko, 2004: Soot climate forcing via snow and ice albedos. *Proceedings of the National. Academy of Sciences*, 101, 423-428. Also see Jacobson, M. Z., Strong radiative heating due to mixing state of black carbon in atmospheric aerosols, *Nature, 409*, 695-697, 2001.

December 2008; minor revisions were also made in January 2010. The Air District's greenhouse gas inventory only includes GHGs that are emitted within the Bay Area, as well as GHGs emitted in the production of electricity that is imported to the region. The inventory does not include GHGs associated with other goods or products that are imported into the region. If GHGs from imported goods were included, the region's actual GHG footprint would be considerably larger.

Greenhouse gas emissions have been increasing on a regional, statewide, national, and global scale for many decades. Under "business as usual" conditions – that is, absent some combination of regulatory, policy, land-use, and/or market-based changes - Bay Area GHG emissions would be expected to continue to increase at an average rate of approximately 1.4 percent per year in the future due to population growth, economic expansion, and other factors.

Figure 2-21 shows the current Bay Area inventory by source category. The industrial/ commercial and the transportation sectors combined account for over 70% of GHG emissions in the Bay Area inventory.

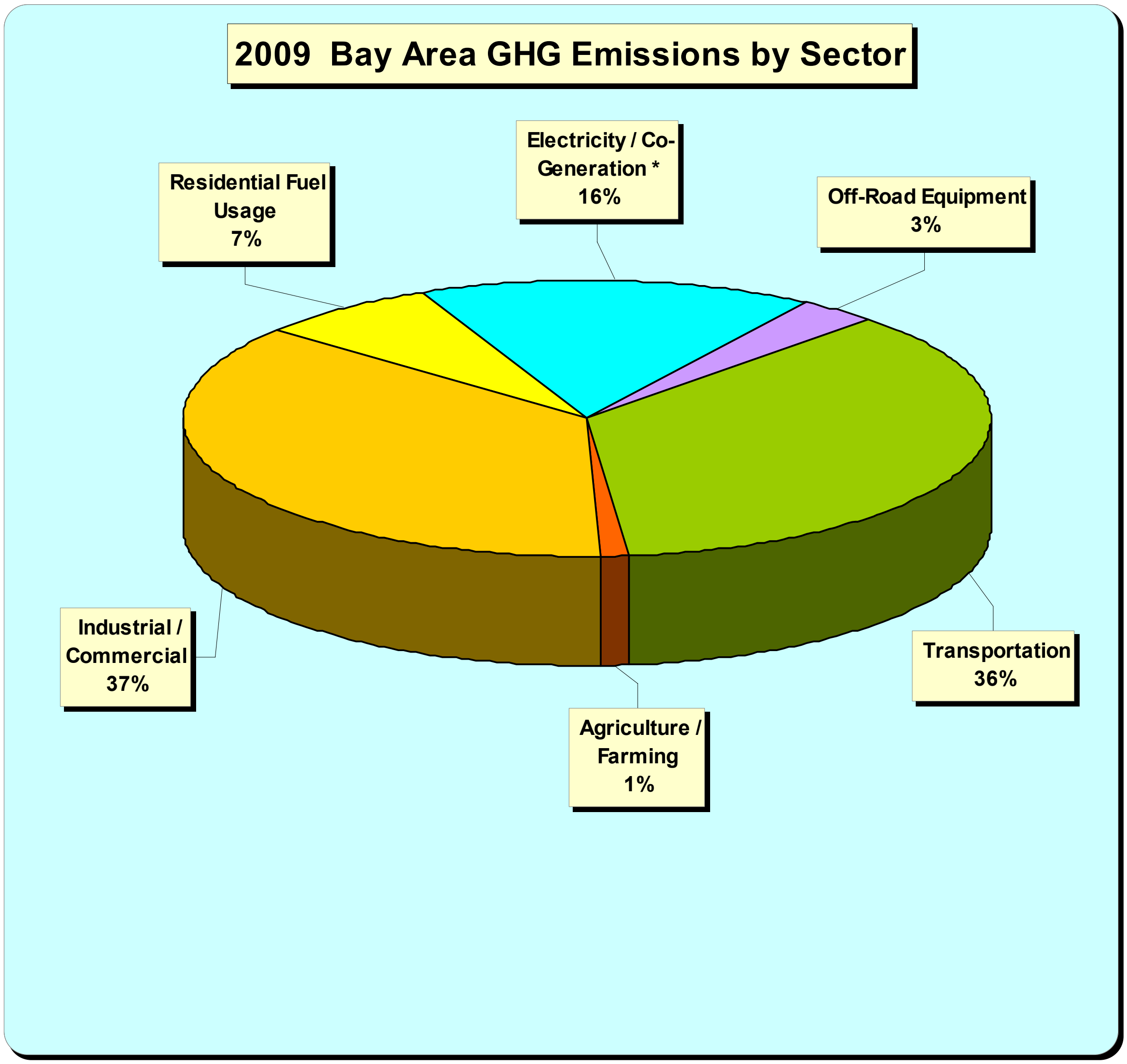

Figure 2-21. Bay Area GHG emissions by source category.

The latest Bay Area GHG inventory shown in Table 2-12 reflects regulatory programs that were in place as of 2007.[67]

[67] The benefits of CARB's GHG regulation for motor vehicles adopted in 2004, the "Pavley regulations" (AB 1493) to reduce emissions of GHGs from motor vehicles, are not included in Table 2-12. This regulation had been on hold, pending U.S. EPA approval of a waiver required under the terms of the federal Clean Air Act. The waiver was finally approved in June 2009. However, CARB has not yet updated its emission factors to incorporate the projected benefits of AB 1493.

Table 2-12. Bay Area greenhouse gas emission inventory projections for 2005-2020 (million metric tons CO2 equivalent).

SOURCE CATEGORY	Year 2005	Year 2009	Year 2012	Year 2015	Year 2020
INDUSTRIAL/ COMMERCIAL					
Oil Refineries					
Refining Processes	3.4	3.5	3.6	3.7	3.9
Refinery Make Gas Combustion	4.7	4.9	5.0	5.2	5.4
Natural Gas and Other Gases Combustion	4.8	5.0	5.1	5.3	5.5
Liquid Fuel Combustion	0.1	0.1	0.1	0.1	0.1
Solid Fuel Combustion	1.0	1.0	1.1	1.1	1.1
Waste Management					
Landfill Combustion Sources	0.0	0.0	0.0	0.0	0.0
Landfill Fugitive Sources	1.2	1.2	1.2	1.2	1.2
Composting/POTWs	0.4	0.4	0.4	0.4	0.4
Other Industrial/ Commercial					
Cement Plants	0.9	0.9	0.9	0.9	1.0
Commercial Cooking	0.1	0.1	0.1	0.1	0.2
ODS Substitutes/Nat. Gas Distrib./Other	3.6	5.2	6.3	7.5	9.4
Reciprocating Engines	0.6	0.6	0.6	0.7	0.7
Turbines	0.4	0.4	0.4	0.4	0.4
Natural Gas- Major Combustion Sources	1.6	2.5	2.6	2.7	2.8
Natural Gas- Minor Combustion Sources	8.8	9.2	9.5	9.9	10.4
Coke Coal	1.0	1.0	1.1	1.1	1.2
Other Fuels Combustion	0.3	0.4	0.4	0.4	0.4
Subtotal	32.8	36.3	38.4	40.6	44.2
RESIDENTIAL FUEL USAGE					
Natural Gas	6.4	6.6	6.8	6.9	7.2
LPgas/Liquid Fuel	0.2	0.2	0.2	0.2	0.2
Solid Fuel	0.1	0.2	0.2	0.2	0.2
Subtotal	6.7	6.9	7.1	7.2	7.5
ELECTRICITY/ CO-GENERATION					
Co-Generation	5.5	5.5	5.7	6.0	6.4
Electricity Generation	2.8	3.1	3.2	3.3	3.5
Electricity Imports	6.8	7.3	7.6	7.9	8.3
Subtotal	15.1	15.8	16.5	17.2	18.3
OFF-ROAD EQUIPMENT					
Lawn and Garden Equipment	0.1	0.1	0.1	0.1	0.1
Construction Equipment	1.7	1.9	1.9	2.0	2.2
Industrial Equipment	0.7	0.8	0.8	0.9	1.0
Light Commercial Equipment	0.2	0.2	0.3	0.3	0.3
Subtotal	2.8	3.0	3.2	3.3	3.6

Table 2-12 (continued). Bay Area greenhouse gas emission inventory projections for 2005-2020 (million metric tons CO2 equivalent).

SOURCE CATEGORY	Year 2005	Year 2009	Year 2012	Year 2015	Year 2020
TRANSPORTATION					
Off-Road					
Locomotives	0.1	0.1	0.1	0.1	0.1
Ships	0.7	0.8	0.8	0.9	1.0
Boats	0.6	0.6	0.5	0.5	0.6
Commercial Aircraft	1.8	2.0	2.1	2.3	2.6
General Aviation	0.2	0.2	0.2	0.3	0.3
Military Aircraft	0.5	0.5	0.5	0.5	0.5
On-Road					
Passenger Cars/Trucks up to 10,000 lbs	26.6	27.1	27.9	29.0	30.9
Medium/Heavy Duty Trucks > 10,000 lbs	3.3	3.3	3.4	3.5	3.7
Urban, School and Other Buses	0.8	0.8	0.8	0.8	0.9
Motor-Homes and Motorcycles	0.2	0.2	0.2	0.2	0.2
Subtotal	34.8	35.6	36.7	38.1	40.7
AGRICULTURE/ FARMING					
Agricultural Equipment	0.2	0.2	0.2	0.2	0.2
Animal Waste	0.6	0.6	0.6	0.6	0.6
Soil Management	0.3	0.3	0.3	0.3	0.3
Biomass Burning	0.0	0.0	0.0	0.0	0.0
Subtotal	1.1	1.1	1.1	1.1	1.1
GRAND TOTAL EMISSIONS	**93.4**	**98.7**	**103.0**	**107.5**	**115.4**

Chapter 3 – Planning Context

This chapter provides the policy and planning context for the CAP. The 2010 Clean Air Plan builds on many other plans and programs, including existing and new Air District initiatives, as well as plans developed and implemented by other agencies. This chapter describes:

- Progress in implementing the Bay Area 2005 Ozone Strategy;
- Key Air District programs and initiatives that are linked to the CAP;
- External plans and programs that complement the CAP; and
- State and federal emission reduction programs.

Implementation of the Bay Area 2005 Ozone Strategy

The 2010 CAP updates the Air District's most recent state ozone plan, the 2005 Ozone Strategy. The 2005 Ozone Strategy laid out a comprehensive plan to reduce emissions of ozone precursors, including 15 Stationary Source Measures (SSMs), four Mobile Source Measures (MSMs), and 20 Transportation Control Measures (TCMs). The Air District and its partner agencies have taken action to implement the control measures in the 2005 Ozone Strategy, as summarized below. SSMs have been implemented through the Air District's rule development process. MSMs and TCMs have been implemented through a wide range of mechanisms, including partnerships, grants, and public outreach and education.

In addition, the 2005 Ozone Strategy identified 20 Further Study Measures (FSMs). These FSMs were not a formal part of the control strategy, but the Air District did make a commitment to evaluate these measures further to determine whether they could be developed into formal control measures. Several FSMs were in fact developed into formal measures and adopted as rules, as discussed below.

Stationary Source Measures in the 2005 Ozone Strategy

Table 3-1 shows the outcome of Stationary Source Measures identified in the 2005 Ozone Strategy. Of the 15 stationary measures, 13 have been adopted.

Table 3-1. Implementation of stationary source measures in 2005 ozone strategy.

Control Measure (Reg. – Rule) 2005 Ozone Strategy Control Measure #	Date Adopted	Emissions Reduced (tons per day)	
		ROG	NOx
SSM 1: Auto Refinishing (8-45)	12/3/08	3.7	
SSM 2: Graphic Arts Operations (8-20)	11/19/08	1.65	
SSM 3: High-Emitting Spray Booths [1]			
SSM 4: Polyester Resin Operations (8-50)	12/02/09	0.15	
SSM 5: Wood Coating Operations (8-32)	8/5/09	0.45	
SSM 6: Petroleum Refinery Flares (12-12) [2]	7/20/05	Unknown	
SSM 7: Gasoline Bulk Terminals/Plants (8-33 & 39)	4/15/09	0.07	
SSM 8: Marine Loading Operations (8-44)	12/7/05	0.44	
SSM 9: Organic Liquid Storage (8-5)	10/18/06	0.03	
SSM 10: Pressure Relief Devices (8-28) [3]	12/21/05	0.001	
SSM 11: Wastewater Systems (8-8)	9/15/04	2.1	
SSM 12: Boilers (9-7)	7/30/08		3.8
SSM 13: Residential Water Heaters (9-6)	11/7/07		2.5
SSM 14: Stationary Gas Turbines (9-9)	12/6/06		0.43
SSM 15: Promote Energy Conservation [4]	NA		
Total Emission Reductions		8.59	6.73

1 SSM 3 is proposed for deletion, as discussed below.
2 Regulation 12, Rule 12 reduces emissions or ROG, NOx, PM and SOx.
3 The amendments to SSM 10 increase monitoring, inspection and reporting requirements to ensure that any significant release is detected, measured and controlled, thereby reducing potential exposure in nearby communities.
4 SSM 15 has been reconfigured as ECM 1 in the 2010 CAP.

SSM 3 (High Emitting Spray Booths) is proposed for deletion. Analysis by Air District staff indicates that due to the adoption of other control measures (SSM-1 and SSM-5), plant closures and voluntary reductions, the potential emissions reductions from this measure are de minimis; therefore further rule development is not warranted at this time.

SSM 15 (Promote Energy Conservation), which was not proposed to be adopted as an Air District rule, has been implemented primarily through the District's Climate Protection Program. SSM 15 has been reconfigured and incorporated into measure ECM 1 in the 2010 CAP control strategy.

Additional Rules Adopted Since 2005

In addition to rules adopted pursuant to the Stationary Source Measures in the 2005 Ozone Strategy, the Air District has adopted or amended a number of other rules since

2005, as shown in Table 3-2. Several of these rules had been included as Further Study Measures (FSMs) in the 2005 Ozone Strategy. The additional actions include:

- Rules to reduce emissions of air toxics, including Regulation 2, Rule 5, New Source Review for Toxic Air Contaminants; as well as Regulations 11-16 and 8-17, both of which apply to dry cleaning operations
- Rules to require that agricultural feed lots (large confined animal sources) of a certain size obtain permits and mitigate their emissions;
- Rules to reduce emissions of PM pursuant to SB 656, including stationary internal combustion engines (Reg. 9-8), commercial broiling operations (Reg. 6-2), and residential wood-burning devices (Reg. 6-3).

Table 3-2. Additional rules adopted in 2005-2009 period.

Control Measure (Reg. – Rule) 2005 Ozone Strategy Control Measure #	Date Adopted	Emissions Reduced (tons per day)	
		ROG	NOx
FSM 2: Architectural Coatings (8-3)	7/1/09	5.4	
FSM 3: Commercial Broiling Operations (6-2) [1]	12/5/07	0.09	
FSM 15: Stationary IC Engines (9-8)	7/25/07		9.6
New Source Review / Toxic Air Contaminants (2-5)	6/15/05	Unknown	
Petroleum Refinery Flares (12-12) [2]	4/5/06	Unknown	
Large Confined Animal Sources (1, 2-1, 2-10)	7/19/06	Unknown	
Wood-burning Devices (6-3)	7/9/08	unknown	
Dry Cleaning Operations (11-16, 8-17)	3/4/09	unknown	
Total emission reductions		5.49	9.6

[1] In addition to reducing PM, Reg. 6-2 also reduces ROG emissions generated by cooking meat, thus helping to reduce ozone.

[2] Amendments to Reg. 12, Rule 12 were adopted on April 5, 2006 (in addition to the rule, first adopted on 7/20/05 pursuant to SSM 6.)

The PM rules described above were identified in the PM Implementation schedule adopted by the Air District Board of Directors in November 2005 in response to Senate Bill 656. SB 656 required CARB, in consultation with local air districts, to develop and adopt a list of the most feasible and cost-effective control measures that could be employed by CARB and local air districts to reduce PM10 and PM2.5. The bill required air districts to review the CARB list and develop implementation schedules for feasible PM control measures based on their local PM conditions. In response to SB 656, the Air District adopted the three PM rules listed above.

Implementation of Mobile Sources Measures in the 2005 Ozone Strategy

Table 3-3 summarizes implementation actions and progress in implementing the Mobile Source Measures in the Bay Area 2005 Ozone Strategy.

Table 3-3. Implementation of mobile source measures in 2005 ozone strategy.

Mobile Source Measures			
CM #	**Source Category**	**Description**	**Status**
MSM-1	Diesel Equipment Idling Model Ordinance	Reduce emissions from the idling of diesel equipment	BAAQMD has entered into an MOU with CARB and began implementing a Mobile Source Compliance Program in late 2009 to help enforce CARB diesel idling rules, with objective of establishing an ongoing presence in communities highly impacted by diesel truck traffic. BAAQMD provided approximately $47 million in grants to reduce diesel emissions in the 2005-2009 period.
MSM-2	Green Contracting Model Ordinance	Develop and promote a model ordinance to help local government agencies to encourage contractors to use clean vehicles, equipment and fuels.	BAAQMD provided grants to Sonoma and Marin Counties, and the Town of Hillsborough for development of local ordinances. This measure has been replaced by the new Mobile Sources Measures in the 2010 CAP.
MSM-3	Low Emission Vehicle Incentives	Encourage the purchase of new low-emission vehicles to reduce emissions from existing vehicles.	Between 2005 and 2009, BAAQMD awarded approximately $47 million in grants for the purchase of low-emission vehicles, cleaner engines and retrofit devices for transit buses, school buses, garbage trucks, public and private fleets. Reductions realized estimated at 0.04 tons per day (tpd) of ROG and 0.4 tpd of NOx.
MSM-4	Vehicle Buy Back Program	Accelerate the retirement of older, high emitting vehicles from the region's roadways by providing incentives to scrap them.	Between 2005 and 2008 BAAQMD provided incentives to retire approximately 20,500 passenger vehicles model year 1987 and older for a total cost of approximately $20 million. Reductions realized estimated at 1.03 tons per day (tpd) of ROG and 0.55 tpd of NOx.

Implementation of Transportation Control Measures in the 2005 Ozone Strategy

Table 3-4 summarizes implementation actions and progress in implementing the Transportation Control Measures in the Bay Area 2005 Ozone Strategy.

Table 3-4. Implementation of transportation control measures in 2005 ozone strategy.

CM#	Name/Source Category	Description	Implementation
TCM- 1	Support Voluntary Employer Based Trip Reduction Programs	Support and encourage voluntary efforts by Bay Area employers to promote the use of commute alternatives by their employees	BAAQMD has provided grants for 511 Regional Rideshare Program, Marin video-conferencing, Spare the Air employer program, Guaranteed Ride Home Programs in San Francisco, Solano, Napa, and West Contra Costa, other employer-based programs in San Ramon, West and East Contra Costa, Alameda, San Mateo. MTC is the primary funding source for the annual Bike To Work Day promotion.
TCM- 2	Adopt Employer Based Trip Reduction Rule (Deleted)	Deleted	Deleted per Health & Safety Code Section 40717.9.
TCM-3	Improve Local and Area wide Bus Service	Reduce motor vehicle trips, vehicle miles traveled, and mobile source.	MTC funded three express bus projects: Richmond Bridge, East Bay North, and East Bay South; and the Lifeline Transportation Program. BAAQMD provided grants for Tri-Delta, Muni, Napa, and LAVTA transit; and to improve bicycle parking at BART stations. Also, new Intermodal and Park & Ride lots opened in Petaluma, Windsor and Cotati (MTC/BAAQMD funded).
TCM-4	Upgrade and Expand Local and Regional Rail Service	Reduce motor vehicle trips vehicle miles traveled and mobile source emissions	MTC funded Third Street Light Rail Project (Phase 1), Caltrain Express/Rapid Rail Phase I, SCVTA Vasona light rail extension (adds 8 new stations and 5.3 miles), and the Oakland Airport Connector.
TCM-5	Improve Access To Rail and Ferries	Reduce motor vehicle trips, vehicle miles traveled and mobile source emissions by reducing auto trips	BAAQMD funded shuttle projects to connect to rail and ferry stations connecting Caltrain, Samtrans, SFO, SCVTA, West Berkeley, PresidGO, Mid-Day Menlo Park, UCSF, Ace Trains to Stoneridge Business Park and Dublin/Pleasanton BART, and from Benicia Industrial Park to Vallejo ferry.
TCM-6	Improve Inter-Regional Rail Service	Reduce motor vehicle travel and emissions for longer distance interregional trips	See TCM-5 for shuttles funded by BAAQMD connecting Ace Train, Caltrain. BAAQMD funded 4 locomotive engines for passenger service. Plans ongoing to improve and expand service underway (MTC funded).

Table 3-4 (continued). Implementation of transportation control measures in 2005 ozone strategy.

CM#	Name/Source Category	Description	Implementation
TCM-7	Improve Ferry Service	Reduce emissions from Transbay auto trips, which tend to be longer in length, and will also reduce auto traffic in highly congested bridge corridors	BAAQMD funded 11 ferry engine repower projects. MTC and WETA have ongoing plans to improve and expand ferry service
TCM-8	Construct Carpool/ Express Bus Lanes on Freeways	Reduce mobile source emissions by encouraging high occupancy vehicles	MTC funded new regional express bus service; completed HOV lanes on SR 87 in Santa Clara, 1-880/237 and 85/101, 580 in Alameda and I-80 in Solano. MTC funded ramp meters completed on 101 in San Mateo and under construction on 101 in Marin.
TCM-9	Improve Bicycle Access and Facilities	Reduce mobile source emissions by encouraging cycling	MTC adopted Resolution 3765 to encourage routine accommodation of cyclists and pedestrians in projects funded by MTC regional discretionary funds. MTC has provided funding ($8 million per year) via regional bicycle/pedestrian program. MTC and BAAQMD have funded 511 BikeMapper (part of 511 Rideshare). BAAQMD provided grants for bicycle parking or lanes in every Bay Area county. MTC has allocated $27 million from the first funding cycle of the new Federal transportation bill towards a regional bicycle program.
TCM-10	Youth Transportation	Reduce motor vehicle travel and mobile source emissions related to the transportation of youth and students for school and other activities	BAAQMD provided grants for clean school buses throughout region, including San Ramon, Lafayette, Milpitas, River Delta School District, West Sonoma, Pleasant Hill. BAAQMD subsidized transit passes for students in Sonoma and Marin Counties and San Ramon. MTC has allocated $10 million from the first funding cycle of the new Federal transportation bill towards a public outreach effort, including a focus on youth education.
TCM-11	Install Freeway Traffic Management System	Reduce emissions produced by stop and go congestion	MTC, CHP and Caltrans sponsor ongoing Freeway Service Patrols. MTC has allocated $105 million from the first funding cycle of the new Federal transportation bill towards the Freeway Performance Initiative.
TCM-12	Arterial Management Measures	Reduce vehicle idling and acceleration	Completed projects funded by BAAQMD include: San Tomas Expressway, Matilda in Sunnyvale, Lawrence Expressway, McDowell/Baywood in Petaluma, 14th Street arterial in Alameda County, Mowry, Stevenson, Blacow in Fremont, Light Rail Controller Upgrade Project in San Jose, and on Constitution Way/Lincoln in City of Alameda.

Table 3-4 (continued). Implementation of transportation control measures in 2005 ozone strategy.

CM#	Name/Source Category	Description	Implementation
TCM-13	Transit Use Incentives	Programs to increase transit use and reduce vehicle emissions	MTC funded Translink on AC Transit, BART, Golden Gate Transit, MUNI and other systems, and real-time transit info on Muni and BART. (See also TCM-3 for intermodal and Park & Ride facilities and TCM-1, TCM-16.)
TCM-14	Carpool and Vanpool Services and Incentives	Reduce motor vehicle emissions	MTC ongoing funding for 511 Regional Rideshare and rideshare short-term vanpool subsidy and “start-up” incentive subsidy. See also TCM-1.
TCM-15	Local Land Use Planning And Development Strategies	Reduce motor vehicle use and emissions by promoting land use patterns and new development that facilitate walking, bicycling and transit use	Via FOCUS, regional agencies have implemented partnership with local jurisdictions to define priority development areas (PDAs). In June 2008, MTC in partnership with AC Transit launched TransLink® for TOD, offering residents of select transit-oriented development (TOD) complexes around the East Bay unlimited free travel on AC Transit's local and transbay buses during a one-year pilot program. In 2009, MTC awarded $1.8 million in Station Area Planning Grants to six jurisdictions along the Sonoma-Marin Area Rail Transit (SMART) corridor. In addition, MTC has allocated $85 million from the first funding cycle of the new Federal transportation bill towards the Transportation for Livable Communities Program to support PDAs. See also TCM-3 thru TCM-7, TCM-17, 19 and 20.
TCM-16	Public Education / Intermittent Control Measures	Educate the public about air quality in the Bay Area	BAAQMD funded Spare the Air notices, webpage, banner, advertisements, and free transit rides; transit marketing in Sonoma; transit and bicycle marketing in Petaluma. MTC has allocated $10 million from the first funding cycle of the new Federal transportation bill towards a public education effort (see TCM-10)
TCM-17	Conduct Demonstration Projects	Promote demonstration projects to develop innovative approaches to reduce mobile source emissions	BAAQMD and MTC funded PATH demonstration of electronic bicycle lockers at Pleasant Hill BART Station. MTC funded Alameda County CMA Dynamic Ridesharing pilot projects. BAAQMD funded the Travel Choice program pilots in Fruitvale and the City of Alameda. This program was then implemented in Berkeley and San Leandro. BAAQMD funded the SF County Telecommute Pilot Project. See also TCM-15.

Table 3-4 (continued). Implementation of transportation control measures in 2005 ozone strategy.

CM#	Name/Source Category	Description	Implementation
TCM-18	Implement Transportation Pricing Reform	Improving air quality and addressing persistent congestion issues	MTC developed a regional High Occupancy Toll (HOT) lane network proposal included in T2035 regional transportation plan. MTC developed a best parking practices manual and technical resources to assist local governments in revising parking policies. San Francisco is studying congestion pricing and market-based parking pricing.
TCM-19	Improve Pedestrian Access and Facilities	Making pedestrian travel safer, more convenient and more attractive will promote walking, reduce the need to use autos, and therefore reduce mobile source emissions	MTC adopted Resolution 3765 to encourage routine accommodation of cyclists and pedestrians in projects funded by MTC regional discretionary funds. MTC has provided funding ($8 million per year) via regional bicycle/pedestrian program. BAAQMD funded Pedestrian Access projects in Suisun City, Bayview Gateway in SF, and Sunnyvale, and multi-use trails in Morgan Hill, Sebastopol, Suisun, Livermore, Mountain View, American Canyon, Contra Costa, Antioch, and Marin.
TCM-20	Promote Traffic Calming Measures	Reduce motor vehicle emissions	Palo Alto, Menlo Park, Mountain View and Cotati all have plans or studies ongoing. San Francisco has installed curb bulbs, median refuges, lighted crosswalks, ladder crosswalks, and fluorescent yellow crossing signs. Also see TCM 15 re: Station Area Planning Grants and Transportation for Livable Communities Program.

Status of Further Study Measures in the 2005 Ozone Strategy

Table 3-5 summarizes implementation actions and progress in implementing the Further Study Measures in the Bay Area 2005 Ozone Strategy.

Table 3-5. Status of further study measures in 2005 ozone strategy.

Further Study Measures					
FSM # (Reg #)	**Source Category**	**Description**	**Status**		
FSM-1 (8-51)	Adhesives and Sealants	Reduce VOC limits for architectural adhesives	Staff recommendation: Retain as FSM 1 in 2010 CAP.		
FSM-2 (8-3)	Architectural Coatings	Reduce VOC limits from architectural coatings	Adopted 7/1/09	5.4 tpd ROG	
FSM-3 (6-2)	Commercial Cooking Equipment	Reduce NOx and particulate from charboilers	Adopted 12/05/07	0.09 tpd VOC, 0.55 tpd PM10	
FSM-4	Composting Operations	Limit emissions of both VOC and ammonia	Staff recommendation: Retain as FSM 15 in 2010 CAP.		
FSM-5	Food Product Manufacturing and Processing	Reduce VOC limits for food-processing facilities that emit more than 440 pounds/month of organic compound emissions	Staff recommendation: Delete from Further Study Measures due to insufficient emissions reductions to warrant further action.		
FSM-6	Livestock Waste	Reduce emissions of particulate, ammonia (which forms aerosol particulate matter) and VOC	Staff recommendation: Develop into control measure SSM 3 for the 2010 CAP.		
FSM-7 (8-3 & 8-32)	Limitation on Solvents Based on Relative Reactivity	Consider replacing VOC limits in certain rules, measured in mass VOC per volume of product, with limits based on the relative contribution to ozone formation of each of the organic species that make up the VOC of a product.	Staff recommendation: Retain, with revisions, as FSM 2 in 2010 CAP.		
FSM-8 (8-16)	Solvent Cleaning and Degreasing	Reduce VOC limits	Staff recommendation: Retain as FSM 3 in 2010 CAP.		
FSM-9	Emission from Cooling Towers	Reduce organic emission limits	Staff recommendation: Retain as FSM 4 in 2010 CAP.		
FSM-10 (8-8)	Refinery Wastewater Treatment Systems	Reduction in ROG from refinery wastewater systems	Results of this FSM reported to Board of Directors 11/16/2005. No further action		
FSM-11	Vacuum Trucks	Reduce VOC emissions	Staff recommendation: Develop into control measure SSM 5 for the 2010 CAP.		
FSM-12 (8-18)	Valves and Flanges	Reduce emissions from valves and flanges typically found at refineries and chemical plants.	Staff recommendation: Retain as FSM 5 (Equipment Leaks) in 2010 CAP. More stringent standards for oil and gas production to be considered under SSM 4: Natural Gas Production and Distribution.		

Table 3-5 (continued). Status of further study measures in 2005 ozone strategy.

FSM # (Reg #)	Source Category	Description	Status
FSM-13	Wastewater from Coke Cutting Operations	Reduce VOC emissions from coke cutting wastewater.	Staff recommendation: Retain as FSM 6 in 2010 CAP.
FSM-14 (9-10)	NOx Reduction from Refinery Boilers	Reduce NOx emissions from refinery boilers.	Staff recommendation: Develop into control measure SSM 10 for the 2010 CAP. District staff is currently developing rule amendments.
FSM-15 (9-8)	Stationary IC Engines	Reduce NOx limits for IC engines, reduce secondary particulate matter	Adopted 7/25/07 9.6 tpd NOx
FSM-16	Encourage Alternative Diesel Fuels	Exploration of the potential air quality benefits of using biodiesel fuel in place of conventional petroleum diesel	BAAQMD has awarded approximately $5.4 million in grants for emulsified diesel fuel in shipping and shore power projects. These projects are ongoing.
FSM-17	Mitigation Fee for Federal Sources	Mitigation Fee Program, adopted into the South Coast AQMD's 2003 AQMP, but not yet implemented, would charge an air quality impact fee to sources pre-empted from State and local air district authority under the federal Clean Air Act	Staff recommendation: Delete as FSM due to lack of clear authority for local air districts to impose fees on these sources (ships, aircraft, locomotives).
FSM-18	Indirect Source Mitigation Program	Reduce emissions from development projects that generate vehicle trips and thus indirectly cause air pollutant emissions	Staff recommendation: Develop into control measure LUM 2 for the 2010 CAP.
FSM-19	Free Transit on Spare the Air Days	Reduce motor vehicle emissions by providing free transit service on STA days.	Free Transit on Spare the Air (STA) Days was implemented for three years and discontinued when funding ran out. Staff recommendation: Delete this FSM in the 2010 CAP due to lack of funding.
FSM-20	Episodic Measures	Episodic measures are measures implemented only at times when pollution levels are projected to exceed air quality standards.	District continues to implement the Spare the Air (STA) program. STA is evolving to promote clean air choices on an everyday basis. The District's 2009 Summer slogan was "Any ride is worth sharing" (aimed at reducing ozone precursors from motor vehicles). The 2009 Winter campaign was "Check before you burn" and promoted awareness of the wood-burning rule to reduce PM. Both campaigns reduce emissions on an episodic basis.

Air District Programs that Provide Foundation for the CAP

The 2010 CAP is rooted in long-standing core Air District programs, including air quality monitoring; regulation, permitting and enforcement of stationary sources; public outreach and education; and grants and incentives. In addition to these core programs, the Air District has developed new programs and initiatives in recent years to respond to the challenges of protecting public health and protecting our climate. The CAP control strategy described in Chapter 4 incorporates and reinforces the new initiatives underway at the Air District. The section below highlights the Air District's recent efforts in several key areas, including:

- Reducing health risks in impacted communities;
- Reducing emissions from seaports and the goods movement sector;
- Reducing wood-burning and wood smoke; and
- Reducing emissions of greenhouse gases and protecting the climate.

Reducing Health Risks in Impacted Communities

Protecting public health is a fundamental part of the Air District's mission and one of the key objectives of the 2010 CAP. The Air District strives to reduce public health impacts from air pollution throughout the Bay Area, by means of the New Source Review program and the Air Toxics Hot Spots program which are briefly described in Chapter 2. However, because it is clear that certain parts of the region experience higher levels of pollution than others, the Air District has developed several programs that focus on reducing health risks in disproportionately impacted communities. The Air District established the Community Air Risk Evaluation (CARE) program in 2004. In 2009 the District expanded upon the CARE program by creating the Clean Air Communities Initiative (CACI). The overall goal of these programs is to identify the communities most impacted by air pollution, and to develop and implement comprehensive strategies to reduce these impacts. Both programs are described below.

Clean Air Communities Initiative

The Clean Air Communities Initiative encompasses a multi-faceted effort to reduce health risks in impacted communities and to minimize the effects of land use and transportation decisions on cumulative air quality impacts. Certain communities are exposed to high levels of air toxics, especially diesel PM, resulting in elevated health risks. Addressing land use and transportation is critical to solving this problem because on-road and off-road motor vehicles are the largest source of diesel PM and other air toxics, and because land use decisions influence not only transportation patterns but also local exposures to these pollutants. CACI brings a wide range of tools and resources to bear on this important issue, as depicted in Figure 3-1, including regulations and guidance, air quality monitoring, public outreach and community dialogue, targeted grants funding, enforcement of diesel air toxics control measures, and collaboration with county health departments and other local agencies.

The CARE program, described below, provides the foundation for the Clean Air Communities Initiative.

Community Air Risk Evaluation (CARE) Program

In 2004 the Air District initiated the Community Air Risk Evaluation (CARE) program to evaluate and reduce health risks associated with local exposures to air toxics in the Bay Area. The program examines air toxics emissions from point sources, area sources and on-road and off-road mobile sources with an emphasis on reducing population exposure to diesel exhaust. CARE combines technical analysis, outreach to impacted communities, and policy mechanisms to reduce emissions and health risks in those communities. The main objectives of the program are to:

- Characterize and evaluate potential cancer and non-cancer health risks associated with exposure to air toxics from both stationary and mobile sources throughout the Bay Area.
- Assess potential exposures to sensitive receptors including children, senior citizens, and people with respiratory illnesses.
- Identify significant sources of air toxics emissions and prioritize use of resources to reduce air toxics in the most highly impacted areas (i.e., priority communities).
- Develop and implement strategies - such as grants, guidelines, or regulations - to achieve cleaner air for the public and the environment, focusing initially on priority communities.

To help guide this program, the Air District formed a CARE Task Force composed of representatives from impacted communities, business, local public health agencies, and research institutions. The CARE program also includes a robust public outreach component. Air District staff conducts community meetings to provide health risk information, update Bay Area residents about the results of the CARE studies, and to receive public comment.

The technical analysis portion of the CARE program includes an assessment of the sources of air toxics emissions, modeling and monitoring to estimate concentrations of air toxics, and an assessment of exposures and health risks. Information derived from the technical analyses is used to focus emission reduction strategies in areas with high air toxics exposures and high density of sensitive populations.

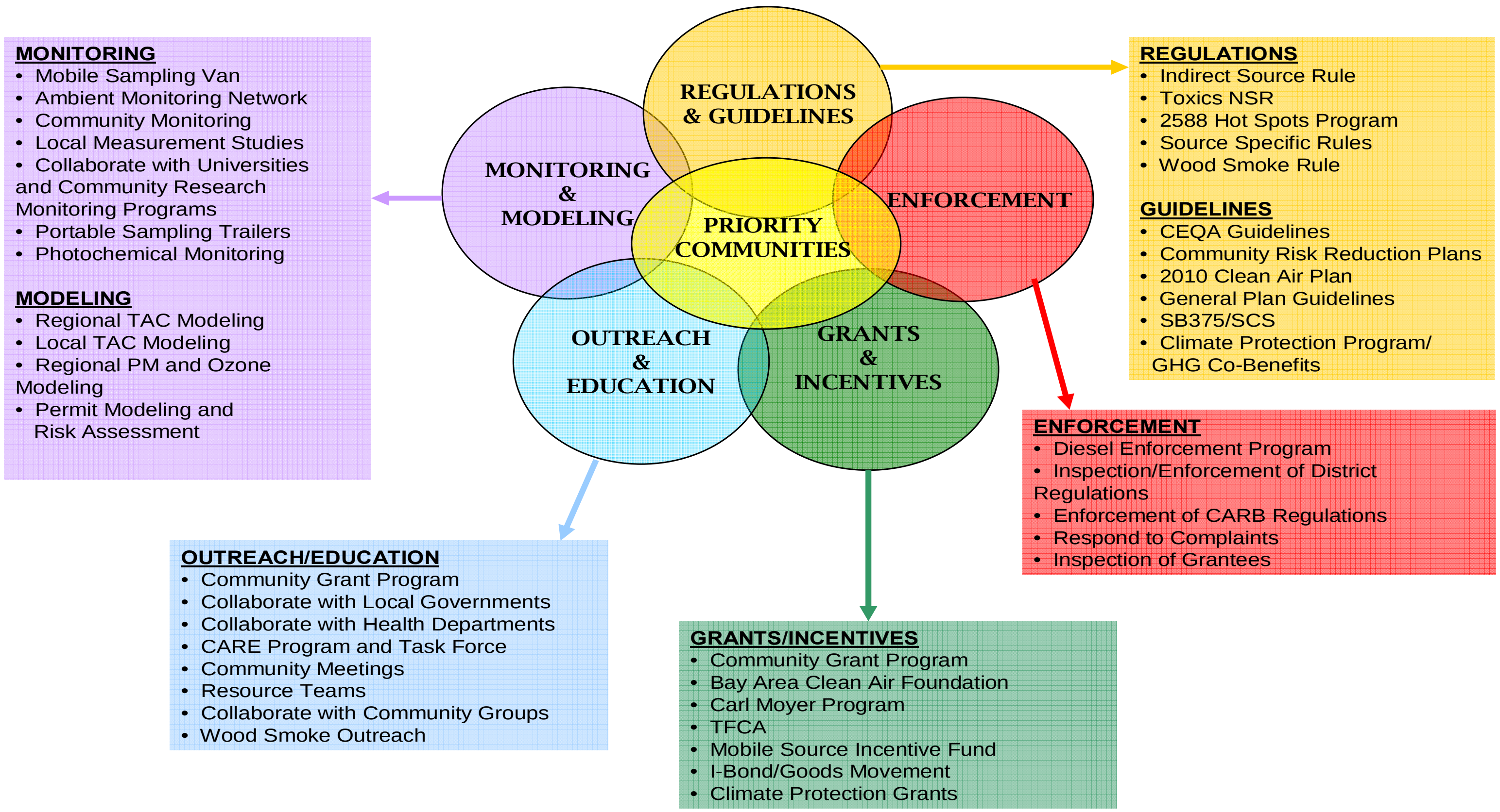

Figure 3-1. Clean Air Communities Initiative.

The Air District first developed a preliminary emissions inventory of air toxics for year 2000 that includes emissions from individual point source facilities, area sources, on-road mobile sources, and off-road sources (e.g., construction equipment, ships, and aircraft). This initial inventory was updated to include the most recent 2005 emission data as shown in Figures 2-18 and 2-19 in Chapter 2. The air toxics emission data was combined with demographic and health statistics data to create risk-weighted emissions maps to help the District identify communities with significant exposures that would most benefit from mitigation strategies, such as Air District grant programs.

The Air District also performed photochemical modeling to estimate pollutant concentrations and risks from diesel PM and other key air toxics, both locally and for the entire Bay Area, as described in Appendix D. This modeling was used to refine the identification of impacted communities where reductions in emissions and exposure are most needed. Six priority communities have been identified based on the following criteria: high exposure of youth and seniors to air toxics, high emissions of air toxics, and low income. The priority communities are shown in Figure 3-2.

In an example of local-scale modeling, the Air District partnered with CARB, the Port of Oakland, and the Union Pacific Railroad to estimate the health risks from diesel exhaust in West Oakland. Final results of the comprehensive health risk assessment (HRA) were made available in December 2008. The HRA found that residents of West Oakland are exposed to diesel PM concentrations that are almost three times higher than the average background diesel PM in the Bay Area. The findings of the HRA confirm findings of the CARE Program that there are certain parts of the Bay Area – such as West Oakland – where emission reductions are especially critical.

Through the Clean Air Communities Initiative, the Air District is focusing comprehensive emission reduction strategies in these communities. The Air District also is partnering with local governments in these areas to prepare community risk reduction plans, in order to allow a community-wide approach to reducing cumulative impacts of air toxics. As noted, these local air quality problems are often closely linked with land use and transportation decisions. The community risk reduction plans will provide a tool to support infill development, while protecting residents from high levels of pollution.

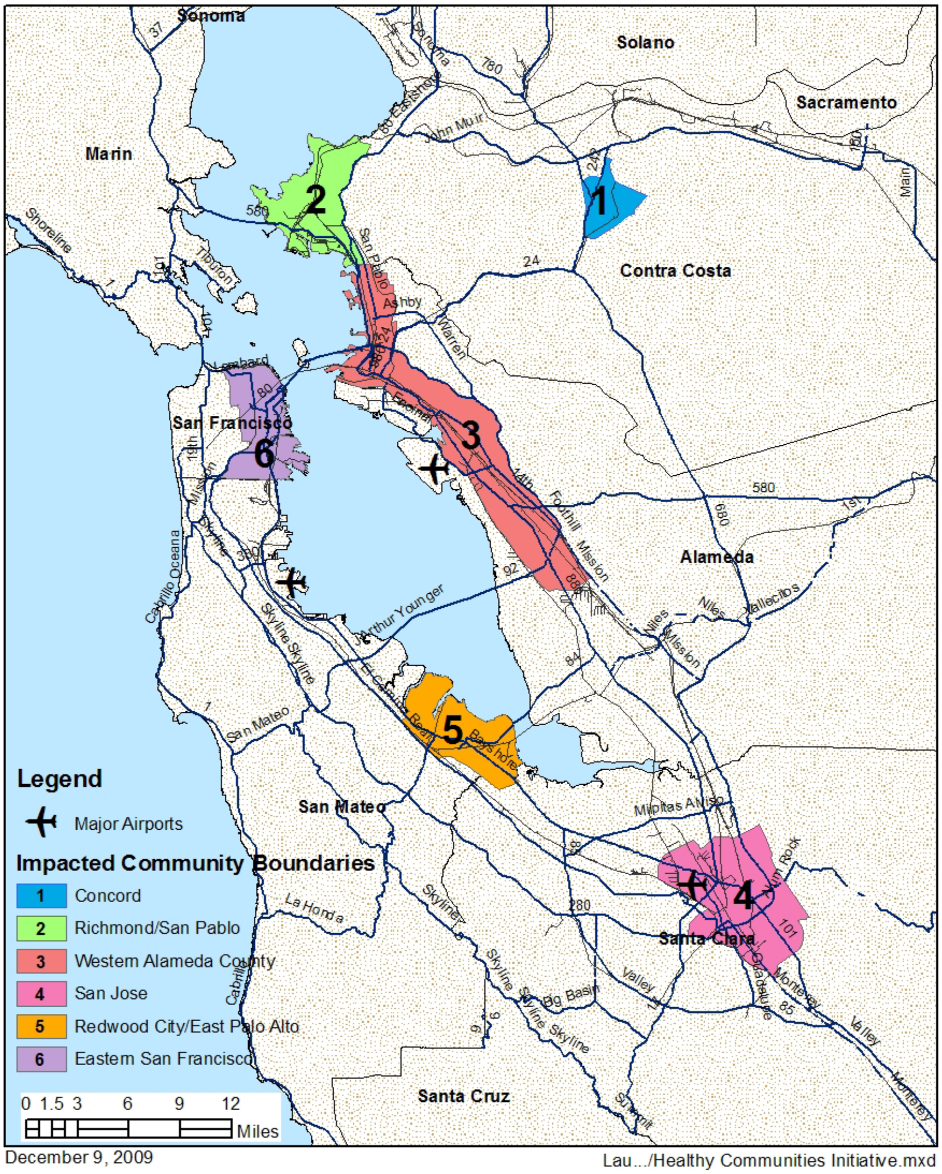

Figure 3-2. CARE impacted community boundaries.

Grant and Incentive Programs

The Air District operates several programs that provide grants and incentives for projects to provide "surplus" emissions reductions; i.e. reductions in advance of, or over and above, regulatory requirements or standards. Key grant programs are summarized in Table 3-6.

The District awarded a total of $186 million in external grants during a five-year period covering FY 03/04 through FY 08/09. In aggregate, these projects provided estimated emission reductions of 1,522 tons of ROG, 12,482 tons of NOx, 1,136 tons of PM, and 763,473 tons of CO2 over the lifetime of these projects.

Table 3-6. Grant funding programs & eligible project types.

Grant Program	Eligible Equipment/Projects
Transportation Fund for Clean Air	• Shuttles • Ride-Sharing • Bicycle Facilities • Bicycle Facilities/ Lockers • Smart Growth • Arterial Management
Carl Moyer Program	• On-road Heavy-Duty Vehicles • Off-Road • Marine Engines • Shorepower for Ships • Locomotives • Agricultural
Goods Movement Diesel Emission Reduction Program	• Drayage Trucks • Other Trucks • Shorepower for Ships • Cargo Handling Equipment • Locomotives • Marine Engines
Low Emission School Bus Program	• School Buses
Alternative Fuel and Advanced Technology Program	• Trucks, Buses, and Light-Duty Vehicles • Alternative Fuel Infrastructure

One of the most direct and tangible ways to reduce emissions and exposures in impacted communities is to replace or retrofit dirty engines and vehicles that operate in these communities. The Air District has made a commitment to target its grant funds to projects in impacted communities. Table 3-7 summarizes lifetime emission reductions and funding awarded for projects in CARE impacted communities in the past five funding cycles. During this five-year period, approximately 48% of Air District grant funds have been directed to these communities.

Table 3-7. Grants provided to projects in impacted communities: FY 03/04 – FY 08/09.

Project Type	ROG Reduced	NOx Reduced	PM Reduced	CO2 Reduced (1)	Funding Amount
Clean Light-Duty Vehicles	5.93	4.17	11.55	0	$834,750
Ridesharing	33.77	24.93	18.93	23,636	$1,836,000
Arterial Mgmt/Signal Timing	8.97	9.37	3.18	5,871	$2,176,731
Smart Growth	22.24	19.02	24.80	258,185	$2,396,811
Bicycle Facilities	13.06	11.03	4.80	8,790	$1,889,922
Shuttles	37.92	90.68	28.46	81,978	$9,626,342
Transit Buses (2)	0.00	81.12	0.00	0	$528,750
School Buses	7.67	52.54	2.22	579	$1,179,641
On-Road Trucks (3)	5.89	1,071.32	167.72	28,152	$32,932,424
Off-Road Trucks (2)	11.63	169.84	8.18	0	$1,195,564
Marine Engines (2)	511.77	6,024.87	367.53	0	$27,991,629
Locomotive Engines (2)	22.38	586.05	10.67	0	$5,786,366
Total	**681.23**	**8,144.94**	**648.04**	**407,191**	**$88,374,930**

Notes

Emission reductions show estimated tons reduced over the life of the projects funded.

1. All emission reductions shown in short tons, except for CO2, which are shown in metric tons.
2. CO2 data is not available for this project type.
3. Data includes TFCA, Carl Moyer Program, and Goods Movement heavy-duty on-road truck projects

Table 3-8 summarizes lifetime emission reductions and funding awarded for projects in other (non-impacted community) areas.

Reducing Emissions from Seaports and Goods Movement

Goods movement is a major source of emissions in the CARE impacted communities and major freeway corridors. Therefore, reducing emissions from seaports and the goods movement sector has been another major focus of Air District efforts in recent years. To provide a technical foundation, the Air District has developed detailed emissions inventories for each of the five Bay Area seaports.[68] Much of the emission reduction effort has been directed at the Port of Oakland, since this port handles by far the

[68] Bay area seaports include the ports of Oakland, Richmond, Redwood City, Benicia, and San Francisco.

greatest volume of goods and is located in proximity to the impacted community of West Oakland as well as the City of Alameda.

Table 3-8. Grants provided to non-impacted communities: FY 03/04 - FY 08/09.

Project Type	ROG Reduced	NOx Reduced	PM Reduced	CO2 Reduced (1)	Funding Amount
Clean Light-Duty Vehicles	1.44	0.82	0.00	0	$726,309
Ridesharing	288.09	304.84	178.80	273,244	$21,864,450
Arterial Mgmt/Signal Timing	166.20	162.17	57.44	5,150	$9,482,540
Smart Growth	42.15	30.70	14.46	7,053	$3,570,393
Bicycle Facilities	88.45	72.41	32.33	9,513	$12,871,293
Shuttles	85.76	102.84	44.46	31,443	$15,992,301
Transit Buses	14.34	603.01	16.74	9,216	$4,010,229
School Buses (2)	0.48	8.85	2.13	0	$324,750
Natural gas infrastructure (2)	1.10	1.55	0.30	0	$1,440,452
EV infrastructure (3)	0.00	0.00	0.00	0	$269,173
On-Road Trucks (4)	13.29	434.82	31.56	20,663	$11,759,793
Off-Road Trucks (2)	107.26	1,267.46	50.27	0	$12,537,234
Marine Engines (2)	22.01	1,265.88	56.14	0	$2,473,822
Agriculture Engines (2)	10.62	91.20	3.28	0	$336,472
Total	**841.19**	**4,346.55**	**487.91**	**356,282**	**$97,659,211**

Notes

* Emission reductions show estimated tons reduced over the life of the projects funded.

1. CO2 reductions are shown in metric tons.
2. CO2 data is not available for this project type.
3. Emission reductions data is not available for this project type.
4. Data includes TFCA and Carl Moyer Program heavy-duty truck projects.

To develop a comprehensive approach to reducing emissions from port operations, the Port of Oakland, in partnership with the Air District, the West Oakland Environmental Indicators Project, and representatives from the maritime industry, developed the Maritime Air Quality Improvement Plan (MAQIP). The MAQIP was adopted by the Port Commission in April 2009, with the overall goal of protecting the health of local residents and workers by reducing their exposure to diesel PM.

The Air District and the Port of Oakland have developed a joint work program that includes outreach to the regulated community to ensure compliance with state and federal regulations; securing authorization to enforce CARB rules and regulations; and cooperating to identify and implement specific projects such as replacement and retrofit

of drayage trucks, shore power (dockside electrification) for ships, vessel speed reduction, and development of a "marine highway" between the Port of Oakland, and the Ports of West Sacramento and Stockton to help reduce on-road truck traffic between these ports.
The Port and its partners anticipate achieving the Plan's main goal through industry compliance with regulations adopted by CARB. The bulk of the needed emission reductions at the Port will occur in 2010 as ships use low-sulfur fuel and drayage trucks are equipped with diesel particulate filters. Additional benefits will be achieved by 2015 as engines in cargo-handling equipment and harbor craft are either replaced or retrofitted, and ships begin using shore power while at berth.

The Air District's Green Ports Initiative will be a significant part of the success of the MAQIP. Under this initiative, the Air District is committing resources for a robust program of financial incentives for early compliance and a joint enforcement program with ARB. The Air District is also undertaking additional air pollution monitoring and developing more refined predictive modeling of health impacts in West Oakland. These efforts will assist with future refinements of the MAQIP.

The Air District and its partners - CARB, US EPA, the Port of Oakland, and local stakeholders - have been making a concerted effort to reduce emissions from the approximately 2,000 to 3,000 drayage trucks that serve the Port of Oakland and constitute a major source of diesel emissions in West Oakland. Using a combination of funding from the District's Transportation Fund for Clean Air (TFCA) program, the Port, State Goods Movement bond funds, and federal stimulus funds, a total of $22 million in grant funding was awarded to port truckers from March through December 2009. Also, approximately $4.5 million in additional State Goods Movement bond funding was added to this effort in January 2010, resulting in a $26.5 million total program to address port drayage truck emissions.

These funds have been used to install retrofit devices on 1,123 trucks to reduce emissions of PM and NOx, as well as to replace 205 old trucks with new trucks that meet stringent emissions standards. This project reduces approximately 0.3 tons of diesel particulate emissions daily at the Port of Oakland and over 14 tons of DPM annually.

Mobile Source Compliance Plan

Enforcement of mobile source regulations has traditionally been under the purview of CARB. However, CARB's diesel PM air toxic control measures (ATCMs) allow air districts to enforce them. In fall 2009 the Air District initiated a Mobile Source Compliance Plan (MSCP) based on a Memorandum of Understanding (MOU) between the Air District and CARB which defines the roles and responsibilities of each agency. The Air District is the first air district in the state to enter into a comprehensive mobile source enforcement partnership agreement with CARB.

The MSCP lays out the Air District's comprehensive strategy for enforcement of specified CARB ATCMs and related mobile source statutes and/or agreements. The goal of the MSCP is to reduce diesel PM health risk in impacted communities, with special focus on the Port of Oakland and West Oakland, using a robust enforcement program. The initial focus of the MSCP was to provide a strong enforcement presence at the Port of Oakland to ensure compliance with the January 1, 2010 Drayage Truck Rule (DTR) compliance deadline. By implementing the MSCP, the Air District will not only provide leadership on mobile source enforcement, but most important, will reduce diesel PM exposures and improve air quality for the communities we serve.

The MSCP is a key element in implementing the Clean Air Communities Initiative and the CARE program, as well as other efforts to reduce emissions from ports and goods movement.

Reducing PM from Wood Smoke

Although the Air District has been working hard to reduce exposure to diesel PM, particulate matter from wood-burning also poses health risks for Bay Area residents. Wood smoke is a major component of PM in the Bay Area, especially on winter days when exceedances of the 24-hour PM2.5 standard are most likely to occur. Reducing emissions from wood-burning is therefore a key component of the Air District's efforts to reduce PM levels in the Bay Area. The Air District has been implementing and strengthening its efforts to reduce wood smoke over the past two decades, as described below.

Public education and voluntary compliance were the early foundation of the Air District's efforts to reduce wood-burning. The District began implementing its *Winter Spare the Air* program in 1991, requesting that Bay Area residents voluntarily curtail wood-burning on days when an exceedance of PM standards is forecast.

In 1998, the Air District developed a model wood smoke ordinance for fireplaces and woodstoves as a guidance document for cities and counties to regulate sources of particulate matter in their communities. The model ordinance promotes the use of cleaner technologies that have been developed to effectively reduce wood smoke pollution. District staff have worked with health agencies and interested residents in the Bay Area to advocate for the adoption of the ordinance. To date, wood smoke ordinances have been adopted by 40 Bay Area cities and eight counties which encompass a large percentage of the region's population.

In 2006, US EPA significantly strengthened the national 24-hour PM2.5 standard, reducing the standard from 65 to 35 $\mu g/m^3$. Recognizing the need to more aggressively reduce PM from wood smoke, especially on days when the region is likely to exceed the standard, the Air District adopted a rule (and amended Regulation 5: Open burning) to limit wood-burning in July 2008, as described below. In addition, the Air District enhanced and expanded its wood smoke public outreach and education program, and lowered the threshold for when to issue *Winter Spare the Air Alerts* to conform to the national standard.

Summary of Wood-Burning Rule

Key provisions of Regulation 6, Rule 3 include the following:

- Prohibits operation of any indoor fireplace, fire pit, wood or pellet stove or fireplace insert on specific days during the winter when the District forecasts that PM2.5 levels may exceed the 35 $\mu g/m^3$ national 24-hour PM2.5 standard. The rule provides limited exemptions from this provision for households whose sole source of heat is a wood-burning device, or in the event of an interruption in gas or electrical service. Regulation 5: Open burning prohibits outdoor recreational fires during periods of elevated PM2.5 levels
- Prohibits excessive visible emissions from wood-burning devices.
- Requires cleaner burning technology (EPA Phase II certified wood-burning device, pellet stove, or other approved device) when wood-burning devices are sold, resold or installed.
- Requires cleaner burning technology (EPA Phase II certified wood-burning device, pellet stove, or other approved device) if wood-burning devices are permitted for installation in new building construction and remodels.
- Prohibits the burning of garbage, non-seasoned wood, plastics and other inappropriate types of materials.
- Requires labeling and disclosure of the moisture content on wood sold for use within the boundaries of the District, including instructions on how to dry wood that has moisture content greater than 20 percent by weight.
- Requires a label on packages of wood and other solid fuels (such as pressed logs and pellets) instructing the user to check local air quality status before burning these products.

Promoting Compliance with the Wood-Burning Rule

The Air District conducted an energetic public education and outreach campaign regarding wood smoke in winters 2008/09 and 2009/10. The campaign focused on educating the public about the requirements of the rule, how to comply, and why it is important to curtail wood-burning to protect public health. The *Winter Spare the Air Alert* advertising and outreach campaign utilized TV, print, billboard, radio, direct mail, public events, door-to-door canvassing and the Air District website. The Air District's "No Burn" phone line received over 500,000 calls in 2008/2009. In 2009/10, the Air District included both English and Spanish on the "No Burn" phone line. Nearly 400,000 calls were received; 39% of the callers used the Spanish option. There were also 117,000 subscribers for email or phone AirAlerts.

For the 2009/2010 season, public outreach to educate Bay Area residents about the health effects of wood smoke and how to comply with the rule were again the primary focus the wood smoke reduction program. Over 10,270 wood smoke information packets were sent out to Bay Area residents to provide information about the wood smoke rule and 254 reminder letters were sent to residences that received violation warning letters from the previous winter. The public could enter wood smoke complaints either online through the website or by phone; 2,355 wood smoke complaints were entered into the system.

The Air District also made several changes to improve the effectiveness of the program in 2009/2010. For example, the District issued *Winter Spare the Air Alerts* the day before the effective date in order to provide the public and the media with more advanced warning. The District also focused its enforcement efforts in areas with high wood-burning rates and public complaints.

As the Air District develops more experience and information regarding the wood smoke rule, additional refinements or enhancements may be considered to the wood smoke reduction program. Potential revisions are described in Further Study Measure 12 in CAP Volume II.

Results of 2008/09 Wood Smoke Reduction Program

The Air District has performed surveys of Bay Area residents every winter for the past five years to monitor trends in residential wood-burning. The surveys performed in winter 2008/09 found that Bay Area residents reduced wood-burning on both STA and non-STA days. Survey findings, corroborated by on-the-ground monitoring, indicate that the overall reduction in wood-burning was on the order of 33% in 2008/09 compared to the average over the prior three years. These findings suggest that the wood smoke rule, in combination with the Air District's public outreach and education efforts, had a very significant impact in the first year of implementation.

Results of 2009/10 Wood Smoke Reduction Program

The Air District continued and expanded its survey program during winter 2009-10 to gauge the on-going effectiveness of the wood smoke reduction program and to develop a better understanding of the impact in reducing wood burning within the Bay Area. The 2009/10 survey data revealed that 63% of the respondents were aware that the District prohibits wood burning on certain nights. Support for the Wood Burning Regulation remained strong at 71%.

The 2009/10 season enforcement program included inspection patrols covering all Bay Area counties for curtailment or visible emissions (opacity) violations. Over 300 violations were documented. Warning letters were issued for the first violation, for the second, a Notice of Violation was issued which assesses a $400 penalty. Eight Notices of Violations were issued, seven for violations of the mandatory curtailment provision and one for excessive visible emissions violation.

BAAQMD Climate Protection Program

As explained in Chapter 1, there is a strong connection between global warming, ozone formation and public health. Therefore, the Air District has made reducing GHGs and protecting the global climate an integral part of its mission. Since establishing a formal climate protection program in June 2005, the Air District has worked to integrate climate protection into all its core functions and initiated innovative climate protection programs. Some of the Air District's key climate protection programs and activities are summarized below.

- The Air District was the first local air district in the nation to develop a detailed regional greenhouse gas emissions inventory (November 2006; updated in December 2008).

- In November 2006, the Air District convened the first-ever Bay Area-wide summit on climate protection. The event was attended by over 500 local leaders from government, education, youth, business, research and the non-profit community and set the stage for wide-spread collaboration and action. A second summit was convened in May 2009 for over 400 local government planners and elected officials.
- In December 2007, the Air District awarded $3 million in grants to 53 local projects to reduce GHG emissions. The innovative grant program is funding such activities as the development of local climate action plans; seed funding for municipal energy officers; innovative approaches such as financing residential and commercial solar power through property tax bills; renewable energy programs; and youth-based projects. With this grant program, the Air District became the one of the largest climate protection funders in the nation to date.

- In May 2008 the Air District imposed a cost-recovery fee on stationary sources of greenhouse gases in the region to defray the costs of the Air District's climate protection work related to stationary sources. Industrial facilities and businesses currently subject to Air District permit requirements pay a fee of $0.048 per metric ton of greenhouse gas emissions.

- The Air District launched the Greenhouse Gas Reduction Grant Program in 2009, using $4.4 million in funds generated by a settlement between the California Attorney General's Office and ConocoPhillips for projects that reduce GHG emissions in the communities nearest the ConocoPhillips refinery: Rodeo, Crockett, Hercules and Pinole. Grants will be used to fund energy efficiency, cool roofs and onsite renewable energy projects on public facilities.

- The Air District created and implemented a 4th/5th grade curriculum on climate protection. The *Protect Your Climate* curriculum contains 16 lessons that address the science and causes of climate change and ways for students to take action. Through various activities, students learn how to reduce greenhouse gas emissions from energy, waste, and transportation uses in their daily lives. Since the curriculum was first piloted in 2007-2008, over 40 classrooms and 1,000 students across the nine Bay Area counties have participated in the program.

- The Air District convened a series of workshops for local governments to provide them with complete data sets and training on how to prepare a local GHG emissions inventory.

- The Air District developed a web portal, in conjunction with the Institute for Local Government, to share information and facilitate local government action regarding best practices to reduce GHGs: www.baaqmd.gov/climateplanning.

- The Air District led the development of an historic white paper for the California Air Pollution Control Officers' Association (CAPCOA) that lays out how local land use and development projects could address GHG mitigation under CEQA. Air District staff also collaborated on a CAPCOA resource document on addressing GHGs in local general plans.
- Air District staff has proposed to establish significance thresholds for GHG emissions in its update of the District's CEQA Guidelines.

In addition, the Air District works closely with its regional agency partners – the Metropolitan Transportation Commission (MTC), the Association of Bay Area Governments (ABAG), the Bay Conservation and Development Commission (BCDC) – along with the local governments, business groups, community organizations, and other stakeholders to develop new ways to reduce emissions of GHGs in the Bay Area and protect the climate.

External Plans that Complement the 2010 CAP

The 2010 CAP will not function in a vacuum. Rather, it is intended to be part of an interlocking set of complementary plans that together provide an integrated air quality, land use, transportation, and climate protection strategy for the Bay Area.

Land Use and Transportation Plans

In combination with the FOCUS program, MTC's recently adopted *T2035* regional transportation plan, ABAG's *Projections 2009*, and BCDC's Bay Plan amendments, the CAP is intended to help lay the groundwork for an effective Bay Area Sustainable Communities Strategy pursuant to SB 375 in the 2013 time frame and beyond, as discussed in Chapter 4.

FOCUS

FOCUS is a regional incentive-based development and conservation strategy for the Bay Area. FOCUS unites the efforts of ABAG, MTC, BCDC, and the Air District into a single program that encourages future growth in areas near transit and within the communities that surround the San Francisco Bay. Promoting future development in these areas provides a variety of housing and transportation choices for all residents, while helping to enhance existing neighborhoods and reduce emissions of air pollutants and GHGs by decreasing motor vehicle use. One of the key elements of FOCUS is the partnership between the regional agencies and local governments to identify Priority Development Areas where future growth should be encouraged and Priority Conservation Areas which should be protected from development.

Transportation 2035 Regional Transportation Plan

In April 2009 MTC adopted the Transportation 2035 regional transportation plan to guide regional transportation investments over the next 25 years. T2035 defined a set of performance targets under the rubric of "Three E's" – Economy, Environment, and Equity. In analyzing how well various investment scenarios would perform relative to the performance targets, MTC concluded that, while the way we invest transportation dollars in the region is very important, we will need to make major changes in land use patterns and make use of pricing policies to manage travel demand in order for the region to make significant progress toward the environmental targets related to reducing vehicle miles of travel (VMT), and emissions of PM and greenhouse gases.

Projections 2009

In August 2009 ABAG issued its most recent biennial population and employment forecasts: *Projections and Priorities 2009: Building Momentum*. ABAG forecasts that that Bay Area population will increase by 1.7 million people over the next 25 years, and that the region will add 1.6 million new jobs and 600,000 housing units. *Projections and Priorities 2009* incorporates the same environmental performance targets as MTC's T2035 plan.

San Francisco Bay Plan Amendments

BCDC administers the *San Francisco Bay Plan*, which guides development on and around the shoreline of the Bay Area. BCDC staff is developing proposed amendments to the Bay Plan to update its policies addressing sea level rise, with the objective of directing development away from low-lying shoreline areas vulnerable to flooding. The proposed amendments are intended to support the region's FOCUS development and conservation strategy by ensuring we do not develop in ways that increase threats to public safety from flooding. The amendments will also outline a process for developing a regional adaptation strategy for areas vulnerable to sea level rise. The strategy will identify ways to integrate adaptation to climate change with the region's GHG reduction efforts.

SB 375

Recognizing the importance of integrating land use, transportation, and climate protection planning, the State of California adopted Senate Bill 375 in fall 2008. SB 375 calls for major metropolitan areas throughout California to develop and implement integrated land use and transportation plans, known as "Sustainable Communities Strategies" or SCS, to achieve greenhouse gas reduction targets established by CARB. The first Bay Area SCS must be developed and adopted by 2013. Development of the SCS is the primary responsibility of ABAG and MTC; however, the Air District will also play an important role in the development of the Bay Area SCS.

Climate Protection Plans

The District's climate protection program described above is intended to work in conjunction with CARB's AB 32 Scoping Plan to reduce greenhouse gases, as well as local Climate Action Plans adopted by many Bay Area cities and counties.

CARB's AB 32 Climate Scoping Plan

In September 2006, Governor Schwarzenegger signed the Global Warming Solutions Act (California Health and Safety Code, § 38500, *et seq*., commonly referred to as "AB32") establishing a statewide target of reducing greenhouse gas emissions to 1990 levels by 2020. This Act required CARB to prepare a scoping plan to lay out how the state will achieve these reductions. The AB 32 Scoping Plan, approved by the CARB Board in December 2008, sets forth the main strategies California will pursue to meet its 2020 climate protection goal.

The Scoping Plan has a range of actions, summarized in Table 3-9, which include direct regulations, alternative compliance mechanisms, monetary and non-monetary incentives, voluntary actions, and market-based mechanisms such as a "cap-and-trade" system. The recommended measures were developed to reduce greenhouse gas emissions from key sources and activities while improving public health, promoting a cleaner environment, preserving natural resources, and ensuring that the impacts of the reductions are equitable and do not disproportionately impact low-income and minority communities.

Most of the measures in the Scoping Plan will be implemented through the rulemaking processes at CARB or other agencies, including local air districts. Discrete Early Actions are expected to be adopted and implemented in the 2010 through 2012 time frame.

District Role in Implementing the CARB Scoping Plan

The Air District is prepared to assist in the implementation of the AB 32 Scoping Plan. Local air districts already implement and enforce stationary source regulations for criteria pollutants, so they are well-positioned to play this role for stationary source regulations that address GHG emissions. Not only are local air districts familiar with the individual facilities and their compliance history, but information contained in district permits can be used to confirm the accuracy of greenhouse gas emissions reported by sources subject to CARB mandatory reporting requirements.

Table 3-9. Recommended AB 32 Scoping Plan greenhouse gas reduction measures.

Recommended Reduction Measures	Estimated Year 2020 GHG Reductions *
California Light-Duty Vehicle Greenhouse Gas Standards	31.7
Energy Efficiency: buildings, appliances, solar water heating, etc.	26.3
Renewables Portfolio Standard (33% by 2020)	21.3
Low Carbon Fuel Standard	15
Regional Transportation-Related GHG Targets pursuant to SB 375	5
Vehicle Efficiency Measures	4.5
Goods Movement: Electric shore power at Ports & System-Wide Efficiency Improvements	3.7
Million Solar Roofs	2.1
Medium/Heavy Duty Vehicles: Aerodynamic Efficiency & Vehicle Hybridization	1.4
High Speed Rail	1.0
Industrial Measures: Refinery Measures, Energy Efficiency	0.3
Industrial Measures: Oil and Gas Extraction and Transmission	1.1
High Global Warming Potential Gas Measures	20.2
Sustainable Forests	5.0
Recycling and Waste (landfill methane capture)	1.0
Additional Reductions Necessary to Achieve the Cap	34.4
TOTAL REDUCTIONS COUNTED TOWARDS 2020 TARGET	**174**
Other Recommended Measures:	
State Government Operations	1.2
Local Government Operations	TBD
Green Buildings	26
Recycling and Waste: Mandatory Commercial Recycling & other measures	9
Water Sector Measures	4.8
Methane Capture at Large Dairies	1.0
Other Recommended Measures Subtotal	**42**

* GHG reductions are expressed in terms of million metric tons CO2-equivalent per year

The Air District will also continue to play a role in assisting local governments in contributing to the GHG reduction goals related to regional transportation and land use and energy efficiency, as described in the Transportation Control Measures, Land Use & Local Impacts Measures, and Energy and Climate Measures in the CAP control strategy.

Joint Policy Committee Climate Actions

Four regional agencies— BAAQMD, MTC, ABAG and BCDC – coordinate on climate change and other issues through the Joint Policy Committee (JPC). In May 2009, the JPC approved a set of 6 joint actions that the regional agencies will implement in 2009-10 to provide climate leadership for the Bay Area. Working together, the regional agencies will:

1. Begin to develop the Sustainable Community Strategy (SB 375). (ABAG/MTC)
2. Design and adopt an Indirect Source Review regulation. (Air District)
3. Develop and advance climate-friendly regional parking policies. (MTC)
4. Provide support for a coordinated public/private regional plan for electric vehicles. (Air District /MTC)
5. Design and implement a regional solar installation/energy efficiency financing program for existing residential/commercial buildings. (ABAG)
6. Coordinate a regional/local approach to climate adaptation. (BCDC/ABAG)

In addition, to help align and coordinate the many climate plans and initiatives underway in the Bay Area, the JPC in fall 2009 established a coordinating group made up of staff from key public, private and community stakeholders. This group, under the name of *Climate Bay Area,* will endeavor to ensure complementary action, reduce duplication, and bring resources to the common problems confronting all Bay Area climate efforts.

Local Government Actions

According to the AB 32 Scoping Plan, local governments are expected to reduce GHG emissions by 5 million metric tons through transportation and land use changes. In addition, local governments will play a key role in implementing many of the strategies contained in the Scoping Plan, such as energy efficient building codes, local renewable energy generation, and recycling programs. Fortunately, local governments in the Bay Area have led the nation in taking action to reduce greenhouse gas emissions. To date, 85 local jurisdictions had completed GHG emissions inventories for their communities, and 23 of these jurisdictions have completed comprehensive climate action plans. Additional jurisdictions are preparing to complete such plans in the near future.

Local governments will play a critical role in climate protection efforts in California. Local governments have primary authority over land use decisions. As discussed in Chapter 4, changes in land use to promote mixed-use, infill development in areas that are well-served by transit are a critical element of the CAP control strategy. To help support local efforts in this direction, and lay the groundwork for successful implementation of SB 375 in the Bay Area, the CAP control strategy includes several Transportation Control Measures and Land Use and Local Impacts Measures to promote focused land use and complementary transportation and parking policies.

Local governments also have the power to adopt building codes that exceed the energy efficiency requirements of the state's Title 24. Many local governments are innovators, testing new technologies or developing new approaches to achieving energy efficiency and emission reductions. For example, the City of Berkeley's innovative "Berkeley First" program offers low-interest financing to help home owners to cover the upfront cost of installing solar panels via property tax assessments. (The Air District provided a Climate Protection Grant to help fund this program.) The CAP will support local efforts to promote energy efficiency by means of the Energy and Climate Measures in the CAP control strategy.

State and National Mobile Source Programs

The state and federal governments are responsible for regulating emissions from mobile sources. Mobile source emissions are regulated by three basic approaches: by establishing emission standards for equipment, by regulating the fuel used in the equipment, and through vehicle in-use performance standards, such as the Inspection and Maintenance or "Smog Check" program. In California, mobile sources are regulated primarily by CARB. Under a provision of the federal Clean Air Act, CARB is authorized to adopt standards, rules and regulations to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to attain air quality standards at the earliest practicable date. The California standards cover motor vehicles (cars, motorcycles and trucks), heavy industrial and construction equipment, off-highway vehicles (dirt bikes and all-terrain vehicles) and lawn, garden and other utility engines. US EPA is responsible for regulating emissions from locomotives, ships and aircraft.

CARB standards for motor vehicle engines and fuels have great impact in reducing emissions of ozone precursors and other pollutants in the Bay Area. Among mobile source categories, passenger cars and light-duty trucks are the two largest contributors to the ROG emission inventory and are also significant contributors to the NOx emission inventory. CARB's Low Emission Vehicle (LEV) program has greatly reduced emissions of ROG and NOx throughout the state. The LEV I regulations reduced emissions in model year 1994-2003 vehicles. The more stringent LEV II program took effect in model year 2004, and will continue to provide major air quality benefits in future years.

State and federal regulations on off-road diesel construction equipment are also important in reducing ozone precursor emissions in the Bay Area. In 1998, US EPA adopted more stringent "Tier 2" and "Tier 3" emission standards for ROG, NOx, and PM from new non-road diesel engines. This program includes the first set of standards for non-road diesel engines less than 50 hp, including marine engines in this size range. The Tier 2 standards were phased in for all engine sizes from 2001 to 2006. The yet more stringent Tier 3 standards for engines between 50 and 750 hp were phased in from 2006 to 2008. EPA's tiered emissions standards for non-road diesel engines, along with CARB's in-use fleet and diesel fuel regulations will provide significant emissions reductions over the next decade.

The federal Clean Air Act directs US EPA to establish emission standards for aircraft engines, new locomotive engines and new non-road engines less than 175 horsepower used in construction or farm equipment. EPA has promulgated regulations or otherwise established programs to control emissions from these important source categories. Gas turbines, used in almost all commercial aircraft, became subject to United Nations International Civil Aviation Organization standards for ROG, NOx, CO and smoke in 1997.

The emission inventories provided in Table 2-3 (ROG and NOx) and Table 2-9 (PM) include the benefit of regulation that had been adopted by December 31, 2006. Since that date, CARB has been adopting additional regulations on mobile sources to implement the 2007 State Implementation Plan (SIP). Table 3-10 provides projected emission reductions of ROG, NOx and PM2.5 in the Bay Area from CARB regulations adopted since 2007. Because CARB rulemaking is ongoing, further emission reductions from measures described in the 2007 SIP are expected through future rulemaking. The ROG reductions will come primarily from on-road sources and consumer products. Most of the NOx reductions will come from CARB regulations on-road and off-road heavy-duty engines; these regulations will also require major reductions in diesel PM emissions, thus providing significant public health benefits.

Table 3-10. Projected Bay Area emission reductions from adopted 2007 state strategy measures (tons per day).

New SIP Measures	ROG		NOx		PM2.5	
	2014	2020	2014	2020	2014	2020
Passenger Vehicles	**4.8**	**3.6**	**--**	**--**	**--**	**--**
Smog Check Improvements (partial)	1.9	1.6	--	--	--	--
Modifications to Reformulated Gasoline Program	2.9	2.0	--	--	--	--
Heavy-Duty Trucks	**2.1**	**0.8**	**23.4**	**9.6**	**1.5**	**0.5**
Cleaner In-Use Heavy-Duty Trucks	2.1	0.8	23.4	9.6	1.5	0.5
Off-Road Equipment	**1.5**	**1.7**	**5.9**	**10.6**	**1.4**	**1.1**
Cleaner In-Use Off-Road Equipment (over 25hp)	1.5	1.7	5.9	10.6	1.4	1.1
Emission Reductions from Adopted New Measures	**8**	**6**	**29**	**20**	**3**	**2**

Source: CARB

In addition to tailpipe emission standards, mobile source emissions are also controlled through fuel regulations. CARB adopts fuel specifications for motor vehicle fuels: gasoline, diesel, alternative gasoline fuels, and alternative diesel. The most current gasoline regulations - the Phase 3 Reformulated Gasoline standards - went into effect on December 31, 2003, requiring lower evaporative compounds and prohibiting the use of the fuel additive MTBE. As of June 2006, the sulfur content in diesel fuel was reduced from 500 ppm to 15 ppm. The low sulfur content enables after-combustion exhaust abatement devices, such as diesel particulate filters, to operate at high levels of efficiency. CARB also conducts ongoing verification of alternative diesel fuel emission benefits.

More recently, CARB and the California Energy Commission have been developing regulations and incentive programs to lower the carbon content of fuels and transition California to renewable substitutes for gasoline and diesel in order to reduce emissions of greenhouse gases from mobiles sources. The centerpiece of this effort is the Low Carbon Fuel Standard (LCFS) Program adopted by CARB in April 2009 pursuant to the AB 32 and the Governor's Executive Order S-01-07. The LCFS, which goes into effect in 2011, calls for a reduction of at least 10 percent in the carbon content of California's transportation fuels by 2020.

Motor vehicle emissions are also controlled through in-use performance standards to ensure that the systems continue to operate properly. The State of California's Inspection and Maintenance (I&M) program operated by the California Bureau of Automotive Repair (BAR) since 1984, tests light-duty on-road gasoline powered vehicles every other year. An enhanced program which requires the use of a dynamometer to test the vehicle's emissions simulating on-road conditions began in the Bay Area in October 2003.

Although emission reductions from CARB and US EPA mobile source regulations and programs may not yet be fully reflected in the emissions inventory, these measures are expected to provide substantial emission reductions overall. A comprehensive summary of CARB's mobile source programs is provided below.

State Programs for Passenger Cars & Light-Duty Vehicles

Smog Check: Operational in California since 1984, the Bureau of Automotive Repair tests all on-road gasoline powered vehicles for compliance with in-use standards. Since October 2003, the Bay Area has been subject to the Enhanced Area Smog Check Program, which tests vehicle emissions while the vehicle is running.

In-Use Testing of Motor Vehicles: Tests in-use passenger cars and light duty vehicles for compliance with standards. In the event of violations, CARB works with the vehicle manufacturer to correct the problem, usually in the form of a recall or statewide repair. A protocol is being developed to test Heavy Duty Diesel Vehicles as well.

Voluntary Accelerated Vehicle Retirement Program: Pays owners of eligible vehicles to voluntarily retire their older, higher-emitting vehicle.

Low Emission Vehicle Program: Establishes improved emission reduction standards for automobiles. LEV II regulations are the most recent and are effective from 2004 through 2010. The new standards extend passenger car emission standards to heavier sport utility vehicles and pickup trucks (with gross vehicle weight up to 8,500 pounds) which formerly had been regulated under less-stringent emission standards.

On-Board Diagnostic (OBD) Program: OBD II systems monitor components in 1996 and newer vehicles less than 14,000 lbs to ensure that a vehicle remains as clean as possible over its entire life, and assists Smog Check repair technicians in diagnosing and fixing problems with the computerized engine controls. ARB is currently developing OBD requirements for heavy-duty vehicles over 14,000 lbs.

On-Road Motorcycle Regulation: Standards adopted in December 1998. Apply to motorcycles with engines over 280cc manufactured for the 2004 model year and later.

Zero Emission Vehicle Program: Creates incentives to promote zero emission vehicles such as battery and fuel cell vehicles. Also certifies vehicles as such.

California Hydrogen Highway: Program working toward a transition to a clean, hydrogen transportation economy in California.

HOV Lane Access: Allows single occupancy use of HOV lanes by zero-emission and alternative fuel vehicles.

Climate Change Emission Control Regulations: Pursuant to AB 1493 (Pavley), CARB regulation will require reduction of CO2 emissions from motor vehicles in California of approximately 30% between 2009 and 2014. CARB regulation adopted in September 2004 has been on hold pending approval of necessary waiver by US EPA. The waiver was finally approved by EPA in June 2009, so the CARB program should now be able to move forward to implement CO2 vehicle emission standards.

State Programs for Heavy-Duty On-Road & Off-Road Mobile Sources

Diesel Risk Reduction Program: After identifying diesel PM as a toxic air contaminant in 1998, CARB developed a comprehensive plan to reduce emissions from diesel engines and vehicles. In 2000 CARB approved a Diesel Risk Reduction Program (DRRP) to reduce diesel emissions from both new and existing diesel-fueled vehicles and engines. The DRRP established a goal of reducing diesel PM emissions, and the associated health risk, 75% by 2010 and 85% by 2020. In addition, recognizing that aggregate emissions from goods movement (shipping, cargo-handling, rail, truck, etc.) are a major source of diesel PM emissions the ARB Board approved a statewide *Emission Reduction Plan for Ports and Goods Movement* in April 2006. These programs are already having a beneficial impact; analysis of the carbon in ambient PM2.5 in the Bay Area suggests that diesel emissions have been cut substantially since 2000. The DRRP is made up of several strategies, including retrofits and control technology. Some of these strategies are part of other programs listed below.

Heavy-Duty Diesel In-Use Strategies Program: Reduces emissions from existing on- and off-road diesel engines, with a special emphasis on reducing particulate emissions through the following implementation programs: Retrofit Assessment and Implementation (solid waste collection vehicles and on-road heavy-duty public fleet vehicles); and Heavy-duty Testing and Field Support.

On-Road Heavy-Duty Diesel New Engine Program: Reduces emissions from new on-road heavy-duty diesel engines through emission control regulations and test procedures for these engines. The final tier of standards which bring truck emissions to near-zero levels become effective in 2010.

Heavy Duty Vehicle Inspection Program: Inspection of trucks and buses for excessive smoke. In June 1998, CARB resumed the Heavy Duty Vehicle Inspection Program (roadside and unannounced inspections). In July 1998 CARB began the Periodic Smoke Inspection Program, where diesel and bus fleet operators are required to annually self-inspect their vehicles and repair those with excessive smoke emissions.

Diesel Engine Software Upgrade: CARB is working with the California Trucking Association (CTA) to get low NOx software installed on every eligible, electronically-controlled engine registered in California. The Air District requires the software upgrades as a condition for receiving heavy-duty vehicles grants from the Carl Moyer Program and the Transportation Fund for Clean Air.

Public Transit Bus Program: This program reduces criteria pollutant emissions and toxic air contaminants from urban buses. In October 2005, CARB aligned urban bus standards for 2007-2009 with national standards for diesel truck engines.

Solid Waste Collection Vehicles: This airborne toxic control measure for diesel PM from on-road heavy-duty diesel-fueled residential and commercial solid waste collection vehicles is one in a series of rules designed to reduce diesel PM from most diesel-fueled heavy-duty vehicles in California.

Heavy-Duty Diesel Idling Control Measure: In July 2004, CARB adopted an idling control measure for heavy-duty diesel commercial motor vehicles, limiting idling to five minutes. In October 2005, this measure was extended to include trucks with sleeper cabs.

Idling Limits at Schools: Requires school buses and other heavy-duty diesel vehicles to turn off engines upon arriving at a school and prohibits restarting engines more than 30 seconds before departure from a school.

The Carl Moyer Program: Provides grants through participating air pollution control districts, including the Bay Area Air District, to cover the incremental cost of cleaner on-road, off-road, marine, and locomotive engines.

Border Inspection Program: CARB, in cooperation with the California Highway Patrol, will establish inspection protocols of heavy duty vehicles entering this state to ensure that each vehicle has a certified engine. While enforcement is expected to take place near California borders, the Bay Area will still benefit from this program.

State Programs for Off-Road Vehicles & Equipment

Off-Road Mobile Sources Emission Reduction Program: Exhaust emission standards have been adopted by CARB and/or U.S. EPA for off-road engines included in the following categories: Small Spark-Ignition Off-Road Engines and Equipment Less Than 25 Horsepower (including Lawn and Garden Equipment, and Small Industrial Equipment);

Off-Road Recreational Vehicles (including Motorcycles and All-Terrain Vehicles); Off-Road Compression Ignition (Diesel) Engines and Equipment; Off-Road Large Spark Ignition (Gasoline and LPG) Engines and Equipment 25 Horsepower and Greater (including Industrial Equipment, Forklifts, and Portable Generators); Airport Ground Support Equipment; Commercial Marine Vessels; and Recreational Marine (including Personal Water Craft, Ski boats, Inboards, and Outboards). Ultra-low sulfur diesel fuel is now required for harbor crafts, ferries, and in-state locomotives. In December 2005 CARB adopted low-sulfur fuel standards for marine auxiliary engines and cargo handling equipment.

Recreational Marine Engines: Reduces emissions of ROG and NOx for certain marine vessels with proposed regulations for other spark-ignition engines used in boats for propulsion. In 2001, all new outboards sold in California were required to meet the U.S. EPA 2006 emission levels. In 2002, CARB adopted regulations governing emissions for all 2003 model year and later inboard engines.

ARB MOU with the Union Pacific and Burlington Northern Santa Fe Railroads: In June 2005 CARB entered into a Memorandum of Understanding (MOU) with Union Pacific Railroad (UP) Railroad and Burlington Northern Santa Fe (BNSF) Railway. The agreement is expected to achieve a 20 percent reduction in locomotive diesel particulate matter emissions at 17 major rail yards throughout the State, including five in the Bay Area. UP and BNSF agreed to phase out non-essential idling within 6 months and install idling reduction devices on California based locomotives within 3 years; identify and expeditiously repair locomotives with excessive smoke; ensure that at least 99 percent of locomotives operating in California pass smoke inspections; maximize the use of ultra low sulfur diesel fuel by January 1, 2007; conduct health risk assessments for 17 major rail yards and use these studies to identify risk reduction measures; and prepare a progress report on plans to implement feasible mitigation measures at all 17 rail yards. Participation from the Air District and local communities is an integral aspect of the MOU.

Chapter 4 – Overview of CAP Control Strategy

The control strategy is the heart of the Bay Area 2010 Clean Air Plan. It describes specific measures and actions that the Air District and its partners will implement to improve air quality, protect public health, and protect our climate. This chapter includes:

- A description of the scope and underlying rationale of the control strategy;
- A summary of the specific control measures that comprise the overall strategy;
- A discussion of key themes that are embedded in the strategy;
- Estimates of emissions reductions and cost-effectiveness for control measures; and
- A description of how the control strategy will be implemented.

As discussed in Appendix B, the control strategy has been developed pursuant to the "all feasible measures" provisions of Section 40914 of the California Health & Safety Code. The control strategy includes 55 measures which are described in detail in Volume II. The control measures that comprise the CAP control strategy are divided into five categories which are discussed below. This includes the three categories used in prior plans - Stationary Source Measures, Mobile Source Measures, and Transportation Control Measures - as well as two new control measure categories: Land Use & Local Impacts Measures, and Energy & Climate Measures.

In developing the control strategy for the 2010 CAP, Air District staff reviewed control measures in other air quality plans throughout California and elsewhere in the U.S., and solicited suggestions from Air District staff, staff of regional agency partners, members of the public, and diverse stakeholder groups. Staff also reviewed emissions inventory data and existing Air District rules and programs to identify emission reduction opportunities. As described in Appendix F, staff analyzed control measures based on the evaluation criteria set forth in the Health & Safety Code, as well as their potential to reduce the range of pollutants addressed in this plan.

Scope and Rationale

The CAP control strategy is designed as an integrated strategy to:

- Reduce emissions and transport of ozone precursors by developing a control strategy that includes all feasible measures to fulfill air quality planning requirements pursuant to the California Health & Safety Code;
- Reduce emissions of other pollutants, including particulate matter (PM), key air toxics, and key greenhouse gases, in addition to ozone precursors;

- Help to forge a multi-agency partnership to combat climate change by developing a regional strategy to address land use, transportation, and air quality.

The control strategy seeks to maximize co-benefits from control measures that reduce ozone precursors, and also to include additional measures that focus on reducing PM, air toxics, and GHGs. Most control measures proposed in the CAP will reduce ozone precursors along with other pollutants. However, the proposed control strategy does include several measures that are focused on reducing PM, air toxics, and/or greenhouse gases, while providing little or no direct ozone benefit.

Although the Air District has clear authority to regulate emissions from stationary sources, its regulatory power is very limited in some areas that have great impact on air quality, such as mobile sources, land use decision-making, energy-efficiency standards for building, etc. Therefore, in developing the control strategy, staff identified the full range of tools and resources available to the Air District, both regulatory and non-regulatory, and applied the most appropriate ones in crafting each measure. Implementation of each control measure will rely on some combination of the following:

- Adoption and enforcement of rules to reduce emissions from stationary sources, area sources, and indirect sources;
- Revisions to the Air District's permitting requirements for stationary sources;
- Enforcement of CARB rules to reduce emissions from heavy-duty diesel engines;
- Allocation of grants and other funding by the Air District and/or partner agencies;
- Promotion of best policies and practices that can be implemented by local agencies through guidance documents, model ordinances, etc.;
- Partnerships with local governments, other public agencies, the business community, non-profits, etc.;
- Public outreach and education;
- Enhanced air quality monitoring;
- Development of land use guidance and CEQA guidelines, and Air District review and comment on Bay Area projects pursuant to CEQA; and
- Leadership and advocacy.

Overview of CAP Control Strategy

The proposed 2010 CAP control strategy proposes a total of 55 control measures in five categories, including:

- 18 measures to reduce emissions from stationary and area sources
- 10 mobile source measures
- 17 transportation control measures

- 6 land use and local impact measures
- 4 energy and climate measures

In addition, to complement the formal control measures outlined above, a total of 18 Further Study Measures, as well as a Leadership Platform, are proposed.

Figure 4-1 provides an overview of the CAP plan framework.

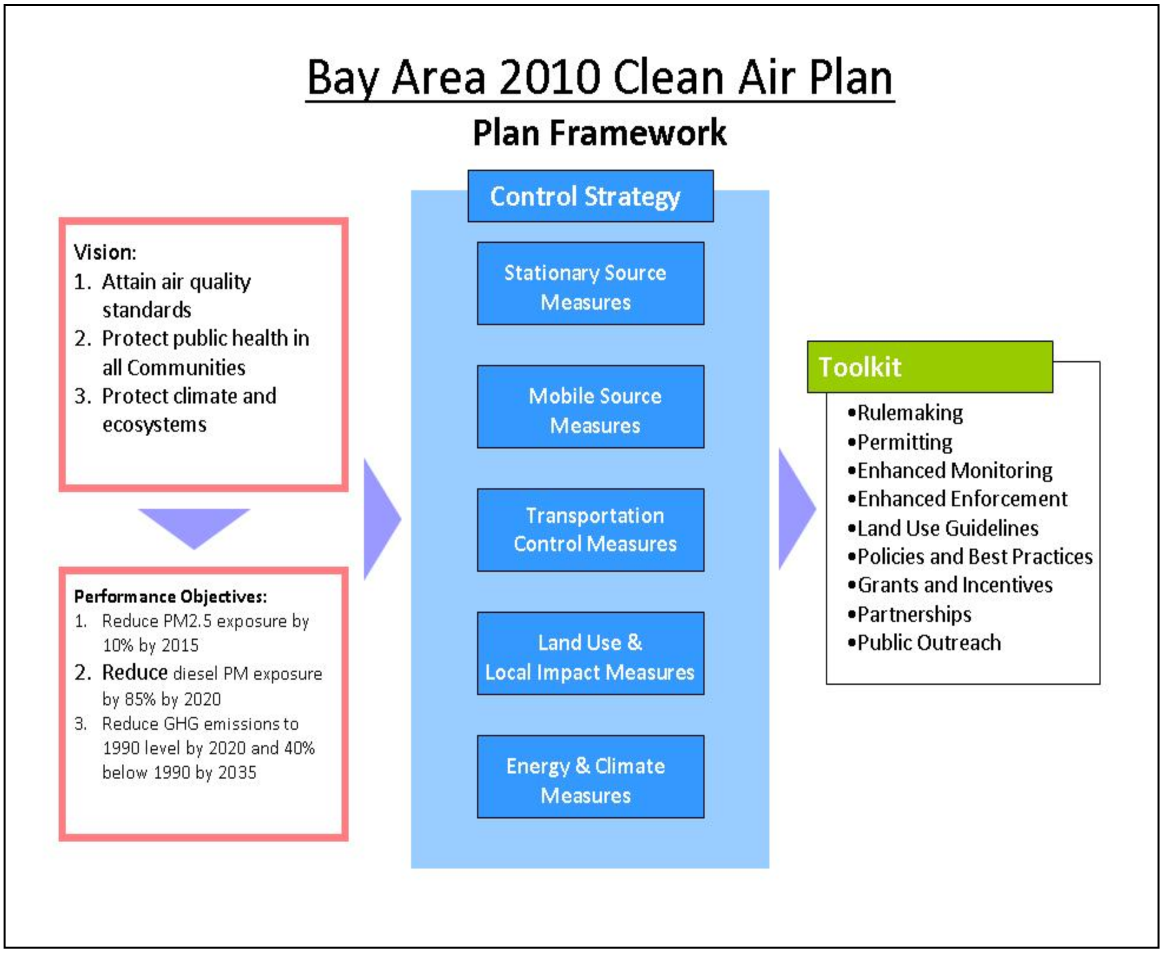

Figure 4-1. 2010 CAP Framework.

A brief summary of each category of control measures is provided in the section below. Detailed descriptions of the CAP control measures, FSMs, and Leadership Platform are provided in CAP Volume II. An overview of the control strategy and discussion of several key themes that run through the strategy are provided below.

Stationary Source Measures (SSMs) are measures that the Air District adopts and enforces pursuant to its authority to control emissions from stationary sources of air pollution such as manufacturing facilities, refineries, dry cleaners, auto body shops, gas stations, etc. Since the adoption of its first state ozone plan in 1991, the Air District has adopted or amended 68 rules to reduce emissions from stationary sources; in aggregate, these rules have reduced ROG emissions by 70-72 tons per day and NOx emissions by 108-123 tons per day.

A total of 18 SSMs are proposed in the 2010 CAP control strategy to enhance the Air District's regulatory program and ensure that the Bay Area remains in the forefront in controlling emissions from stationary sources. The proposed SSMs will provide reductions in emissions of ozone precursors, direct PM and PM precursors, air toxics, and greenhouse gases. The SSMs are briefly summarized in Table 4-1.

Mobile Source Measures (MSMs) are measures that reduce emissions by accelerating the replacement of older, dirtier vehicles and equipment through programs such as the Air District's Vehicle Buy-Back and Smoking Vehicle Programs, and promoting advanced-technology vehicles that reduce emissions of criteria pollutants and/or greenhouse gases. Since CARB is responsible for establishing statewide motor vehicle emissions standards and fuel specifications, implementation of the 10 MSMs relies heavily upon incentive programs, such as the Carl Moyer Program and the Transportation Fund for Clean Air, to achieve voluntary emission reductions in advance of, or in addition to, CARB requirements. The MSMs are briefly summarized in Table 4-2.

Table 4-1. Stationary and area source measures.

Number	Title	Description
SSM 1	Metal Melting Facilities	Limit emissions of organic compounds, fine particulates, toxic compounds, and odors from foundry operations and metal melting facilities.
SSM 2	Digital Printing	Establish VOC limits or control requirements for inkjet, electro-photographic and other digital printing technologies.
SSM 3	Livestock Waste	Establish management practices to reduce ROG, ammonia, PM, GHG.
SSM 4	Natural Gas Processing and Distribution	Reduce emissions of VOCs and methane from natural gas production facilities.
SSM 5	Vacuum Trucks	Require carbon or other control technology on vacuum trucks to reduce emissions of VOCs.
SSM 6	General Particulate Matter Weight Rate Limitation	Reduce particulate weight limitation as a function of exhaust gas volume and/or as a function of process weight rate.
SSM 7	Open Burning	Further limit agricultural burning of some crops to be burned on a given day to reduce VOCs, NOx, and PM.
SSM 8	Coke Calcining	Reduce SOx emissions from coke calcining.
SSM 9	Cement Kilns	Further limit NOx and SOx from cement production and reduce toxic emissions.
SSM 10	Refinery Boilers and Heaters	Further reduce NOx emissions from refinery boilers, heaters, and steam generators.
SSM 11	Residential Fan Type Furnaces	Reduce allowable NOx limits for residential furnaces.
SSM 12	Space Heating	Establish NOx limits for industrial and commercial space heating.
SSM 13	Dryers, Ovens, Kilns	Establish NOx limits for industrial dryers, ovens, and kilns.
SSM 14	Glass Furnaces	Reduce NOx limits for glass furnaces.
SSM 15	Greenhouse Gases in Permitting – Energy Efficiency	Consider greenhouse gas (GHG) emissions during permitting of new or modified stationary sources. This may include (1) adopting GHG CEQA significance threshold for stationary sources, and (2) requiring GHG reduction measures in ministerial permits.
SSM 16	Revise Regulation 2, Rule 2: New Source Review	Amend Reg. 2, Rule 2 to address the District's anticipated non-attainment status of the 24-hour PM2.5 National Ambient Air Quality Standard.
SSM 17	Revise Regulation 2, Rule 5: New Source Review for Air Toxics	Implement more health-protective District permitting requirements in Regulation 2, Rule 5, New Source Review of Toxic Air Contaminants based on revisions to OEHHA risk factors and methodologies. For Priority CARE Communities, track the toxicity-weighted emissions from all sources in the identified communities.
SSM 18	Revise Air Toxics "Hot Spots" Program	Revise the District's Air Toxics Hot Spots program to incorporate more stringent risk reduction requirements from existing sources.

Table 4-2. Mobile source measures.

Mobile Source Control Measures (On-Road Light Duty Vehicles)		
Number	**Title**	**Description**
MSM A-1	Promote Clean, Fuel Efficient Light & Medium-Duty Vehicles	Expand the use of Super Ultra-low Emission (SULEV) and Partial - Zero emission (PZEV) light-duty passenger vehicles and trucks within the Bay Area.
MSM A-2	Zero Emission Vehicles and Plug-in Hybrids	Expand the use of Zero Emission (ZEV) and Plug-in Hybrid (PHEV) passenger vehicles and light-duty trucks within the Bay Area, working in partnership with the Bay Area Electric Vehicle Corridor coalition.
MSM A-3	Green Fleets (Light, Medium & Heavy-Duty Vehicles)	Develop a green fleet certification component of the Bay Area Green Business program, promote best practices for green fleets, and evaluate existing grant programs to ensure incentive funding is directed towards fleets and vehicles that meet stringent fuel economy standards.
MSM A-4	Replacement or Repair of High-Emitting Vehicles	Enhance the Air District's Vehicle Buy Back program to increase participation from car owners; e.g., via higher cash payments and/or increased marketing. Consider including motorcycles in the VBB programs, or other potential enhancements, e.g. implementing a vehicle repair program. Pursue improvements to the Air District's Smoking Vehicle program.
Mobile Source Control Measures (On-Road Heavy Duty Vehicles)		
MSM B-1	HDV Fleet Modernization	Provide incentives to accelerate the replacement or retrofit of on-road heavy-duty diesel engines in advance of requirements for the CARB in-use heavy-duty truck regulation.
MSM B-2	Low NOx Retrofits for In-Use Engines	Provide cash incentives to install retrofit devices that reduce NOx emissions from MY 1994-2006 heavy-duty engines. Continue requiring software updates to engine control modules in model year 1993-1998 diesel trucks as a condition of all heavy duty vehicle retrofit grants.
MSM B-3	Efficient Drive Trains	Encourage development and demonstration of hybrid drive trains for medium- and heavy-duty vehicles, in partnership with CARB, CEC and other existing programs.
Mobile Source Control Measures (Off-Road Equipment)		
MSM C-1	Construction and Farming Equipment	Reduce emissions from construction and farming equipment by 1) cash incentives to retrofit construction and farm equipment with diesel particulate matter filters or upgrade to a Tier III or IV off-road engine; 2) work with CARB, CEC and others to develop more fuel efficient off-road engines and drive-trains; 3) work with local communities, contractors and developers to encourage the use of renewable alternative fuels in applicable equipment.
MSM C-2	Lawn & Garden Equipment	Reduce emissions from lawn and garden equipment through voluntary retirement and replacement programs.
MSM C-3	Recreational Vessels	Reduce emissions from recreational vessels through voluntary retirement and replacement programs.

Transportation Control Measures (TCMs) are strategies to reduce vehicle trips, vehicle use, vehicle miles traveled, vehicle idling, or traffic congestion for the purpose of reducing motor vehicle emissions. The draft Control Strategy includes 17 TCMs to improve transit service; encourage walking, bicycling, and transit use; improve efficiency of the regional transit and roadway systems; support focused growth; and develop and implement pricing strategies. The TCMs for the 2010 Clean Air Plan were developed by reviewing the 2005 Ozone Strategy measures, and modifying and expanding them based on new investment and policy decisions and public input. In particular, the TCMs have been updated to reflect the policy and investment decisions made in MTC's regional transportation plan, *Transportation 2035: Change in Motion*.

The TCMs are organized into five categories:

- Improve Transit Services
- Improve System Efficiency
- Encourage Sustainable Travel Behavior
- Support Focused Growth
- Implement Pricing Strategies

New TCMs have been added to:

- Emphasize the importance of "smart driving" and the need to reduce high-speed driving (TCM C-5)
- Encourage parking policies that will help to reduce motor vehicle travel (TCM E-2)
- Advocate that the Air District and its regional agency partners join forces to develop a regional transportation pricing strategy (TCM E-3)

In preparing the Transportation 2035 Plan, MTC defined performance objectives related to the "Three E's" – Economy, Environment, and Equity – and evaluated how various investment and policy scenarios would perform relative to these objectives. MTC concluded that implementation of innovative pricing and land use policies will be the most effective means of achieving the T2035 objectives.[136] Transportation pricing and parking policies are both potentially potent tools to reduce motor vehicle use, while also generating revenues that can be used to support alternative transportation modes. The plan includes TCM E-1 (value pricing), TCM E-2 (parking), and TCM E-3 (other pricing measures). TCM E-3 calls for the Bay Area regional agencies to join forces to establish a regional pricing task force to define goals, evaluate transportation pricing policy options, develop a recommended regional transportation pricing strategy, and pursue implementation of the strategy. The TCMs are briefly summarized in Table 4-3.

[136] See MTC Transportation 2035 Plan, pages 21-30.

Table 4-3. Transportation control measures.

Number	Title	Description
TCM A-1	Improve Local and Areawide Bus Service	Improve transit by providing new Express Bus or Bus Rapid Transit on major travel corridors, funding the replacement of older and dirtier buses, and implementing Transit Priority Measures on key transit routes.
TCM A-2	Improve Local and Regional Rail Service	Improve rail service by sustaining and expanding local and regional rail services and by providing funds to maintain rail-cars, stations, and other rail capital assets.
TCM B-1	Implement Freeway Performance Initiative	Improve the performance and efficiency of freeway and arterial systems through operational improvements, including implementing the Freeway Performance Initiative, the Arterial Management Program, and the Bay Area Freeway Service Patrol.
TCM B-2	Improve Transit Efficiency and Use	Improve transit efficiency and use through continued operation of 511 Transit, and full implementation of TransLink® fare payment system and the Transit Hub Signage Program.
TCM B-3	Bay Area Express Lane Network	Introduce roadway pricing on Bay Area highways through the implementation of an express lane network, also known as a High Occupancy Toll (HOT) lane network.
TCM B-4	Goods Movement Improvements and Emission Reduction Strategies	Improve goods movement and reduce emissions from diesel equipment through implementation of the Bay Area's Trade Corridors Improvement Fund (TCIF) projects and various funding programs to replace or retrofit diesel equipment.
TCM C-1	Support Voluntary Employer-Based Trip Reduction Program	Support voluntary employer trip-reduction programs through the implementation of the 511 Regional Rideshare Program and Congestion Management Agency rideshare programs, the Spare the Air Program, encouraging cities to adopt transit benefit ordinances, and supporting Bay Area shuttle service providers.
TCM C-2	Implement Safe Routes to Schools and Safe Routes to Transit	Facilitate safe routes to schools and transit by providing funds and working with transportation agencies, local governments, schools, and communities to implement safe access for pedestrians and cyclists.
TCM C-3	Promote Rideshare Services and Incentives	Promote rideshare services and incentives through the implementation of the 511 Regional Rideshare Program and Congestion Management Agency rideshare programs including marketing rideshare services, operating rideshare information call center and website, and providing vanpool support services.
TCM C-4	Conduct Public Outreach and Education	Educate the public about the air quality, environmental, and social benefits of carpooling, vanpooling, taking public transit, biking, walking, and telecommuting, through the Spare the Air campaign and Transportation Climate Action Campaign.
TCM C-5	Promote Smart Driving/Speed Moderation	Educate the public about the air quality and climate protection benefits of reducing high-speed driving and observing posted speed limits.

Table 4-3 (continued). Transportation control measures.

Number	Title	Description
TCM D-1	Improve Bicycle Access and Facilities	Expand bicycle facilities serving transit hubs employment sites, educational and cultural facilities, residential areas, shopping districts, and other activity centers.
TCM D-2	Improve Pedestrian Access and Facilities	Provide funding for projects to improve pedestrian access to transit hubs, employment sites, educational and cultural facilities, residential areas, shopping districts, and other activity centers.
TCM D-3	Support Local Land Use Strategies	Promote land use patterns, policies, and infrastructure investments that support mixed-use, transit-oriented development that reduce motor vehicle dependence and facilitate walking, bicycling and transit use.
TCM E-1	Value Pricing Strategies	Implement value pricing (congestion pricing) on Bay Bridge; consider expanding value pricing to other Bay Area toll bridges to manage travel demand during congested periods. Measure may also include value pricing in the City of San Francisco.
TCM E-2	Parking Pricing and Management Strategies	Promote policies to implement market-rate pricing of parking facilities, reduce parking requirements for new development projects, parking “cash-out”, unbundling of parking in residential and commercial leases, shared parking at mixed-use facilities, etc.
TCM E-3	Implement Transportation Pricing Reform	Develop a regional transportation pricing strategy that includes policy evaluation and implementation. Pricing policies to be evaluated include gasoline taxes, bridge tolls, congestion pricing, parking pricing, HOT lanes, VMT or carbon fees, pay-as-you-drive insurance, etc.

Land Use and Local Impacts Measures (LUMs) are a new category of measures designed to (1) promote mixed-use, compact development to reduce motor vehicle travel and emissions, and (2) ensure that we plan for focused growth in a way that protects people from exposure to air pollution from stationary and mobile sources of emissions. Building on the Air District’s CARE program and Clean Air Communities Initiative, this component of the Control Strategy puts a special emphasis on the need to monitor and reduce population exposure to hazardous pollutants in communities that are most heavily impacted by emissions. The measures in this category draw upon the full range of tools available to the Air District, including rulemaking, notably development of a new indirect source review rule; revised CEQA guidelines and enhanced CEQA review by the Air District; working with local jurisdictions to encourage and assist them in developing Community Risk Reduction Plans to reduce population exposure to air toxics and PM; providing incentives to reduce emissions from heavy-duty diesel equipment; targeted enforcement of CARB diesel control rules; land use guidance; and enhanced air quality monitoring. The LUMs are briefly summarized in Table 4-4.

Table 4-4. Land use and local impacts measures.

Land Use and Local Impact Control Measures		
Number	**Title**	**Description**
LUM 1	Goods Movement	Reduce diesel PM and GHG emissions from goods movement in the Bay Area through targeted enforcement of CARB diesel ATCMs in impacted communities, partnerships with ports and other stakeholders, increased signage indicating truck routes and anti-idling rules, shifts in freight transport mode, shore-side power for ships, and improvements in the efficiency of engine drive trains, distribution systems (roadways, logistic systems) and land use patterns.
LUM 2	Indirect Source Review Rule	Develop an indirect source review rule to reduce construction and vehicular emissions associated with new or modified land uses.
LUM 3	Enhanced CEQA Program	1) Develop revised CEQA guidelines and thresholds of significance and 2) expand District review of CEQA documents.
LUM 4	Land Use Guidelines	Provide guidance to local governments re: 1) air quality and greenhouse gases in General Plans, and 2) how to address and mitigate population exposure related to land use development.
LUM 5	Reduce Risk in Impacted Communities	Establish a system to track cumulative health risks from all emissions sources in impacted communities (as identified by the District's CARE program) in order to monitor progress in reducing population exposure.
LUM 6	Enhanced Air Quality Monitoring	Expand monitoring program to provide better local air quality monitoring data in impacted communities.

Energy and Climate Measures (ECMs) are a new category of measures designed to reduce ambient concentrations of criteria pollutants, reduce emissions of CO2, and protect our climate by:

- Promoting energy conservation and energy efficiency in homes, schools, and commercial and industrial buildings;
- Promoting renewable forms of energy production, such as solar panels and solar thermal;
- Reducing "urban heat island" effects by increasing reflectivity of roofs and parking lots, in order to decrease energy consumption by air conditioning, reduce evaporative emissions from motor vehicles, and help offset temperature increases associated with global warming; and
- Promoting the planting of (low-VOC emitting) trees in order to reduce biogenic emissions from trees, lower air temperatures, provide shading to reduce energy use, and absorb CO2 and other air pollutants.

The ECMs are briefly summarized in Table 4-5.

Table 4-5. Energy and climate measures.

Energy and Climate Control Measures		
Number	**Title**	**Description**
ECM 1	Energy Efficiency	Provide 1) education to increase energy efficiency; 2) technical assistance to local governments to adopt and enforce energy- efficient building codes; and 3) incentives for improving energy efficiency at schools.
ECM 2	Renewable Energy	Promote distributed renewable energy generation (solar, micro wind turbines, cogeneration, etc.) on commercial and residential buildings, and at industrial facilities
ECM 3	Urban Heat Island Mitigation	Mitigate the "urban heat island" effect by promoting the implementation of cool roofing, cool paving, and other strategies.
ECM 4	Tree-Planting	Promote planting of low-VOC-emitting shade trees to reduce urban heat island effects, save energy, and absorb CO2 and other air pollutants.

These new Energy & Climate measures are proposed in recognition of the fact that promoting energy efficiency, renewable energy, and green building standards are essential for purposes of both air quality and climate protection. However, the Air District has very limited direct regulatory authority in the area of energy or building standards. A well-defined regulatory structure is already in place via regulations and programs developed by the California Energy Commission, the California Public Utilities Commission, and other entities, and California has the most stringent energy efficiency standards in the nation. Energy efficiency and renewable energy use in the buildings sector also play a major role in the AB 32 Scoping Plan. Therefore, in crafting energy and climate measures for the CAP, the challenge is to identify where gaps may exist in the current structure and how the Air District can play a useful role in this arena within the constraints of its authority and resources.

The four ECMs focus on promoting voluntary action, largely by local governments, to adopt best practices and model policies to further energy conservation. The Air District can play an important role in facilitating the spread of best practices, for example, by drawing on the experience gained from projects funded by the District's Climate Protection Grant Programs. The District can also build on its relationships with the local planning community, via CEQA commenting, supporting the development of local climate action plans, and other activities, to promote these measures at the local level.

The ECMs focus on reducing GHG emissions and offsetting anticipated temperature increases related to global warming; this will have the effect of mitigating ozone increases that would occur with increased temperatures. To the extent that these measures are successful in reducing energy use, they will also contribute to reducing emissions of pollutants such as NOx, PM, and air toxics.

Further Study Measures: In reviewing potential control measures for the CAP, District staff identified 18 potential measures that appear to have merit but are not yet ready to be included as formal control measures. These measures have been included as further study measures (FSMs), as described in CAP Volume II. Measures have been classified as FSMs for a variety of reasons, including lack of emissions data for the targeted source, uncertainty as to the cost-effectiveness of a measure, or because the proposed control technology has not been adequately demonstrated. By designating measures as FSMs, the District commits to continue to evaluate these measures. However, the District makes no commitment to actually adopt or implement any FSM as a control measure unless and until a given measure has been demonstrated to be feasible pursuant to the control measure evaluation criteria specified in the Health & Safety Code. The FSMs are briefly summarized in Table 4-6.

Table 4-6. Further study control measures.

Further Study Measures		
Number	**Title**	**Description**
FSM 1	Adhesives and Sealants	Research the emission inventory for this source category, reconcile discrepancies with the inventories of other districts in the State, and determine if some VOC limits found in South Coast Rule are feasible in the Bay Area.
FSM 2	Reactivity in Coating and Solvents	Consider replacing VOC limits in certain rules, measured in mass VOC per volume, with limits based on the relative contribution to ozone formation of each of the organic species that make up the VOC content of a product.
FSM 3	Solvent Cleaning and Degreasing Operations	Consider reducing VOC emissions from solvent cleaning and degreasing operations based on CARB's statewide study.
FSM 4	Emissions from Cooling Towers	Research ways to reduce VOC emissions from cooling towers in refineries.
FSM 5	Equipment Leaks	Research ways to reduce VOC emissions from equipment leaks through remote sensing technologies and other methods.
FSM 6	Wastewater from Coke Cutting	Review coke cutting operations to determine if emissions reductions can be achieved from the resulting wastewater.
FSM 7	SO2 from Refinery Processes	Review refinery processes to identify opportunities to reduce SO2 emissions.
FSM 8	Reduce Emission from LPG, Propane, Butane, and other Pressurized Gases	Reduce emissions of LPG, propane, butane and other pressurized organic gases by requiring tanks and relief valves to be gas tight, prohibiting venting during tank filling, and establishing a leakage allowance for hoses.
FSM 9	Greenhouse Gas Mitigation in BACT and TBACT Determinations	Consider flexibility in BACT/TBACT determinations in order to reduce secondary green house gas (GHG) emissions from abatement devices.
FSM 10	Further Reductions from Commercial Cooking Equipment	Consider reducing emissions from commercial wok cooking, and solid fueled cooking devices such as wood-fired pizza ovens.

Table 4-6 (continued). Further study control measures.

Number	Title	Description
FSM 11	Magnet Source Rule	Explore the viability of developing a magnet source rule to reduce mobile source emissions from facilities such as airports, seaports, warehouses, distribution centers, shopping centers, and other facilities that generate mobile source emissions of criteria air pollutants, toxic air contaminants and greenhouse gases.
FSM 12	Wood Smoke	Study the impacts of existing Air District rules regarding wood burning and open burning, in order to develop more effective methods to implement, promote, enforce, and possibly expand, existing rules.
FSM 13	Energy Efficiency and Renewable Energy	Review the results of ECM1 and ECM 2 in 2010 CAP, and consider potential enhancements to promote energy efficiency and renewable energy.
FSM 14	Winery Fermentation	Review emissions generated by fermentation at wineries to determine if reductions in VOC emissions can be achieved.
FSM 15	Composting Operations	Review emissions generated by composting operations and consider reductions in emissions from composting.
FSM 16	Vanishing Oils and Rust Inhibitors	Research VOC emissions reductions from vanishing oils and rust inhibitors.
FSM 17	Ferry System Expansion	Work with MTC and the Water Emergency Transportation Authority to ensure that expansion of the regional ferry network will provide the greatest possible air quality benefit.
FSM 18	Greenhouse Gas Fee	Evaluate the idea of adopting a GHG fee on stationary sources to promote energy efficiency and reduce GHG emissions.

Leadership Platform: Some of the most potentially beneficial measures to improve air quality will require action by other agencies such as CARB or US EPA, or adoption of new legislation. Therefore, the CAP also includes a Leadership Platform, summarized in Table 4-7, which identifies policies and actions by other entities to complement the CAP control strategy.[137] The control measures that these actions would complement are identified in parentheses.

[137] The Leadership Platform is intended to help define the District's priorities for legislation and advocacy over the term of the CAP. However, it is not intended to preempt or supplant the Legislative Agenda that the District's Board of Directors defines each year.

Table 4-7. CAP leadership platform.

#	Advocacy Area	Actions
1	Cleaner Vehicles & Equipment	1. Advocate for more enforcement by CARB in Bay Area of diesel air toxics control measures and snap-idle inspection program. (MSM A-1) (LUM 1) 2. Support major revisions to the Smog Check program to improve its performance, such as using on-board diagnostics and remote sensing technologies to diagnose and repair vehicle emission malfunctions more quickly. (MSM A-4) 3. Support improvements to existing Smog Check program: older vehicles and newer high-mileage vehicles should be checked annually; also test for exhaust particulate matter (PM). (MSM A-4) 4. Support a motorcycle SmogCheck program. (MSM A-4) 5. Advocate for CARB to allow BAAQMD to include motorcycles and heavy-duty trucks in VAVR. (MSM A-4) 6. Support the phase out of new and in-use two-stroke engines. (MSM C-2, C-3) 7. Support public sector light- and heavy-duty green fleets. (MSM A-2) 8. Seek an on-going source of funding to provide incentives to reduce emissions from light-duty off-road equipment, such as lawn & garden and recreational watercraft. (MSM C-2, C-3)
2	Land Use/Building Standards	1. Support legislation to expand "parking cash-out." (TCM E-2) 2. Support enforcement of "parking cash-out." (TCM E-2) 3. Support legislation to require un-bundling of parking in leases. (TCM E-2) 4. Advocate for local building code requirements to exceed Title 24 requirements for commercial & residential multi-family housing to meet "cool roof" standards. (ECM 3) 5. Advocate for local zoning ordinances for "cool paving" standards and adding shade trees when existing parking lots undergo re-surfacing; also require shade trees in new lots. (ECM 3, 4) 6. Encourage CARB to provide credits for local government land use actions that can be used in GHG cap & trade system.
3	Pricing & Tax Policy	1. Support congestion pricing to reduce motor vehicle emissions. (TCM B-3, E-1) 2. Support a regional parking fee for privately owned lots, more cash-out incentives. (TCM E-2) 3. Support mileage-based vehicle and registration and/or license fees. (TCM E-3) 4. Support gas taxes or fees, and/or floor price for gasoline & diesel. (TCM E-3) 5. Support "pay as you drive" insurance. (TCM E-3) 6. Support cash incentives for the purchase of fuel efficient vehicles "feebates." (TCM E-3) 7. Support container fees at Ports. (LUM 1)

Table 4-7 (continued). CAP leadership platform.

#	Advocacy Area	Actions
4	Trip Reduction / Alternative Modes	1. Support legislation to empower air districts and local governments to adopt employer-based trip reduction requirements. (TCM C-1) 2. Support legislation to expand incentives for employer-based trip reduction programs, such as tax deductions and credits. (TCM C-1) 3. Encourage local governments to replicate San Francisco Commute Benefits Ordinance (allow employees to purchase transit passes with pre-tax $$). (TCM C-1) 4. Advocate for more diverse ways to measure Level of Service (LOS) than solely based on vehicle service volume to capacity ratios. (TCM D-1, D-2)
5	Other	1. Advocate with Caltrans and CHP for better enforcement of speed limits on freeways. (TCM C-5)

Key Themes Embedded in CAP Control Strategy

The CAP control strategy described above is wide-ranging and ambitious. To further explain the underlying rationale for the control strategy, we discuss in this section several key themes that are embedded in the strategy, including:

- Efficiency
- Reducing motor vehicle emissions
- Land use and community design
- Transportation pricing
- Goods movement

Efficiency

To date, most pollution control efforts have focused on reducing smokestack or tailpipe emissions, primarily by means of installing emission control devices. However, to address today's air quality and climate challenges, we need to address the root causes of air pollution and greenhouse gas emissions by analyzing energy consumption and emissions of air pollutants on a cradle-to-grave basis, promoting efficiencies, and making fundamental changes in fuels and/or production processes.

Incomplete combustion of fossil fuels results in emissions of ROG, NOx, PM, and air toxics.[138] To date, emissions of these pollutants have been reduced primarily by installing abatement devices on smokestacks and motor vehicle engines. Although this approach has generally been effective in reducing emissions of air pollutants, it does not

[138] NOx emissions result from combustion in the presence of nitrogen. NOx emissions have been reduced by using abatement devices or by reducing combustion temperatures.

address fundamental causes. Moreover, emission control devices often consume energy or affect efficiency, and thus may indirectly increase CO_2 emissions.

CO_2, the principal greenhouse gas, presents an entirely new problem. Unlike the pollutants discussed above which are emitted as byproducts of incomplete combustion, emissions of carbon dioxide are the direct and unavoidable product of complete combustion of fossil fuels. We cannot reduce emissions of CO_2 simply by installing emission control devices. Ensuring more complete combustion, which might work to reduce ROG, PM, and air toxics, will increase CO_2 emissions.

The most fundamental solution to reduce emissions of criteria pollutants, air toxics, and CO_2 is to reduce the amount of fossil fuels that we burn. Thus, we need to make our vehicles, our buildings, and our production processes more efficient, and we need to find alternative ways to produce energy that do not rely on fossil fuels.

To attain our greenhouse gas and air quality goals, we need to pursue efficiency in all sectors, including:

- Energy generation and transmission
- Community design and building design
- Goods movement and distribution
- Motor vehicles propulsion systems
- Transportation infrastructure and systems

In addition to improving air quality, promoting efficiency and reducing energy consumption provides economic benefits in the form of cost savings and increased productivity. The concept of promoting efficiency is integrated into the CAP control strategy, and is expressed most directly in SSM 5, MSM A-1, MSM B-3, TCMs B-1 through B-4, and ECMs 1 and 3.

Reducing Motor Vehicle Emissions

Motor vehicles and other mobile sources are the primary source of ROG, NOx, air toxics, and greenhouse gas emissions in the Bay Area, as well as substantial contributors of PM emissions.
The CAP control strategy includes a comprehensive set of measures to reduce emissions from mobile sources. Overall, the CAP measures are based on the idea that we need to:

- Drive cleaner
- Drive smarter
- Drive less

Driving Cleaner

Driving cleaner – that is, reducing tailpipe emissions via technological controls - has been the primary strategy to improve air quality over the past several decades. Fleet-wide emission rates decline as older, more-polluting vehicles are replaced by newer, cleaner ones that meet more stringent emissions standards. The CAP includes Mobile Source Measures to accelerate the retirement or retrofit of older vehicles and to encourage the introduction of new, advanced technology vehicles, especially vehicles that use alternative (non-fossil) fuels, including electric vehicles and plug-in hybrid vehicles. These measures will help to reduce emissions of criteria pollutants and greenhouse gases from motor vehicles.

Driving Smarter

There are many easy, low-tech ways that we can reduce emissions by driving smarter, as described in TCM C-5. We can greatly reduce emissions of air pollutants and greenhouse gases and improve fuel economy by keeping tires properly inflated and vehicles well maintained, and by practicing sensible driving habits such as avoiding hard accelerations and braking.

Speed moderation is perhaps the most important aspect of smart driving. Emission rates of ROG, NOx, PM, and CO2 all increase significantly at high speed. As shown in Figure 4-2, emission factors for all these pollutants are lowest in the range of 35 mph to 50 mph. A vehicle driven at 75 mph consumes approximately 40% more fuel and emits 35% more emissions than one driven at 60 mph. Approximately 60% of Bay Area driving (VMT) takes place on the freeway system and, according to Caltrans data, 34% of freeway driving occurs at speeds in excess of 65 mph. Observing posted speed limits can have a major impact in reducing emissions, conserving energy, decreasing expenditures on gasoline and diesel, and saving lives by reducing traffic accidents.

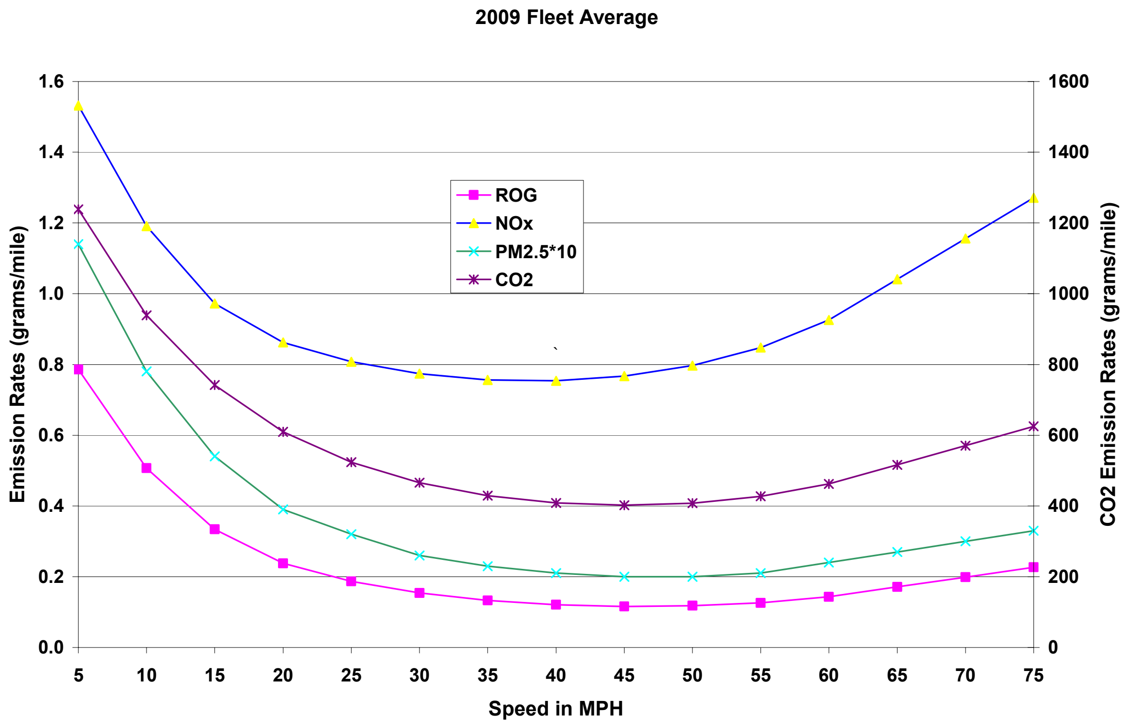

Figure 4-2. Emission rates vs. speed. Note: PM2.5 emission rates have been multiplied by a factor of 10 so as to best fit on the y-axis using the scale provided.

Driving Less

California has the most stringent motor vehicle tailpipe emission standards in the world. This accounts for much of our air quality progress to date. But it also means that once older vehicles have been replaced by new ones, and all the vehicles on the road meet these stringent standards, it will be difficult to squeeze more emissions reductions out of the Bay Area fleet. Motor vehicles will likely continue to be the primary source of air pollution in the future, so it will be imperative to continue to reduce motor vehicle emissions. Simply put, this means that we will need to drive less in the years to come to continue to improve air quality and protect our climate. However, experience to date shows that this will be difficult to accomplish. Reducing motor vehicle use will require an integrated strategy based on revising land use patterns, transportation pricing, providing viable alternatives to auto use, and public education.

VMT and Vehicle Ownership

Considerable effort is being invested at both the State and regional level to better integrate land use, transportation, air quality, and climate planning. Much of this effort is focused on the need to reduce the amount that we drive, often expressed by the term *vehicle miles of travel* (VMT). As shown in Figure 4-3, vehicle ownership and VMT have both doubled since 1970, and vehicle ownership and VMT have both increased significantly faster than population.

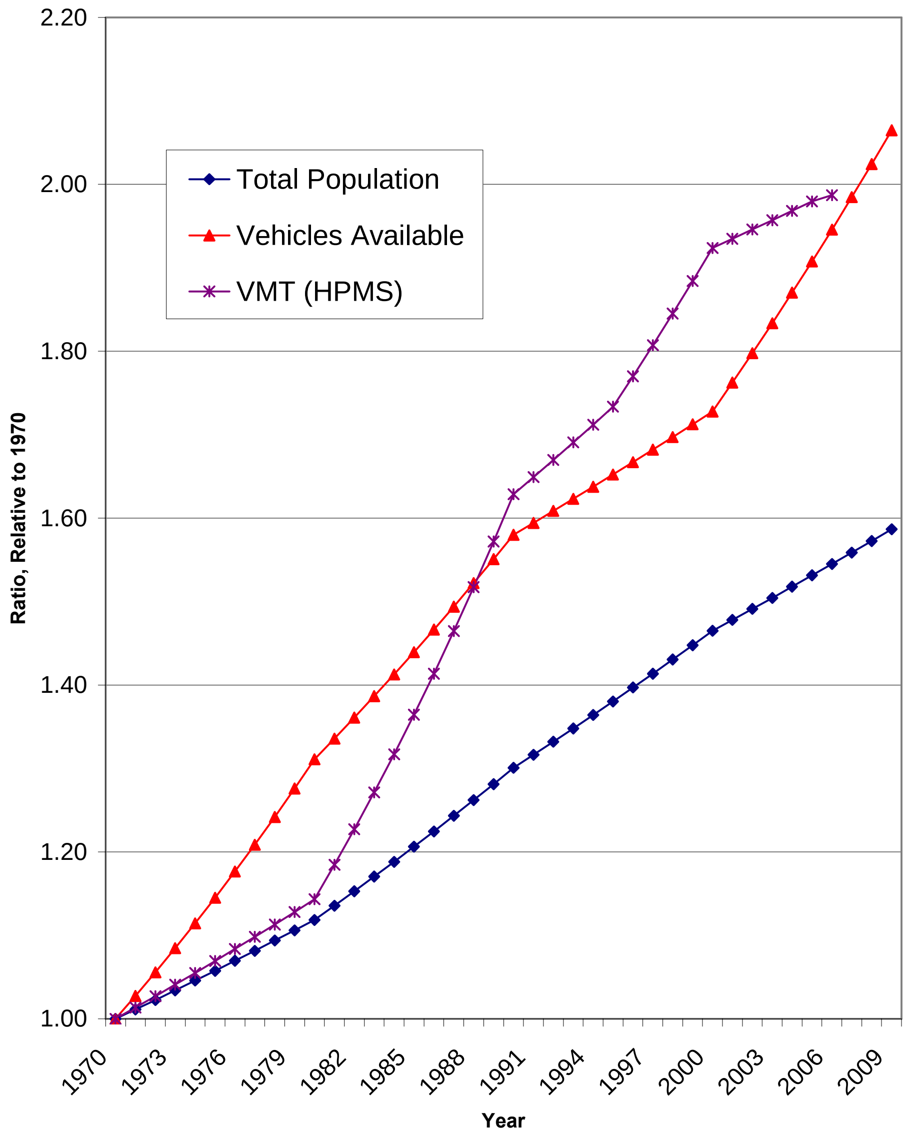

Figure 4-3. Growth in Bay Area population and motor vehicle use: 1970-2009.

This trend is expected to continue in the future. MTC forecasts that vehicle ownership and vehicle miles of travel (VMT) will both increase by approximately 30% in Bay Area [139] over the next 25 years; this is slightly faster than the rate of increase in population. An increase of this magnitude will translate into 1.25 million more vehicles driving an

[139] See MTC Travel Forecasts for Transportation 2035 Vision Analysis (November 2007). Per capita vehicle ownership is projected to increase from 638 per 1000 persons to 650 vehicles per 1000 persons by 2030. Household vehicles in Bay Area will increase from 4.33 million to 5.69 million by year 2030, an increase of 31.5% in 30 years.

additional 40 million miles per day on our already-congested roadways. This projected growth in vehicle ownership and VMT will lead to a wide range of negative impacts: more emissions of criteria pollutants and greenhouse gases, pressure to make costly investments to expand the roadway network and the supply of parking, increased water and noise pollution, and urban heat island effects that contribute to ozone formation.

A wide range of policies, many of which have been incorporated in the 2010 CAP control strategy, are proposed to reduce VMT. However, reducing motor vehicle ownership is rarely discussed as a means to reduce VMT, let alone as a legitimate objective in its own right. Yet there are good reasons to focus on reducing vehicle ownership, both on its own merits and as one of the most effective ways to reduce VMT.

- Motor vehicles can and do pollute even when they are not in use. On hot summer days, diurnal evaporative emissions from parked cars account for a significant amount of ROG, the key ozone precursor in the Bay Area.[140]
- Vehicle ownership rates are a strong predictor of VMT. Research indicates that at least 80% of the difference in VMT per household can be traced to differences in household vehicle ownership rates.[141]
- Once someone makes an investment to purchase and insure a motor vehicle, that vehicle generally becomes their default mode of transportation. In fact, having invested the money to purchase a car, it makes perfect economic sense for the owner to use the vehicle in order to maximize his or her return on that investment.

Even a modest reduction in vehicle ownership could provide significant benefit. For example, if the projected rate of increase in vehicle ownership could be reduced by 10% (i.e., from 1% per year to 0.9% per year) this would prevent the addition of 125,000 more vehicles on Bay Area roads in the coming decades. The potential benefits of reducing vehicle ownership include:

- Reduced VMT and reduced tailpipe emissions;
- Reduced evaporative emissions of ROG which contribute to ozone formation on hot days;
- Reduced need for parking, thus freeing space for other uses and helping to reduce urban heat island impacts (see control measure ECM 3);
- Reduced traffic congestion;
- Increased transit ridership, and thus a better return on capital investment in transit;
- Reduced roadway maintenance costs;
- Less need to expand the region's roadway network;

[140] In the Bay Area, diurnal evaporation accounts for 18.8 tons of ROG on a typical summer day. This represents 15% of the estimated 126.0 tons of ROG per day emitted by on-road motor vehicles (EMFAC2007, November 2006) and approximately 5% of the total ROG inventory.

[141] "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use" John Holtzclaw et al, *Transportation Planning and Technology*, March 2002

- Better water quality (due to reduction in run-off of pollution from non-point sources);
- Reduced household transportation costs;[142] this could be especially beneficial for low-income households, for whom vehicle ownership costs may represent a major burden.[143]

The objective of reducing vehicle ownership is not to be punitive or to actively discourage any one from owning a car; on an individual level, motor vehicle ownership can provide important economic and social benefits. Rather, the objective is to create communities where people have a viable choice as to whether they want to own a vehicle or not. This requires fostering policies and conditions that make it possible, or even more advantageous, for people to choose a reduced-car or car-free option.

The CAP control strategy includes a number of measures to help reduce the need for vehicle ownership, such as promoting infill, mixed-use development (TCM D-3); improving transit service and efficiency (TCMs A-1, A-2, and B-2); promoting other modes including walking and bicycling (TCM D-1 and D-2); promoting ride-sharing and car-sharing (TCM C-3); and implementing transportation pricing strategies (TCMs E-1, E-2, and E-3).

Land Use and Community Design

There is a growing recognition in the Bay Area and beyond that current land use patterns, and the transportation infrastructure needed to serve those land uses, are core causes of some of our most fundamental problems, including air quality, water quality, climate change, high energy consumption, reliance on imported oil, and public health and fitness. A key long-term solution is to channel future growth into vibrant urban communities where goods and services are close at hand, and people have a range of viable transportation options.

To a great extent, community design dictates individual travel mode. For people who live (and/or work) in low-density, car-oriented development, the motor vehicle is often the only viable transportation option. In such situations, even the most robust strategy to promote alternative modes of travel can have, at best, only a very modest effect. In contrast, compact communities with a mix of land uses make it much easier to walk, cycle, or take transit for at least some daily trips.

[142] On average, Bay Area household spend approximately 15% of household income on transportation. A November 2009 Urban Land Institute study entitled "Bay Area Burden" documents that on average Bay Area residents who live in the urban core spend significantly less on transportation than people who live in outlying parts of the region.
[143] Low-income Bay Area households spend 27% of their income on transportation; compared to 11% for high- income households. See MTC's Equity Analysis Report for T2035: Appendix E, Table E-2.

Focused growth needs to address *where we work* as well as where we live. Over the past 40 years, Bay Area job growth has increasingly migrated to suburban areas. The percentage of jobs located in core business districts that are well-served by transit has declined significantly. Today, the central business districts of San Francisco, Oakland, and San Jose collectively account for only 10% of total regional employment.[144] This suggests that policies to promote job growth in core areas well served by transit should be an important part of a comprehensive land use strategy to reduce VMT and emissions of air pollutants.

In addition to reduced air pollution, the benefits of focused development include reduced infrastructure costs, protection of open space and agricultural land, and encouraging vibrant communities with a strong retail tax base. Bay Area regional agencies are collaborating with local governments to promote infill development and identify priority development areas through the FOCUS program described in Chapter 3. But a stronger effort will likely be needed to build consensus in support of a sustainable plan for future Bay Area development in response to SB 375.

Senate Bill 375

Recognizing the importance of integrating land use, transportation, and climate protection planning, the State of California adopted SB 375 in fall 2008. SB 375 mandates that major metropolitan areas throughout California develop and implement integrated land use and transportation plans, known as "Sustainable Communities Strategies" or SCS, to achieve greenhouse gas reduction targets established by CARB. Programs to reduce on-road GHG emissions to meet SB 375 requirements will also result in reductions in ozone precursors, fine PM and air toxics.

The first Bay Area SCS must be developed and adopted by 2013. Development of the SCS is the primary responsibility of ABAG and MTC. However, the Air District can also play an important role in the development of the Bay Area SCS. The Air District for many years has worked with cities and counties on air quality issues, providing technical information and policy guidance, In addition, the Air District enjoys a strong working relationship with its regional agency partners; can exercise policy levers that influence new development, such as its CEQA guidelines and a forthcoming indirect source review regulation; and can provide technical expertise to ensure that the region and local jurisdictions pursue focused development in a way that protects public health.

Promoting Focused Development and Protecting Public Health

Promoting focused development in core areas of the region is essential in order to reduce emissions of criteria pollutants, air toxics and greenhouse gases from motor

[144] See March 2009 issue of *Urbanist*, published by the San Francisco Planning & Urban Research Association (SPUR).

vehicles, and thus achieve our air quality and climate protection goals. However, there is a potential tension, at least in the short term, between promoting focused development and protecting public health. Some areas that are well-suited for focused infill development, including areas designated as "priority development areas" by the region's FOCUS program, are in close proximity to heavily traveled roadways, industry, distribution centers, and ports. As a result, these areas currently experience high levels of emissions and/or population exposure to air pollutants on a localized level. To address this tension, Bay Area regional agencies and local governments will need to work together to nurture infill development that provides long-term benefits to the region as a whole, without exposing residents of the infill areas to undue exposure and health risk.

This issue was a key concern in developing the CAP control strategy. Building on the CARE program and the District's Clean Air Communities Initiative described in Chapter 3, the control strategy established the new category of Land Use and Local Impacts measures, as described above, to address this issue. See additional discussion in the "Reducing Impacts of Air Toxics in Local Communities" section in Chapter 5.

Pricing Strategies

While land use and community design are critical solutions over the long term, these strategies will take time to implement. To reduce motor vehicle emissions in the near term, pricing strategies are potentially the most effective tool. Motor vehicle travel imposes a variety of costs on society, including air pollution, that are not fully reflected in the price that drivers currently pay to own and operate a vehicle. There is widespread agreement among economists and planners that pricing policies could be a powerful means to reduce hidden subsidies that increase motor vehicle use, as well as to encourage more efficient use of our transportation systems.

There are a wide range of potential pricing policies and mechanisms, as described in TCM E-3. Both the conceptual framework and the technical capabilities to implement pricing measures are available, and real world examples have been successfully implemented for many pricing mechanisms. There are, however, significant differences among potential pricing policies in terms of their impacts on motor vehicle use and vehicle emissions, their socio-economic impacts, their revenue-generating potential, and their degree of political acceptability.

Pricing measures have, in fact, been indentified as important elements in Bay Area air quality and transportation plans for the past two decades, but relatively little progress has been achieved to date. No single agency has the resources and authority to develop and implement a pricing strategy on its own. The real challenge is how to develop and execute a clear strategy to implement transportation pricing in the Bay Area. As noted above, TCM E-3 calls for the Bay Area regional agencies to join forces to establish a regional pricing task force to develop a recommended regional transportation pricing strategy and pursue implementation of the strategy. Forging support to implement transportation pricing policies will require political leadership, public outreach, and education, strategies to minimize impacts on low-income households, and coordination among the Bay Area's regional agencies and local jurisdictions.

Reducing Emissions from New Development

Although the Air District has no direct authority over land use decisions, the District can play an important role in helping to reduce the air quality and climate change impacts of new development and protect public health in impacted communities by means of indirect source review, CEQA, and guidelines for local land use plans (see LUMs 2, 3, and 4), as discussed below.

CEQA and Land Use Guidelines

The Air District is developing proposed revised guidelines and thresholds of significance for lead agencies to use in reviewing the air quality and greenhouse gas impacts of new projects under the California Environmental Quality Act (CEQA). The guidelines are intended to ensure that the appropriate level of environmental review occurs and that meaningful mitigation measures are implemented to reduce a project's emissions of criteria pollutants, air toxics, and greenhouse gases by:

- Adding the first-ever significance thresholds for GHGs;
- Adding a new threshold for localized PM2.5 impacts;
- Adding a new threshold for cumulative air toxics impacts;
- Recommending preparation of Community Risk Reduction Plans; and
- Recommending preparation of greenhouse gas reduction plans.

Air District staff will work closely with local agencies to help them implement the CEQA guidelines, and provide training and support in the use of the guidelines.

Indirect Source Review Regulation

Pursuant to Health & Safety Code Section 40716, air districts in California have authority to regulate emissions from indirect sources. The term "indirect source" refers to development that attracts or generates motor vehicle trips, such as housing, office parks, shopping centers, universities. As described in LUM 2, Air District staff will develop a proposal, for consideration by the District's Board of Directors, to adopt and implement an indirect source review regulation in order to reduce emissions associated with new or modified land use development. The rule may also achieve co-benefits by reducing emissions of greenhouse gases. The measure is intended to encourage projects to be sited, designed, and constructed so as to reduce construction and operating emissions from motor vehicles as well as area sources, such as fireplaces, heating and cooling, and landscape maintenance equipment. In developing the ISR regulation, the Air District will work with its regional agency partners and local agencies to ensure that the regulation will serve to complement and support regional focused growth development programs.

Reducing Emissions from the Goods Movement Sector

Goods movement, a key function of the regional transportation system, is a critical component of the Bay Area economy. Nearly 40 percent of the region's economic output is in manufacturing, freight transportation, and the warehouse and distribution businesses, and goods movement accounts for over 10 percent of regional employment. The Port of Oakland is one of the nation's busiest container ports. Although cargo volumes are currently down due to the economic recession, projections show cargo volumes at the Port and throughout the region and state will grow significantly over the next 20 years. The Port of Oakland also plays an important role in supporting the state's agricultural sector, providing the primary means of transporting produce from the Central Valley to the Pacific Rim.

Despite its economic contributions, the goods movement sector is a significant source of air pollution, primarily PM and NOx. Exposure to diesel emissions from goods movement impacts the health of residents near ports, rail yards, distribution centers, and roads with high truck volumes. Diesel engines directly emit fine PM, and their NOx emissions contribute to formation of ozone and secondary PM2.5.

The 2010 CAP proposes a comprehensive strategy to reduce emissions and population exposure to diesel emissions, based upon the following principles:

- Promote greater efficiency and/or mode shift in order to move freight with less energy and fewer environmental impacts;
- Promote the use of the cleanest, most efficient mode of transportation (alternative fuels/ hybrid technologies);
- Ensure that any conventional vehicles and equipment used in goods movement are equipped with the most effective emission control systems available;
- Ensure that all vehicles and equipment used in goods movement are fully compliant with applicable State or federal regulations; and
- Encourage local land use decisions that do not expose sensitive populations to high levels of diesel emissions.

The CAP goods movement strategy will be implemented through a combination of actions. Key elements of the implementation include the following:

- Providing grants and incentives for the use of clean heavy-duty vehicles, as described in MSMs B-1, B-2, and B-3, and TCM B-4;

- Improving goods movement infrastructure in key corridors, as described in TCM B-4;
- Reducing local population exposure to diesel exhaust through enforcement, signage, and other measures described in LUM 1; and
- Pursuing partnerships with key stakeholders and promoting best practices to enhance efficiency and reduce emissions, as discussed in LUM 1.

Emission Reductions, Costs, and Benefits

Air District staff developed estimated emission reductions and implementation / compliance costs for the CAP control measures, as described below.[145] Per the requirements of the Health & Safety Code Section 40922, staff calculated the cost-effectiveness of control measures based upon reductions in ozone precursors (ROG and NOx). In addition, staff used the MPEM (described in Chapter 1) to estimate the public health and climate protection benefits of CAP control measures in monetary terms.

Emission Reductions: Air District staff estimated the emission reductions for all categories of control measures. In addition to ROG, NOx, and direct emissions of PM2.5, emission reductions were estimated, wherever possible, for SO2 and ammonia (precursors to secondary PM2.5 formation), the five air toxics addressed in the CAP, and the "Kyoto 6" greenhouse gases (CO2, methane, N2O, etc.).[146] Emission reductions could not be estimated for several control measures, either because the measure would not directly reduce emissions (e.g., LUM 5, LUM 6) or because additional analysis will be required during the rule development process (SSM 1, SSM 2, SSM 15, SSM 16, SSM 17, SSM 18).

Emissions reduction estimates for TCMs were calculated using CARB's most recent emissions inventory model, EMFAC2007, operating in the "BURDEN" mode. The BURDEN mode produces detailed reports on mobile source, on-road emissions at the county, air basin, and regional level, distributed by 13 distinct "speed bins" based upon time of day, which were forecast as a part of the Transportation 2035 travel forecasts.

The task of estimating emission reductions was complicated by the fact that the various control measures address a wide range of emissions sources and rely upon a diverse set of implementation mechanisms. In addition, many of the measures, especially measures that address land use, transportation pricing, and energy and climate, will rely heavily on partnerships and collaboration with other stakeholders, and/or preparation of guidance documents; it is difficult to quantify the emissions reductions for these measures. Because of these uncertainties, staff used relatively conservative emission

[145] MTC staff played a major role in developing emission reduction and cost estimates for the Transportation Control Measures.
[146] For some types of control measures, emission factors were not available for all pollutants.

reduction assumptions, so as not to over-estimate the reductions that the plan can deliver.

Analysis Years: Emissions reductions were estimated for years 2012 and 2020. The year 2012 was selected in order to evaluate the impact of control measures over the short-term, three-year horizon of the plan. However, because some measures will take longer to implement, 2020 was also selected to analyze longer term emissions reductions.

Costs: Many of the challenges in estimating emission reductions described above also apply in trying to estimate implementation costs for the various control measures. The types of the potential costs vary greatly among the measures. For stationary source measures, costs are based on the compliance cost to regulated industries. For many of the mobile source measures, costs are based on anticipated grants and incentives awarded by District programs and/or the incremental cost of cleaner, advanced-technology vehicles. For transportation control measures, there are various types of costs, depending upon the measure: e.g., capital costs to expand transit; costs to operate pubic outreach and information programs; or potential user fees as in the case of TCMs B-3, E-1, E-2, and E-3. It should also be noted that some measures that promote energy efficiency or the use of fuel-efficient engine technologies may provide significant user savings over the life of a project, which may offset or exceed the initial capital investments.

To provide additional information on cost impacts, the District also commissioned the preparation of a report entitled *Bay Area 2010 Clean Air Plan: Socio-Economic Analysis* to evaluate the potential impacts of control measures on regulated industries, public agencies, Bay Area households, and the regional economy as whole. Key findings of this report, which is available on the Air District website, include the following:

- The CAP control strategy as a whole will have a net positive economic impact on the Bay Area.
- Some regulated industries would potentially experience economic impacts if proposed rules are adopted, but compliance costs for proposed stationary source measures would not be deemed significant, based on the threshold defined in the report.
- The CAP control measures would not impose significant costs or unfunded mandates on local governments in the Bay Area.

For the proposed control measures that will be adopted as rules by the Air District Board of Directors, such as the stationary source measures and the Indirect Source Review regulation, additional analysis regarding potential costs and socio-economic impacts will be developed during the rule-making process for each measure.

Benefits: Evaluation of control measures has traditionally focused on the cost-effectiveness of measures in reducing ozone precursors, by dividing compliance costs by the tons of ROG and NOx reduced. However, for purposes of this plan, the Air District also evaluated control measures on the basis of their potential to reduce multiple pollutants. In addition, using the multi-pollutant evaluation method (MPEM) described in Chapter 1, certain benefits of the various control measures have also been estimated; i.e., their potential to reduce negative health impacts, including premature mortality, and impacts related to climate change. It should be noted, however, that the MPEM does not fully consider all benefits related to improving air quality. Nor does the MPEM include other co-benefits for certain measures such as improved mobility, reduced traffic congestion, enhanced safety for pedestrians and bicyclists, reduced water pollution, etc.[147]

The 2010 CAP breaks new ground in attempting to quantify the benefits of control measures in monetary terms. From the standpoint of policy-making, Air District staff believes that it makes sense to consider health and climate protection benefits, in addition to compliance costs, in the evaluation of control measures.

The Air District estimates that, summing the benefits of the individual control measures, the control strategy as a whole will provide health and climate protection benefits with a monetary value in the range of $270 million to $1.5 billion per year, with a likely value on the order of $770 million per year. Roughly 80% of the estimated economic benefits from the CAP control measures can be attributed to reductions in PM2.5 (66% non-diesel PM2.5 and 14% diesel PM2.5). Reductions in greenhouse gases account for approximately 20% of the economic benefits.

As discussed in Chapter 1, there is uncertainty involved in the assumptions and methods incorporated in the MPEM. To address this issue, Air District staff has performed a MPEM Probability Analysis[148] to evaluate the uncertainty in the estimated benefits calculated by the MPEM. The Probability Analysis is used to find a range of likely values for each control measure and for the CAP control strategy as a whole, and to determine whether the differences in the estimated benefits of the various control measures are statistically significant. As described in the Probability Analysis, for each variable or parameter, a set of 1,000 values was simulated according to the appropriate distribution, resulting in 1,000 vectors of simulated parameter values. The methodology is designed so that, even though there may be considerable uncertainty in the estimated “bottom line" benefit for each of the control measures, it is possible to determine with confidence that the benefit for one measure is significantly greater than the benefit of

[147] The MPEM does not include all pollutants or all health effects, nor the benefits of improvements in air quality beyond the boundaries of the Air District due to reduced emissions in the Bay Area. Nor does it consider economic benefits such as reduced damage to agricultural crops and to property (tires, building surfaces, paints, etc.), the benefit of clean air for property values, tourism, ecosystems protection, water quality etc. Finally, the MPEM does not include the potential co-benefits of transportation measures such as improved transit service, reduced traffic accidents, etc.

[148] The MPEM Probability Analysis is available on the Resource and Technical Documents tab of the 2010 CAP web page at www.baaqmd.gov/Divisions/Planning-and-Research/Plans/Clean-Air-Plans/Resources.aspx.

another measure. An example comparing two control measures is provided in Section 6.1 of the Probability Analysis.

Summary of Emission Reductions, Costs, and Benefits: Table 4-8 shows the estimated emission reductions for ROG, NOx, PM2.5, and greenhouse gases (CO2-e), as well as:

- the estimated annual cost of each measure
- the cost-effectiveness in reducing ozone precursors (ROG & NOx reductions combined)
- the weighted cost-effectiveness based on MPEM weighting factors[149]
- estimated annual benefit in reducing health and climate-related impacts, and
- the ratio of estimated benefit to estimated cost

A more detailed version of this table which also shows estimated emission reductions for other pollutants, including ammonia, SO2, benzene, butadiene, acetaldehyde, formaldehyde, and methane is provided on the Resource and Technical Documents tab of the 2010 CAP web page.

[149] The weighted multi-pollutant cost-effectiveness is calculated by multiplying the estimated emission reductions for each pollutant by the MPEM weighting factor shown in Table 1-2, and then dividing the annual weighted emission reductions by the annual cost of the control measure.

Table 4-8. Emission reduction, cost, and benefit summary table.

DRAFT CONTROL STRATEGY EMISSIONS REDUCTIONS (tons per day)			ROG	NOx	PM2.5	CO2-e (See note #11)	Cost/Yr	C-E for ROG & NOx	Weighted Multi-Pollutant C-E	$ Benefit/Yr from MPEM
Stationary Source Measures		***Notes***								
SSM1	Metal Melting Facilities	2								
SSM2	Digital Printing	2								
SSM3	Livestock Waste		0.3000			65	$1,200,000	$11,000	$1,500	$1,126,000
SSM4	Natural Gas Processing	1,4	0.3000			120				$1,636,000
SSM5	Vacuum Trucks		6.0000				$21,900,000	$10,000	$10,000	$10,459,000
SSM6	General PM Weight Rate Limitation	1			0.2870					$47,811,000
SSM7	Open Burning		0.0400	0.0100	0.0900					$15,089,000
SSM8	Coke Calcining	1					$5,700,000		$760	$35,993,000
SSM9	Cement Kilns	1		4.3800			$2,800,000	$1,800	$1,100	$11,641,000
SSM10	Refinery Boilers & Heaters	1		2.9000						$7,709,000
SSM11	Residential Fan Type Furnaces	7		4.2000			$5,000,000	$3,300	$2,100	$11,163,000
SSM12	Large Space Heating	7		1.2000			$6,833,333	$15,600	$10,200	$3,191,000
SSM13	Dryers, Ovens, Kilns	1		0.2000			$570,000	$7,800	$5,100	$532,000
SSM14	Glass Furnaces			0.3800			$760,000	$5,500	$3,600	$1,197,000
SSM15	GHG in Permitting - Energy Efficiency	2								
SSM16	Revise Reg 2 Rule 2 NSR	2								
SSM17	Revise Reg 2 Rule 5 NSR TAC	2								
SSM18	Changes to Toxic Hot Spots Program	2								
	Stationary Source Subtotal		6.640	13.270	0.377	184.800				$147,547,000

Table 4-8 (continued). Emission reduction, cost, and benefit summary table.

DRAFT CONTROL STRATEGY EMISSIONS REDUCTIONS (tons per day)			ROG	NOx	PM2.5	CO2-e (See note #11)	Cost/Yr	C-E for ROG & NOx	Weighted Multi-Pollutant C-E	$ Benefit/Yr from MPEM
Mobile Source Measures		***Notes***								
MSM A-1	Promote Clean Fuel Efficient Vehicles		0.0500	0.0300	0.0050	0.0001	$10,000,000	$342,000	$48,000	$1,005,000
MSM A-2	Zero Emissions Vehicles & Plug-In Hybrids		0.0100	0.0100	0.0050	0.0001	$14,400,000	$1,973,000	$78,000	$883,000
MSM A-3	Green Fleets		0.0200	0.0200	0.0200	0.0002	$550,000	$38,000	$800	$3,422,000
MSM A-4	Reduce High-Emitting Vehicles		4.3700	2.0600	0.0200	44.1425	$333,000	$140	$80	$17,279,000
MSM B-1	HDV Fleet Modernization		0.1000	5.0000	0.0330	0.6390	$58,333,000	$31,000	$9,300	$30,042,000
MSM B-2	Software/Catalytic Convertors			0.9900			$12,500,000	$35,000	$23,000	$2,632,000
MSM B-3	Efficient Drive Trains		0.0100	0.2900	0.0095	0.2274	$6,667,000	$61,000	$13,300	$2,374,000
MSM C-1	Construction & Farming Equipment		0.0400	0.7200	0.0190		$2,400,000	$9,000	$2,200	$5,149,000
MSM C-2	Lawn & Garden Equipment		0.0400	0.0090	0.0060	0.0008	$2,000,000	$112,000	$8,700	$94,000
MSM C-3	Recreational Vessels		0.0600	0.0090	0.0090	0.4156	$1,000,000	$40,000	$2,900	$1,632,000
	Mobile Source Subtotal		4.700	9.138	0.127	45.426				$64,511,000
Transportation Control Measures		***Notes***								
TCM A-1	Improve Local & Area-Wide Bus Service		0.0279	0.0316	0.0010	23	$340,433,000	$15,670,000	$1,018,000	$617,000
TCM A-2	Improve Local & Regional Rail Service	3	0.1386	0.1520	0.0280	516	$1,200,000,000	$11,315,000	$165,000	$12,430,000
TCM B-1	Implement Freeway Performance Initiative		0.9216	3.3150	0.1190	2,451	$51,667,000	$33,000	$1,500	$54,387,000

Table 4-8 (continued). Emission reduction, cost, and benefit summary table.

DRAFT CONTROL STRATEGY EMISSIONS REDUCTIONS (tons per day)			**ROG**	**NOx**	**PM2.5**	**CO2-e (See note #11)**	**Cost/Yr**	**C-E for ROG & NOx**	**Weighted Multi-Pollutant C-E**	**$ Benefit/Yr from MPEM**
Transportation Control Measures		***Notes***								
TCM B-2	Improve Transit Efficiency & Use		0.0039	0.0045	0.0003	6.13	$25,667,000	$8,377,000	$296,000	$152,000
TCM B-3	Bay Area Express Lane Network		0.8603	1.3617	0.2750	1,892	$108,000,000	$133,000	$3,400	$70,685,000
TCM B-4	Goods Movement Improvements	1	0.5850	4.8175	0.0613	4,045	$40,000,000	$20,000	$700	$82,172,000
TCM C-1	Voluntary Employer Trip Reduction		0.0761	0.0943	0.0040	97	$3,600,000	$88,000	$4,100	$2,240,000
TCM C-2	Safe Routes to School and Transit		0.0084	0.0082	0.0004	8.18244	$13,333,000	$3,361,000	$172,000	$211,000
TCM C-3	Promote Rideshare Services		0.0837	0.1051	0.0080	153	$5,667,000	$125,000	$4,000	$3,808,000
TCM C-4	Public Outreach and Education		0.0200	0.0200	0.0020	40.42	$4,333,333	$297,000	$7,600	$981,000
TCM C-5	Smart Driving/Speed Moderation		0.0744	0.1683	0.0090	180	$1,000,000	$11,000	$400	$3,753,000
TCM D-1	Improve Bicycle Access and Facilities		0.0037	0.0041	0.0002	4.44	$1,500,000	$527,000	$24,000	$110,000
TCM D-2	Improve Pedestrian Access and Facilities		0.0028	0.0020	0.0001	1.76	$40,000	$23,000	$1,500	$49,000
TCM D-3	Support Local Land Use Strategies		0.2418	0.3111	0.1450	873.63	$5,866,667	$29,000	$400	$36,598,000
TCM E-1	Value Pricing Strategies		0.0000	0.0105	0.0030	9.87	$26,000,000	$6,784,100	$107,300	$733,000
TCM E-2	Parking Pricing & Management Strategies		0.1800	0.1882	0.0164	294	$1,478,171,000	$10,996,900	$354,000	$7,268,000
TCM E-3	Implement Transportation Pricing Reform		0.1152	0.1204	0.0105	188	$471,143,000	$5,478,100	$165,000	$5,561,000
	TCM Subtotal		3.343	10.714	0.683	10,783.543				$281,755,000

Table 4-8 (continued). Emission reduction, cost, and benefit summary table.

DRAFT CONTROL STRATEGY EMISSIONS REDUCTIONS (tons per day)			ROG	NOx	PM2.5	CO2-e (See note #11)	Cost/Yr	C-E for ROG & NOx	Weighted Multi-Pollutant C-E	$ Benefit/Yr from MPEM
Land Use Measures		***Notes***								
LUM1	Goods Movement		0.0120	1.7188	0.2207	2,561	$1,449,000	$2,000		$65,101,000
LUM2	Indirect Source Review Rule		0.3020	0.2441	0.1076	340	$1,412,000	$7,100	$100	$52,864,000
LUM3	Enhanced CEQA Program	1	0.4400	0.3500	0.1600	447				$76,216,000
LUM4	Land Use Guidelines		0.0774	0.0810	0.0070	139				$2,805,000
LUM5	Reduce Risk in Impacted Communities	2								
LUM6	Enhanced Air Quality Monitoring	2								
	LUM Subtotal		0.831	2.394	0.495	3,487.504				$196,986,000
Energy and Climate Measures		***Notes***								
ECM1	Energy Efficiency	1	0.05	0.52		543.06	-$20,086,000	-$97,000	-$1,100	$65,906,000
ECM2	Renewable Energy	1	0.000004	0.000049		0.056488	$11,392,000	$584,159,000	$6,273,000	$6,000
ECM3	Urban Heat Island Mitigation		0.002	0.025		30	-$39,649,000	-$4,023,000	-$42,600	$3,137,000
ECM4	Tree Planting		0.0050	0.072000		76	$71,049,000	$2,528,000	$27,000	$9,093,000
	ECM Subtotal		0.0570	0.6170		649.5099				$78,142,000
Total for All Measures			15.5718	36.1334	2.0611	15,151				$768,942,000

Notes:

1. These emission reductions are estimates for year 2020. No information available for year 2012.
2. At this time, emission reductions cannot be determined for this control measure.
3. Emission reductions and costs are for year 2020.
4. Control Measure SSM-4 presents emission reductions as a range between 6 and 9 TOG. The most conservative reduction is represented here.
5. Unable to calculate costs for this measure.
6. CO2-e includes the "Kyoto 6" greenhouse gases (including CO2, methane, and N2O) weighted by their global warming potential.
7. Estimated NOx reductions for this measure represent reductions that will be achieved upon full implementation of the measure. Full implementation is not anticipated until year 2030 or 2040.

Implementing the CAP Control Strategy

Stationary source measures in the 2010 CAP, along with LUM 2 (Indirect Source Review Regulation), will be developed and adopted through the District's rule development process, as described below. The other types of control measures (MSMs, TCMs, LUMs, and ECMs) will be implemented via a variety of mechanisms, including partnerships, grants and incentives, public outreach, developing guidance documents for local agencies, etc. The specific mechanisms for each control measure are specified in the "Implementation Actions" section of the control measures descriptions provided in Volume II.

Progress in implementing the MSMs, TCMs, LUMs, and ECMs will depend upon the availability of resources among the many parties who have a role in implementing the control measures, as well as success in further enhancing existing partnerships among regional agencies, local governments, the business community, community groups, and other stakeholders. In particular, significant resources will be needed on the part of the Air District and/or other partners to implement measures such as an indirect source review regulation, an enhanced CEQA program, land use guidelines for local agencies, urban heat island mitigation, and assisting local governments in the development of Community Risk Reduction Plans and climate action plans.

Summary of the Air District's Rule Development Process for Stationary Source Measures

The Air District goes through a detailed process to adopt rules and regulations to impose standards on and limit emissions from stationary and area sources in the Bay Area. The legal authority for these regulations and many of the requirements that establish the process are found in the California Health and Safety Code.[83] The Air District follows a set of guiding principles for the rule development program:

- Strengthen and refine rules to do a better job of protecting the public health, environment and economy of the Bay Area
- Meet environmental goals in the most efficient and effective manner
- Respect all different points of view and knowledge
- Identify stakeholders with an interest in the outcome of our regulations
- Provide businesses maximum flexibility to meet air quality goals in a way that works best for them, allowing them to be cleaner at a lower cost

Air District staff undertakes a rigorous process to prepare a new rule or rule amendment for consideration by the Board of Directors. Following is a brief summary of the steps involved in developing a new or modified rule:

[83] See e.g. California Health and Safety Code § 40702, 40703, 40725 *et seq.*

- **Internal Scoping Meeting**: Staff conducts an internal meeting to discuss an identified air pollution problem, including divisions that may have relevant expertise. For example, the source test and laboratory departments in the Technical Services Division have input on appropriate test methods to create enforceable standards.
- **Technical Assessment Memorandum**: Staff performs an analysis of the various options for addressing the problem, including technology available to achieve controls, cost effectiveness, and potential environmental impacts. A technical assessment memorandum may precede or may be derived from a control measure.
- **Stakeholders Meetings:** Staff conducts meetings with the affected businesses and other interested parties to discuss issues, exchange information, and ensure effective communication among the various parties. In some cases stakeholder meetings precede and assist in development of technical assessment memoranda.
- **Initial Draft of the Proposed Rule:** After technical assessment, stakeholders meetings, and consultation with affected parties, if staff determines that a new rule or rule amendment is warranted, the District develops a draft rule.
- **Workshops**: Staff conducts one or more public meetings for each new rule or rule modification so that all affected and interested parties can discuss, comment on, and ask questions about a proposed rule.
- **CEQA Determination:** As a draft rule is developed, a CEQA (California Environmental Quality Act) analysis is prepared to determine whether a rule or rule amendment might have any adverse environmental impacts.
- **Socioeconomic Impact Analysis:** Staff researches and prepares cost estimates for implementation of the control strategy and calculates cost effectiveness on a dollars/ton of emissions reduced basis. An analysis of the socioeconomic impact of the rule proposal is prepared to assess the impact of the costs of the rule on the impacted industry and the Bay Area economy, including jobs.
- **Staff Report:** The results of the CEQA determination and socioeconomic analysis are incorporated into a staff report. The staff report explains the technical basis for the rule. It contains emission estimates, a description of the industry, control requirements, as well as rule amendments, costs, incremental costs, impacts on Air District staff resources, and the rule development process, and makes legal findings necessary for rule adoption. Comments and responses on the rule proposal and on the CEQA analysis are also included.
- **Public Hearing:** Staff presents the rule or amendments to the Air District's Board of Directors at one of the Board's regularly scheduled meetings. These meetings are always open to the public, and notice is provided 30 days in advance. Anyone may comment on the proposed rule or amendments during the meeting. At the conclusion of the hearing, the Board decides whether to adopt the rule or amendments.

Subsequent to rule adoption by the Board, staff implements the rule by preparing inspection protocols, policies, and procedures and issuing compliance advisories to notify affected parties of the rule and compliance dates. Staff also forward the rule to CARB and, if appropriate, prepare a State Implementation Plan (SIP) submittal to EPA.

Rule Adoption Schedule

Table 4-9 shows the proposed schedule for rule adoption during 2010, 2011, and 2012. Factors that were considered in developing this schedule include the estimated emission reduction benefit of each measure, the potential of measures to reduce localized health risks and impacts, the expected amount of time required to complete the rule development process for each measure based on data needs and other technical factors, as well as the need for participation in the rule development process by affected and interested parties.

Consistent with the CAP's emphasis on protecting public health, the proposed rule adoption schedule places high priority on developing regulations that reduce emissions of PM 2.5, as well as air toxics in impacted communities.

The schedule is as expeditious as practicable. Any particular control measure may be advanced or delayed based on information discovered in the rule development process or Air District staff allocation priorities. Also, during the rule development process, it may be determined that a measure may not provide sufficient emission reductions to warrant regulation or may not be cost effective.

Table 4-9. Rule adoption schedule, 2010-2012.

2010 Regulatory Agenda		
CM #	Control Measure (Regulation and Rule)	ER Potential
SSM 1	Metal Melting Facilities	TBD PM [1]
SSM 5	Vacuum Trucks	6.0 tpd ROG
SSM 6	General Particulate Matter (Reg. 6-1)	2.87 PM
SSM 9	Cement Kilns	4.38 tpd NOx [2]
SSM 10	NOx from Petroleum Refinery Boilers and Heaters (Reg. 9-10)	2.9 tpd NOx
SSM 17	New Source Review for Toxic Air Contaminants (Reg. 2-5)	n/a [4]

2011 Regulatory Agenda		
CM #	Control Measure (Regulation and Rule)	ER Potential
SSM 4	Natural Gas Production and Distribution (Reg. 8-37)	0.3 – 0.4 tpd ROG [3]
SSM 7	Open Burning	0.04 ROG
SSM 8	Petroleum Coke Calcining	2.6 tpd SO2
SSM 11	NOx from Residential Fan Furnaces (Reg. 9-4)	4.2 tpd NOx
SSM 12	NOx from Large Residential and Commercial Space Heating	1.2 tpd NOx
SSM 18	Air Toxics Hot Spots	TBD
LUM 2	Indirect Source Review Rule	0.3 ROG, 0.24 NOx, 0.47 PM10 [2]

Table 4-9 (continued). Rule adoption schedule, 2010-2012.

2012 Regulatory Agenda		
CM #	Control Measure (Regulation and Rule)	ER Potential
SSM 2	Digital Printing	TBD ROG
SSM 3	Livestock Waste	0.3 tpd ROG [3]
SSM 13	NOx from Dryers, Ovens and Kilns	0.2 tpd NOx
SSM 14	NOx from Glass Furnaces (Reg. 9-12)	0.38 tpd NOx
SSM 15	GHG in Permitting	n/a [4]
SSM 16	New Source Review for PM2.5	n/a [4]

1 Control Measure would also reduce toxic air contaminants.
2 Control Measure would also reduce toxic air contaminants, SOx and PM.
3 Control Measure would also reduce methane, a potent greenhouse gas.
4 New Source Review and permitting decisions mitigate emissions from future sources; consequently, no reductions from baseline are projected.

Chapter 5 – Summary and Looking Forward

The 2010 CAP updates the state ozone plan for the Bay Area and also applies a multi-pollutant framework to develop an integrated control strategy to:

- Attain air quality standards;
- Protect public health; and
- Protect the climate.

This chapter summarizes how the CAP fulfills the goals and objectives described in Chapter 1.

Updating the Bay Area's State Ozone Plan

The 2010 CAP serves as the triennial update to the Bay Area ozone plan for state air quality planning purposes, pursuant to the requirements of the California Health & Safety Code. Key requirements are that the plan must include all feasible control measures and must mitigate the transport of ozone and its precursors to neighboring air basins. A complete description of state air quality planning requirements and how the 2010 CAP fulfills all requirements is provided in Appendix C, State Air Quality Planning Requirements.

CAP Performance Objectives

As described in Chapter 1, the CAP defines numerical performance objectives related to the goals of protecting public health and protecting the climate. The CAP performance objectives are as follows:

- Reduce PM2.5 exposure by 10% by 2015
- Reduce diesel PM exposure by 85% by 2020
- Reduce GHG emissions to 1990 levels by 2020 and 40% below 1990 by 2035

PM2.5 performance objective: The PM2.5 performance objective is based on the estimated reduction in ambient PM2.5 concentrations needed to achieve the federal 24-hour PM2.5 standard. Air District staff believes that this health-based standard is the most appropriate benchmark to use as the basis for the PM2.5 performance objective. However, analysis performed for the CAP, as discussed both in Chapter 1 and in Appendix A, points to PM2.5 as the air pollutant that poses the greatest health risk to Bay Area residents. Furthermore, epidemiological research suggests that there may be health effects from PM2.5 levels below the current federal standards. Therefore, Air District staff recognize the need to make all feasible efforts to reduce PM emissions and exposure to the greatest extent possible.

Diesel PM performance objective: In the case of the diesel PM objective, EPA and CARB set emissions standards for most diesel engines, including trucks, buses, construction equipment, harbor craft, etc. For the past decade, CARB has been adopting and implementing ambitious air toxics control measures (ATCMs) to reduce emissions from all types of diesel engines, both new and existing, with a goal of reducing diesel PM by 85% by 2020. To implement recent changes in State law intended to address the current severe economic recession, CARB has modified compliance timelines for the construction equipment diesel ATCM (i.e., the in-use off-road diesel vehicle regulation). CARB is currently also considering changes to the requirements for in-use on-road trucks and further changes to the in-use off-road diesel vehicle regulation, to account for emission reductions occurring due to the current economic downturn. However, none of the recent or proposed changes to the in-use off-road and in-use on-road regulations would result in fewer reductions of diesel PM by 2020. Combined diesel emissions from all sources should still ultimately be reduced by 85%, although achievement of this objective may not occur by 2020. Nevertheless, the Bay Area should still see a very significant reduction in diesel PM emissions.

In support of the desired 85% reduction of diesel PM emissions by 2020, the Air District will continue to aggressively implement its effort to reduce diesel PM emissions and exposure via enhanced monitoring and analysis of impacted communities, targeted enforcement of CARB regulations in impacted communities, and targeting its grant programs to projects in impacted communities.

GHG performance objective: The CAP GHG performance objective is based on state goals articulated in AB 32 and the Governor's Executive Order S-3-05. The analysis described in Appendix G indicates that additional measures will be needed to achieve the CAP GHG performance objective, beyond the measures defined and quantified in the CARB AB 32 Scoping Plan and the 2010 CAP. The additional reductions may be obtained via some combination of future actions at the state level, the Sustainable Communities Strategy that will be developed by Bay Area regional agencies in cooperation with local governments pursuant to SB 375, local climate action plans, future Air District actions, and voluntary actions by Bay Area residents and businesses. All these efforts will be vitally important in reducing the region's GHG emissions, but their potential impact cannot yet be quantified.

How CAP Performs Relative to Performance Objectives: Air District staff performed an analysis, described in Appendix G, as to how well the CAP, in combination with state measures to reduce these pollutants, will achieve these performance objectives. [84] This analysis finds that the Bay Area will reach the performance objective to reduce PM2.5

[84] Since it is difficult to accurately measure population exposure to PM, our analysis of progress in meeting the PM2.5 and diesel PM performance objectives uses emissions reductions as a surrogate for reducing population exposure.

by 10% by 2015, but that it will fall short of the diesel PM and the greenhouse gas reduction objectives.

Multi-Pollutant Planning

Chapter 1 presented the rationale for the Air District's decision to expand the scope of the 2010 CAP as a multi-pollutant plan. Because little or no guidance is yet available on how to prepare a multi-pollutant plan, the Air District grappled with fundamental questions about the scope and content of such a plan. Nonetheless, the effort to devise a multi-pollutant plan did yield tangible results and achievements, including:

- Development, for the first time, of an integrated control strategy to reduce ozone, PM, air toxics, and greenhouse gases in the Bay Area;
- Evaluation of co-benefits and trade-offs among pollutants in analyzing potential control measures; and
- Development of a powerful analytic tool, the Multi-Pollutant Evaluation Method (MPEM), to compare the relative benefits of reducing the various pollutants, and to estimate in dollar terms the health and climate protection benefits of each control measure.

Multi-Pollutant Planning: Future Enhancements and Directions

In developing the Multi-Pollutant Evaluation Method and preparing the CAP, the District made use of the best technical data and tools at its disposal: emissions inventory data, monitoring data, air quality modeling results, and public health data. The effort to develop a multi-pollutant plan and create the MPEM helped Air District staff to understand both the strengths and limitations of its current tools and information, and to identify areas for future improvements.[85]

The experience of developing a multi-pollutant plan should provide on-going benefit to the Air District in the years to come. Developing a multi-pollutant plan has motivated Air District staff to analyze air quality issues from a broader perspective, and to consider, if not yet fully resolve, the many technical and policy issues that multi-pollutant planning raises. From this perspective, the process of developing the plan has been just as valuable as the plan itself. Ideally, the 2010 CAP can serve as a platform for introducing a multi-pollutant perspective into the full spectrum of Air District programs and the District's overall approach to air quality and climate protection. For example, looking forward, the Air District may explore the idea of applying a multi-pollutant framework in programs such as stationary source permitting, New Source Review, and Best Available Control Technology (BACT). However, any move in this direction would

[85] Plans to develop an integrated platform for multi-pollutant air quality modeling are described in Appendix E. Potential enhancements to the MPEM are described in Section 6 of the MPEM Technical Document (June 2009).

require serious analysis of the technical and policy implications, and would likely entail revisions in state and federal laws and guidelines.

The Bay Area 2010 Clean Air Plan represents an effort to demonstrate that multi-pollutant planning is both feasible and worthwhile. The Air District hopes that this plan provides a useful example that other agencies, including US EPA, CARB, and other air districts, can build upon to advance the multi-pollutant approach to air quality planning.

Protecting Public Health

Protecting public health is a core element of the Air District's mission, and a key objective of the 2010 CAP. The CAP builds upon on-going Air District efforts to identify and protect impacted communities through the CARE program and Clean Air Communities Initiative. Key ways that public health is addressed in the CAP include:

- Developing a control strategy to reduce PM, air toxics, and greenhouse gases, in addition to ozone;
- Establishing numerical performance objectives for reducing population exposure to PM2.5 and diesel PM;
- Developing a Multi-Pollutant Evaluation Method to quantify the health benefits of potential control measures and express these benefits in monetary terms;
- Analyzing the overall health burden of air pollution on Bay Area residents, and comparing the past burden to the current burden;
- Comparing the health benefit of reducing the various air pollutants, to help guide policy-making;
- Explaining how climate change threatens to increase air pollution and damage public health;
- Emphasizing reductions in population exposure and health impacts, both at the regional scale and in localized communities, in developing the measures that comprise the CAP control strategy;
- Prioritizing measures that will provide the greatest public health benefit in the rule-making calendar for stationary source measures; and
- Creating a new category of Land Use & Local Impact Measures. These measures focus on reducing local exposures, recognize the need for additional monitoring and risk assessment in impacted communities, and highlight the need to protect public health as the region promotes focused development.

The Importance of Reducing PM

As discussed in Chapter 1 and in Appendix A, exposure to PM2.5 poses the greatest public health risk from air pollution in the Bay Area. There has been a great deal of focus in recent years on the need to reduce emissions of diesel PM. However, analysis of the relative health risk associated with air pollutants in the Bay Area highlights the importance of reducing emissions and ambient concentrations of types of fine particulate matter, including direct emissions of PM2.5, as well as precursors that contribute to the secondary formation of PM2.5. Residential wood-burning is a major source of PM in winter months. The Air District's program to reduce residential wood-burning in winter months, described in Chapter 3, is an important means of reducing PM concentrations and population exposure to wood smoke, and a critical element of the effort to attain state and national PM standards.

Because of the health risks related to PM, measures that reduce PM have been given high priority in the implementation schedule for CAP control measures. The CAP control strategy includes several measures to further reduce direct PM emissions from stationary sources, including SSM 6 to increase the stringency of the general PM weight rate limitation, SSM 7 to amend the open burning regulation, and SSM 16 to amend the New Source Review rule to reduce PM. In addition, many of the other SSMs, such as SSM 8 (coke calcining) and SSM 9 (cement kilns), will reduce emissions of NOx, SO2, or ammonia, which are precursors to the secondary formation of PM.

In terms of reducing PM from mobile sources, the Air District already operates the Vehicle Buy-Back Program to accelerate the retirement of old vehicles, and the Smoking Vehicle Program, as well as grant programs such as the Carl Moyer Program and Low Emission School Bus Program. The District will continue to operate and enhance these programs, as described in the Mobile Source Measures in the CAP control strategy. In addition, the Air District will help to enforce CARB regulations to reduce emissions from heavy-duty easel engines by means of its Mobile Source Compliance Program described in Chapter 3.

All TCMs in the CAP that reduce motor vehicle travel should also reduce PM emissions. Measures in the CAP that should be especially effective in reducing PM emissions from mobile sources include MSMs A-4, B-1, B-2, B-3, and C-1, as well as TCM B-4 and LUM 1, both of which address goods movement. Development of a new Indirect Source Review regulation (see LUM 2), as well as the District's revised CEQA guidelines (see LUM 3), which establish thresholds of significance for local PM2.5 impacts, will provide important mechanisms to limit PM emissions from new development.

The CAP also describes several Further Study Measures, including FSM 7 (to reduce SO2 from refinery processes), FSM 10 (commercial cooking), FSM 11 (magnet source measure), and FSM 12 (wood smoke), all of which may provide opportunities for additional PM reductions.

Reducing Impacts of Air Toxics in Local Communities

The Air District and its partners must also continue to reduce population exposure to air toxics to protect public health. Reducing local impacts of air pollutants in the most heavily impacted communities, especially those communities identified by the CARE program, will continue to be a major focus of Air District efforts in the years to come.

Reducing diesel PM must continue to be a high priority. Analysis performed for the Air District's CARE program indicates that diesel PM is by far the leading air toxic in the Bay Area in terms of cancer risk, both at the regional scale and in the most impacted communities. Recent regulations to reduce emissions from heavy-duty diesel engines in trucks, cargo-handling equipment, construction machinery, and other equipment will greatly reduce emissions of diesel PM over the next 5-10 years. Building on regulations adopted pursuant to CARB's Diesel Risk Reduction Program, the Air District will work with all concerned stakeholders, including regional agencies, local cities, community groups, county health officers, and industry to analyze potential risks and develop effective mitigation measures to reduce population exposure to diesel PM and other air toxics.

As described in Chapter 3, the Air District has been striving to protect public health in recent years through programs such as the CARE Program, the Clean Air Communities Initiative, and the Goods Movement Emission Reduction Program to reduce emissions from port drayage trucks. Building on these efforts, the CAP control strategy includes measures to reduce population exposure to PM and to air toxics, and emphasizes the need to improve the Air District's ability to track cumulative risks in impacted communities and to enhance air quality monitoring capabilities at the local scale.

Protecting public health in impacted communities is a complex issue. Most of the health risk in these communities is due to emissions from mobile sources generated by freeways and major arterials, ports, distribution centers, etc. The region's transportation and goods movement infrastructure is well established and cannot easily be relocated. Although CARB regulations will greatly reduce emissions from diesel engines over the next 5-10 years, some of the benefit of these regulations may be offset by the projected increase in goods movement activity, as well as the overall volume of motor vehicle traffic, in future years. Reducing emissions and exposures in impacted communities will require a sustained effort based upon promoting cleaner and more efficient vehicles and equipment, ensuring full compliance with regulations to reduce emissions from mobile sources, sound land use planning and site-design, and site-specific mitigation measures.

In conjunction with proposed revisions to its CEQA Guidelines, the Air District is encouraging local governments to develop Community Risk Reduction Plans. Such plans are potentially one of the most effective ways to reduce overall health risk in impacted communities, because they provide an opportunity to develop a comprehensive strategy to reduce population exposure and health risk on a community-wide basis, while taking account of local needs and priorities regarding community development.

Protecting the Climate

Protecting the climate is another key objective of the 2010 CAP. There are many compelling reasons to protect the climate and combat global warming, but from the standpoint of the Air District's mission, the primary reason is to protect our hard-won improvements in air quality. The CAP addresses climate protection by:

- Explaining that air quality and climate change are closely related, and that higher temperatures are expected to exacerbate air quality problems;
- Incorporating the State of California GHG reduction targets in the CAP performance objectives;
- Including the estimated social benefit of GHG emissions reductions in the Multi-Pollutant Evaluation Method; and
- Considering the potential reduction (or increase) of GHG emissions, and their estimated monetary value, in evaluating the benefits of CAP control measures.

Protecting air quality is the Air District's core mission. From this perspective, the best way to protect air quality and the climate is to develop control measures that simultaneously reduce both traditional air pollutants as well as greenhouse gases. All measures in the CAP control strategy that reduce fossil fuel consumption by decreasing motor vehicle use, by promoting the use of fuel-efficient vehicles, or by other means of improving energy efficiency, should help to reduce GHG emissions.

In addition, many measures in the control strategy will have the additional benefit of reducing short-lived climate forcers, such as black carbon, methane and hydroflourocarbons (HFCs). For example, measures that reduce fine PM, by limiting burning and by reducing diesel PM, will also reduce the production of black carbon. The lifespan of these climate forcers in the atmosphere is relatively short (days to weeks, compared to over 100 years for CO_2), so they do not accumulate in the atmosphere like CO_2 does. However, because they are potent GHGs with high global warming potential, reducing emissions of these short-lived climate forcers can have an immediate impact in terms of reducing global warming.

The CAP also proposes control measures that will help to reduce GHG emissions from stationary sources, including

- SSM 3: Livestock Waste (methane)
- SSM 4: Natural Gas Processing & Distribution (methane)
- SSM 15: Greenhouse Gases in Permitting (CO_2)

In addition, the CAP contains new Energy and Climate Measures, including two measures to reduce GHGs from the energy sector, and two measures that focus on offsetting or mitigating temperature increases.

- ECM 1: Energy Efficiency (CO_2)
- ECM 2: Renewable Energy (CO_2)

- ECM 3: Urban Heat Island Mitigation
- ECM 4: Tree-planting

The CAP also includes two important measures that will reduce emissions of greenhouse gases from new development: CEQA Guidelines and Indirect Source Review. Finally, the CAP includes, as a further study measure (FSM 18), the concept of levying a greenhouse gas fee on stationary source to promote energy efficiency and reduce GHG emissions.

CEQA Guidelines: As described in LUM 3, the Air District expects to issue revised CEQA Guidelines in 2010, including new and revised thresholds of significance. The current staff proposal includes new thresholds of significance for greenhouse gas emissions; if adopted, the proposed GHG thresholds would be the most comprehensive and stringent thresholds of any air district in California, and would place the Bay Area at the forefront of the effort to reduce GHG emissions from new development.

Indirect Source Review (ISR) Regulation: As described in LUM 2, the CAP includes a measure to develop and implement an Indirect Source Review regulation to reduce emissions of criteria pollutants from new development. This regulation is expected to provide reductions in GHG emissions as a co-benefit. The ISR regulation will be developed in consultation with regional agencies partners, local governments, and other interested stakeholders. Whereas the CEQA guidelines will rely on implementation by local lead agencies, the ISR regulation would be implemented by the Air District as the lead agency, and would be structured to complement the CEQA Guidelines.

In addition to reducing GHGs through the CAP control strategy, the Air District will continue to facilitate the implementation of the state's AB 32 Scoping Plan. The District will contribute to the implementation of AB 32 in the following ways:

- Using its experience and expertise in regulation and rule enforcement to help CARB implement AB 32 climate measures that target GHGs from stationary sources;
- Working with regional agencies and cities and counties to promote land use development that minimizes energy use and motor vehicle travel; and
- Encouraging actions by local government and other Bay Area stakeholders to facilitate implementation of AB 32 by organizing meetings such as the Air District's 2006 and 2009 regional climate protection summits; providing incentives, such as the Climate Protection Grant Program; and providing technical expertise, such as its local government GHG inventory workshop series.

Looking Forward

Clean air, healthy communities, and a stable climate are essential to the continued vitality and economic strength of the Bay Area. As the Air District's first multi-pollutant plan, the 2010 Clean Air Plan provides a comprehensive strategy to improve air quality, protect public health in all Bay Area communities, and protect the climate. The CAP anticipates and responds to the challenges and opportunities that the Bay Area will face in coming years, emphasizing the need to promote energy efficiency, to reduce motor vehicle use, and to promote focused development as key long-term solutions.

The 2010 CAP is designed to complement a broader set of plans and programs adopted and implemented by CARB, US EPA, regional agency partners, and local governments, as well as voluntary actions on the part of the business community, non-profit organizations, and Bay Area residents. Successful implementation of the CAP control strategy will require internal and external resources, public support, and partnerships and collaboration among many agencies and stakeholders.

To fulfill its objectives of attaining air quality standards, protecting public health, and protecting the climate, the Air District will implement the CAP control strategy; enhance its multi-pollutant planning capabilities; continue and expand its efforts to reduce health risk in impacted communities; engage local governments and stakeholders to promote focused development in a way that protects public health; and refine and strengthen its efforts to reduce emissions of greenhouse gases.

To build upon this plan in future years, the Air District will continue its efforts to achieve the CAP goals and to build its multi-pollutant planning capacity by:

- Developing an integrated emissions inventory that includes all pollutants;
- Developing an integrated air quality modeling platform;
- Enhancing the Multi-Pollutant Evaluation Method developed for the 2010 CAP to include a wider range of pollutants and health effects;
- Enhancing its capacities to measure and analyze ambient concentrations and population exposure in impacted communities;
- Developing better measurements of population exposure to pollutants on a region-wide basis;
- Evaluating the potential benefits and policy and technical issues related to extending the risk-weighted multi-pollutant approach to programs such as stationary source permitting and New Source Review; and
- Better integrating strategies to reduce criteria pollutants and greenhouse gases.

The Air District elected to develop the 2010 CAP as a multi-pollutant plan as a matter of choice. However, future challenges are likely to make multi-pollutant planning a necessity in years to come. In addition to serving as a blueprint for the Bay Area, the Air District offers the 2010 CAP as one example of a multi-pollutant plan that other agencies can build on to advance this concept.

Chapter 6 – Source Documents

BAAQMD documents

Base Year 2005 Emissions Inventory Summary Report, BAAQMD Special Projects Section, December 2008.

Bay Area 2005 Ozone Strategy, BAAQMD, January 2006.

CARE Phase I Findings and Policy Recommendations Related to Toxic Air Contaminants in the San Francisco Bay Area, BAAQMD, September 2006.

The Effects of Climate Change on Emissions and Ozone in Central California, by Su-Tzai Soong, Cuong Tran, David Fairley, Yiqin Jia, and Saffet Tanrikulu. Paper #590 presented in the 101st Annual Meeting, Air and Waste Management Association, June 2008 Portland OR.

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Multi-Pollutant Evaluation Method Probability Analysis, BAAQMD, March 2010.

Ozone Modeling & Data Analysis During CCOS, BAAQMD Research & Modeling Section, September 2009. Pub. # 200909-01-O3

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Source Inventory of Bay Area Greenhouse Gas Emissions, BAAQMD Special Projects Section, December 2008.

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Appendix A – Bay Area Air Pollution Burden: Past & Present

Analysis of trends in monitoring data shows that in recent decades Bay Area air quality has improved dramatically. This has been accomplished even as regional population, the number of motor vehicles and miles driven, and the value of the region's economic production have grown significantly. Our progress in improving air quality is due to a comprehensive program to reduce emissions from both stationary and mobile sources of air pollutants.

The purpose of this analysis is to estimate the health and social impacts of air pollution in the Bay Area today compared with the earliest period for which reliable ambient air quality measurements were available. To facilitate comparison between earlier years and today, we have calculated the benefit of pollutant reductions based upon the current Bay Area population. That is, the health burden is analyzed as if today's population were exposed to the pollution levels that prevailed in earlier years, and then compared that to the health burden associated with current air pollution levels.

The good news is that exposure to unhealthy concentrations of local air pollutants in the Bay Area - ozone, particulate matter (PM), and air toxics - and hence their health effects, have been reduced by more than half since the 1970 Clean Air Act was enacted.[86] However, despite this progress, a variety of health effects, including premature mortality, are still associated with exposure to air pollution in the Bay Area today, and these health effects result in direct and indirect economic impacts to the region that are valued in billions of dollars per year.

Methodology

The analysis presented here is based upon a methodology which is described in detail in the Air District's *Multi-Pollutant Evaluation Method Technical Document* (MPEM).[87] The MPEM by necessity incorporates many assumptions and approximations; these are described in the *MPEM Technical Document*. For example, for purposes of estimating population exposure to pollutants, the MPEM assumes "backyard" exposure; i.e., that people are at home and outside in their yards 24 hours a day, 7 days a week. Because the MPEM is a complex methodology, the estimates of social benefits that it generates

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[86] By contrast, emissions of greenhouse gases that contribute to global warming have increased significantly during this period. However, after years of steady increase, emissions of greenhouse gases should begin to decline in California in coming years as a result of AB 32 and regulations that will be adopted to implement the Air Resources Board's AB 32 Climate Change Scoping Plan.

[87] See Draft Multi-Pollutant Evaluation Method Technical Document at www.baaqmd.gov/Divisions/Planning-and-Research/Plans/Clean-Air-Plans/Resources.aspx.

are subject to considerable uncertainty. To address this uncertainty, Air District staff performed a probability analysis of MPEM results.[88]

Air Toxics

The air toxic health effects considered here are limited to cancer. The Air District and CARB began regular air toxics monitoring in the late 1980s. However, some toxics such as formaldehyde and acetaldehyde were not monitored until several years later. Except for diesel PM, estimates were made of the annual mean for the earliest year available and for 2008.

Diesel PM, the air toxic with the greatest health impact, cannot presently be measured directly. Indirect estimates were made for recent years using elemental carbon measurements for various Air District sites. For earlier years, Coefficient of Haze measurements[89] were used. The Addendum below presents details of which toxics were considered and how the risks were calculated.

Ozone

The Air District has monitored ozone since the 1950s and since 1968 has had a spatially dense set of ozone measurements. These measurements were used to estimate population exposure for 2008 and what the exposure would have been if the ozone levels had not been reduced since 1970. For purposes of this analysis, we assumed that ozone health effects occurred for hourly ozone concentrations at or above 50 parts per billion (ppb), but not below.

$PM_{2.5}$

$PM_{2.5}$ consists of many components, some man-made, some natural. The health burden of $PM_{2.5}$ was based on the amount of anthropogenic (man-made) $PM_{2.5}$, subtracting natural background $PM_{2.5}$ (sea salt, windblown dust, etc.) which is estimated to average about 3 micro-grams per cubic meter ($\mu g/m^3$). $PM_{2.5}$ has been measured routinely only since 1999. To estimate $PM_{2.5}$ concentrations prior to 1999, other PM measurements made since the late 1980s and early 1990s were used to approximate $PM_{2.5}$ concentrations in 1990. The Addendum provides details of how this was done.

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[88] District staff performed an uncertainty analysis based upon the Monte Carlo method to evaluate the MPEM calculations for each control measure, as described in the MPEM Probability Analysis which is posted on the 2010 CAP page on the District website: www.BAAQMD.gov.

[89] Coefficient of Haze (COH) was a measurement of PM that is highly correlated with elemental carbon (EC). A regression relation was established between COH measurements and EC from the few Air District sites with simultaneous measurements of both.

Diesel PM is a key component of $PM_{2.5}$ and warrants separate treatment. Therefore, anthropogenic $PM_{2.5}$ is divided into diesel PM and non-diesel PM. Diesel PM cannot be measured directly, but is approximated from other measurements. See the Addendum below for details.

Health Summary

Figure A-1 shows the number of cases of selected health effects that are related to population exposure to current Bay Area air pollution levels (2008, labeled "now") compared to the estimated number of cases that would have occurred if the quantifiable air quality improvements had not been made (labeled "then"). The "then" data is based on the earliest data available – 1970 for ozone, and the late 1980s for toxics and PM.

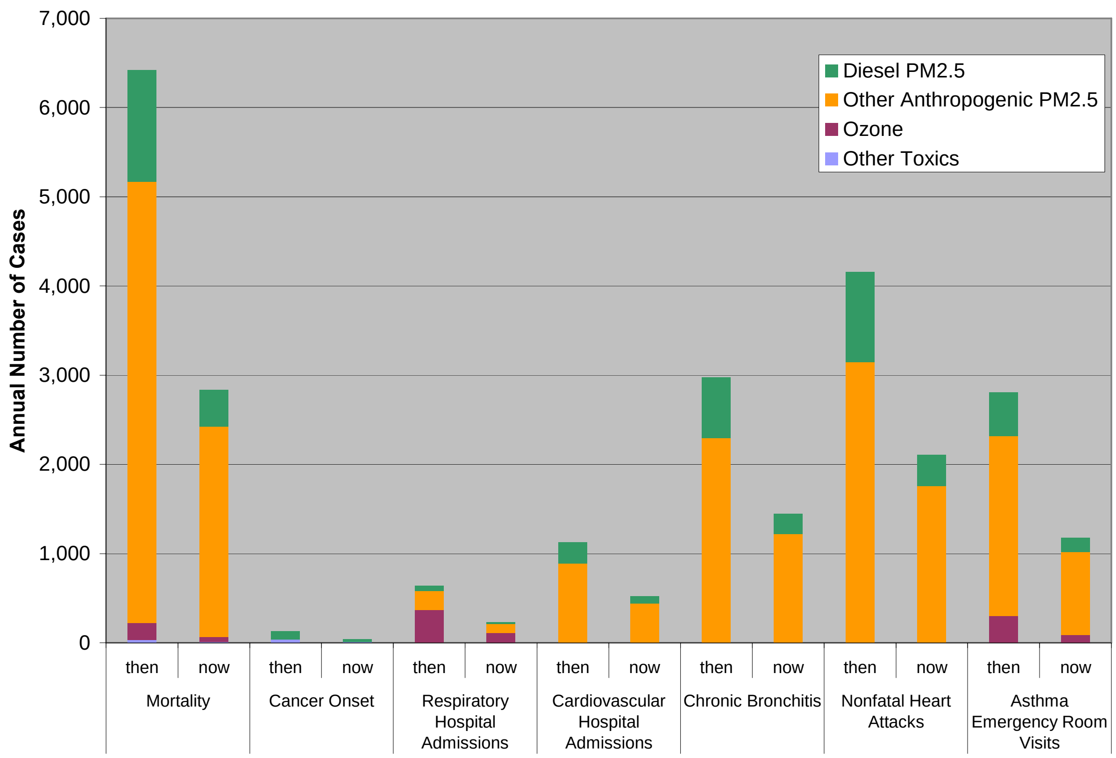

Figure A-1. Incidence of selected health effects among Bay Area residents from air pollution today versus without air quality improvements. "Then" is 1970 for ozone, and the late 1980s for toxics and PM2.5. "Now" is 2008.

Table A-1 shows the reduction in the estimated number of annual cases; i.e., the difference between "then" and "now" for each of the health effects shown in Figure A-1. Table A-1 provides the "best estimate" as well as the lower bound (10^{th}

percentile) and upper bound (90th percentile) for an 80% confidence interval. The range of values is provided in Table A-1 in order to emphasize that all the health effects figures provided in this analysis are estimates; the numbers in this analysis are intended to convey a sense of overall trends and relative magnitudes, but they are not precise figures.

Table A-1. Reductions in annual cases, "then" to "now" including an 80% confidence interval.

	Mortality	Cancer Onset	Respiratory Hospital Admissions	Cardiovascular Hospital Admissions	Chronic Bronchitis	Nonfatal Heart Attacks	Asthma Emergency Room Visits
Best Estimate	3,600	90	200	700	1,900	2,700	1,400
10th Percentile	1,400	40	100	500	600	1,300	900
90th Percentile	6,400	170	300	900	3,000	3,800	1,900

Figure A-1 shows that the annual numbers of health effects associated with exposure to air pollutants in the Bay Area has dropped dramatically, by more than half. Of particular interest, premature mortality related to air pollution has decreased from an estimated 6,400 per year to an estimated 2,800 per year. For purposes of comparison, the total number of annual deaths in the Bay Area is about 45,000, and the annual number of transportation-related deaths in the Bay Area is 600 to 700.

Life expectancy is widely regarded as an indicator of the overall health of a given population. Life expectancy measures the average number of years a baby born today would live given the present distribution of age-specific probabilities of death. Premature mortality is a measure of unfulfilled life expectancy. The reduction in mortality risk as shown in Figure A-1 and Table A-1 can be expressed in terms of increased life expectancy. Over the past 20 years, Bay Area life expectancy has increased by almost 5 years, from 75.7 in 1990 to 80.5 today, due to a variety of factors. Of the overall increase in life expectancy during this period, we estimate that the improvements in air quality can be credited with extending average life expectancy in the Bay Area by 6 months. Thus, approximately 10% of the improvement in Bay Area average life expectancy over the past decade and a half can be attributed to cleaner air. (See Addendum below for details.)

The vast majority of the mortality risk related to air pollution is correlated with exposure to fine particulate matter ($PM_{2.5}$), shown as the combination of diesel $PM_{2.5}$ and other anthropogenic $PM_{2.5}$ in Figure A-1. Several robust epidemiological studies have shown that $PM_{2.5}$ concentrations in a given area affect the death rate. The studies are based on data sets where the health and health-relevant information for a set of people from different areas has been collected for an extended period. These records allow the estimation of mortality rates for various areas, where the rates are adjusted for key factors such as age, gender, smoking, and obesity. The adjusted death rate for each area is compared with the average PM concentrations in the area, showing clear correlations.

After reviewing the literature, we use a risk factor based on the assumption that every 1.0 µg/m^3 reduction in $PM_{2.5}$ concentration results in a 1% reduction in mortality rate for individuals over 30 years old.[90] For the MPEM, the change in premature mortality from $PM_{2.5}$ was calculated by estimating the percentage change in mortality from a given change in $PM_{2.5}$ concentration and applying that to the annual deaths to persons over 30 years old. Currently, Bay Area $PM_{2.5}$ concentrations average about 9.5 μg/m^3, or about 6.5 μg/m^3 above natural background levels. Thus, we estimate that total elimination of anthropogenic $PM_{2.5}$ would reduce the death rate by about 6.5% for those over 30, or about 2,800 deaths per year.

Although research is still on-going to determine the precise biological mechanisms through which $PM_{2.5}$ is associated with increased mortality, it appears that cardiovascular problems, such as heart attacks, are the leading cause (EPA 2009). Although diesel PM is the leading air toxic in the Bay Area, it should be noted that perhaps only 10-20% of these PM-related deaths are linked to diesel exhaust. Other sources of PM, such as wood smoke, cooking, and secondary formation of PM from precursors such as NOx, SO2, and ammonia, collectively account for most of the ambient PM, and PM-related mortality, in the Bay Area. To the extent that diesel PM does contribute to premature mortality, it appears to be primarily due to the mechanisms mentioned above. Cancer accounts for a smaller number of total deaths related to air pollution. The total annual number of cancer deaths, including lung cancer, related to exposure to diesel PM in the Bay Area, is approximately 80-90 per year. Thus, mortality related to exposure to fine PM (including diesel particles) appears to be associated much more with cardiovascular problems than with cancer.

Summary of Costs and Disbenefits

Air pollution imposes costs on society in terms of public health, the environment, and the economy. Approximations can be made for the direct costs of treatment for pollution-related health effects, as well as indirect costs based upon people's willingness to pay to avoid those health effects. Table A-2 presents a list of health effects and the estimated dollar value of these effects on a per-case basis. For greenhouse gases, we use an estimate of $28 per metric ton of CO2-equivalent emitted for the overall social cost of anticipated impacts of climate change. Chapter 5 of the MPEM Technical Document provides more detailed explanations for these cost estimates.

[90] The key study serving as the basis of our estimate is the *Expanded expert judgment assessment of the concentration-response relationship between $PM_{2.5}$ exposure and mortality*, prepared for OAQPS-EPA by Industrial Economics Inc, September 21, 2006. A summary of this study is provided in Roman, HA et al., *Environ. Sci. Tech.* 2008, *42*, 2268-2274.

Figure A-2 summarizes the figures for health burden associated with exposure to ozone, $PM_{2.5}$, and air toxics, and also the social cost of GHG emissions. The cost estimates in Figure A-2 are based upon individual case values shown in Table A-1. Note that the data in Figure A-2 is based upon a wider range of health effects than the subset of health effects portrayed in Figure A-1 above. In each case, estimates for the earliest reliable period are compared with the present. The data in Figure A-2 indicates that, in aggregate, annual health and social costs have declined by roughly 50%, from approximately $50 billion to approximately $24 billion per year. It should be emphasized that the numbers in Figure A-2 are estimates only; they should not be seen as precise values. Nonetheless, we can conclude with a high degree of confidence that the benefits of air pollution reductions run in the billions of dollars annually.

Table A-2. Estimated dollar value per case for key health effects related to Bay Area air pollution.

Health Effect	Unit Value (Cost per Incident, 2009 dollars)
Mortality (all ages)	$6,900,000
Chronic Bronchitis Onset	$409,189
Respiratory Hospital Admissions	Age 65 < : $35,228 Age 65 > : $33,375
Cardiovascular Hospital Admissions	Age 65 < : $43,889 Age 65 > : $38,759
Non-Fatal Heart Attacks	$84,076
Asthma Emergency Room Visits	$468
Acute Bronchitis Episodes	$534, for a 6 day illness period
Upper Respiratory Symptom Days	$35
Lower Respiratory Symptom Days	$22
Work Loss Days	Daily Median Wage by County ($168 to $243)
School Absence Days	$91
Minor Restricted Activity Days	$61
Cancer	$1,750,000
Greenhouse Gases	$28 per metric ton ($CO_2$ equivalent)

In contrast to ozone, PM, and air toxics, emissions of GHGs have risen steadily since 1980. The estimated costs presented in Figure A-2 are a few billion dollars a year, but this represents a median estimate, not an upper bound. The potential effects from global warming could be catastrophic.

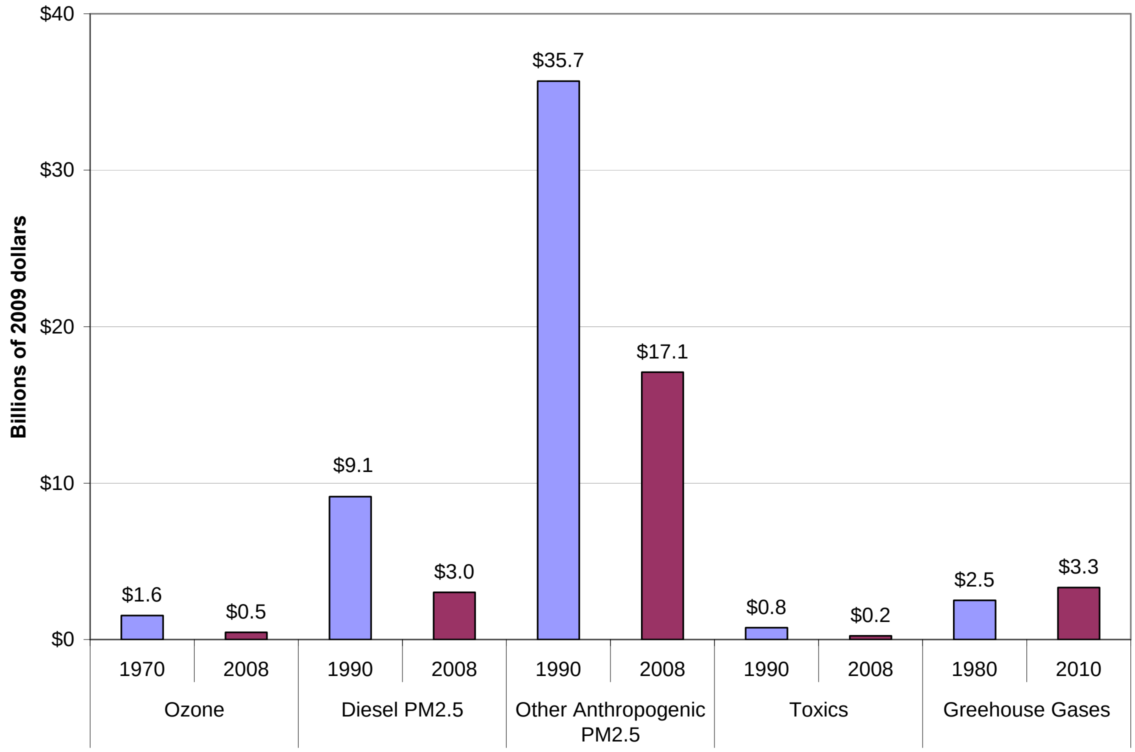

Figure A-2. Estimated current annual health and other social costs of Bay Area air pollution: prior years compared to 2008.

Summary of Key Findings

The analysis described in this appendix indicates that, due to improved air quality in the Bay Area, annual health effects, and the related social and economic cost of these health effects, have declined by at least 50% over the past several decades. The estimated number of premature deaths related to air pollution in the Bay Area decreased from approximately 6,400 per year in 1990 to about 2,800 per year in 2008. The reduction in premature mortality related to air pollution over the past two decades has contributed to an increase in average life expectancy. We estimate that improved air quality has extended average life expectancy on the order of six months per Bay Area resident. However, despite this substantial progress, Bay Area residents continue to experience significant health effects from exposure to air pollution. These health effects impose on-going costs to the individuals who experience these impacts and to the region as a whole.

Additional detail describing the methodology used in this analysis is provided in the Addendum below.

Addendum to Appendix A

Air Toxics

Table A-3 shows the estimated annual means for the carcinogenic toxics that the Air District or CARB measures. These are annual, District-wide means. The earliest available means are presented along with the means for 2008 (or the most recent available year).

The table also shows the cancer risk factors and the lifetime risks from each of the toxics. To facilitate comparison, the arithmetic mean for each toxic was linearly interpolated or extrapolated to 1990. We assume exposure is spatially constant, that is, that all Bay Area residents are exposed to the mean concentration of each toxic. The lifetime risk from these 1990 concentrations is shown in the table compared with the risk for 2008. The reductions in risk are shown in the last column. With the exception of carbon tetrachloride,[91] the reductions are statistically significant. The overall reduction in risk has been 69%, i.e., two-thirds.

Table A-3. Estimated annual mean values of carcinogenic toxics & lifetime risk factors.

	1st year	Most recent year	Estimated Annual Bay Area Mean (µg/m^3)		Lifetime Risk per million per ug/m3	Lifetime Risk per million Bay Area Residents		
Compound			Earliest	2008		1990	2008	Reduction
Diesel	1987	2008	3.50	1.06	300.0	933.2	318.0	66%
Benzene	1987	2008	1.80	0.23	29.0	146.1	20.9	86%
1,3-butadiene	1989	2008	0.37	0.04	170.0	131.5	14.0	89%
Formaldehyde	1996	2008	2.11	1.37	6.0	18.2	10.1	44%
Acetaldehyde	1996	2008	0.84	0.69	2.7	4.5	3.4	25%
Carbon tetrachloride	1987	2006	0.10	0.10	42.0	27.0	26.2	3%
Methylene dichloride	1987	2006	0.83	0.31	1.0	2.6	1.1	59%
Perchloroethylene	1987	2008	0.39	0.02	5.9	13.1	0.7	95%
PAHs (risk-weighted)	1995	2004	0.15	0.09	1320.0	0.2	0.1	57%
Hexavalent chromium	1991	2006	0.28	0.07	150000.0	43.3	10.9	75%
Lifetime cancer risk	1990	2006				1318.7	405.3	69%

Figure A-3 compares lifetime cancer risk from air toxics in the Bay Area for 1990 versus 2008 on a cases per million population basis. The estimated number of lifetime cases has declined from approximately 1,300 per million people to approximately 400 per million, a decrease of roughly 70% over this relatively short time period.

[91] The use of carbon tetrachloride was banned in the United States in 1996. It has a long atmospheric residence time. Thus, the concentrations experienced in the Bay Area derive from a persistent global background.

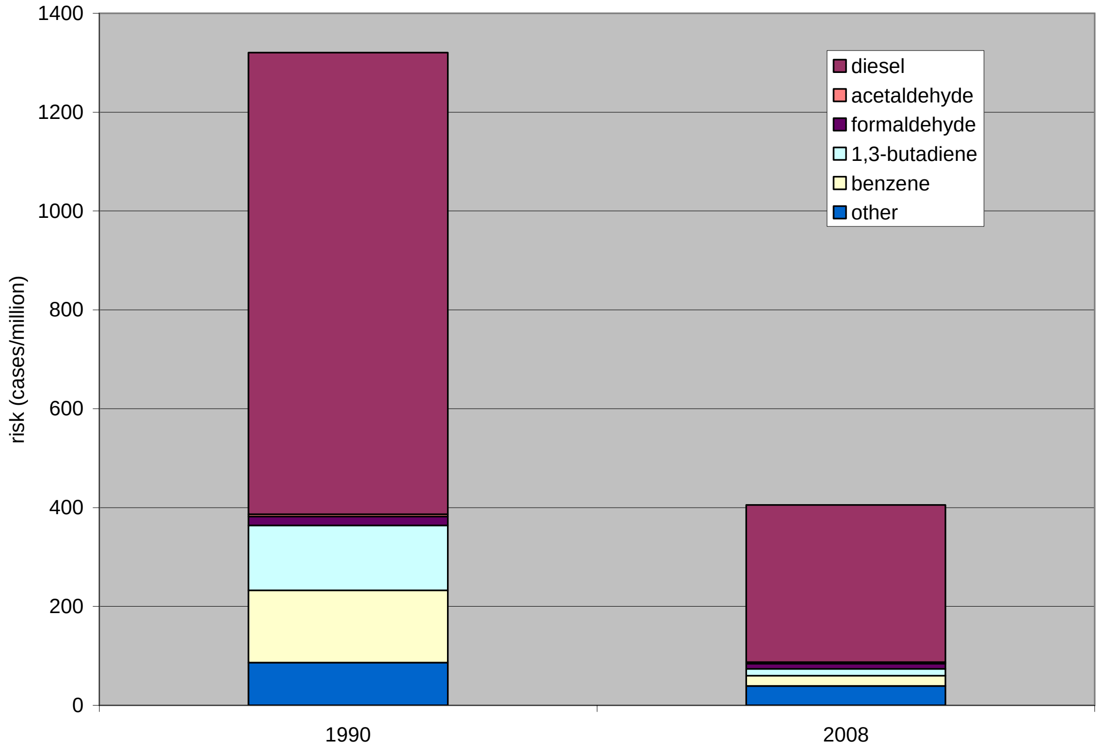

Figure A-3. Lifetime cancer risk per million people from air toxics in the Bay Area: 1990 versus 2008.

Ozone

For this analysis, 50 ppb was used as the ozone health effects threshold; that is, we assume that health effects may occur above 50 ppb.[92] Daily maximum 1-hour ozone values were interpolated to each census tract and any excess above 50 ppb was multiplied times the (year 2000) population for the tract. This was done for every year from 1968 to 2008. Five-year annual averages of these values were computed for 1968-1972 and 2004-2008, and the results summed for each county. The MPEM health effects were then calculated using present population data.

Figure A-4 shows the results. Overall, there has been a significant reduction in the health burden related to ozone. This includes an estimated reduction of 134 deaths per year, from 193 in the 1968-72 period to 59 in the 2004-08 period. There is still a substantial impact from ozone today, but exposure to high concentrations has been reduced by more than two-thirds since 1970. Compared to an annual cost of less than

[92] The decision to use an ozone health effects threshold of 50 ppb is based on several health studies. In their ozone health benefit analysis, Ostro et al. (2006) stated "…no clear threshold for effects has been reported…" They used their estimate of 40 ppb for ozone background as their threshold. In this analysis for the 2010 CAP, we use a somewhat higher concentration at the upper end of background ozone levels.

$500 million for the 2004-2008 period, the impact of ozone in the 1968-72 period would have been almost $1.6 billion for today's population in 2009 dollars.

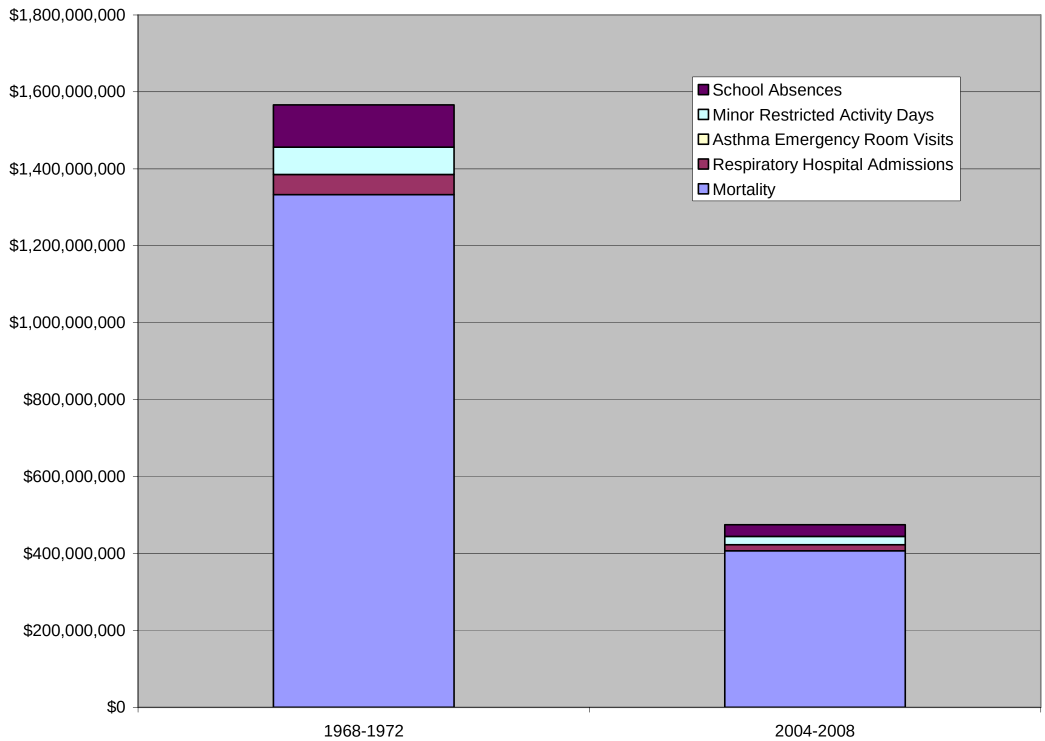

Figure A-4. Estimated health burden from exposure of Bay Area residents to ozone: 1968-72 v. 2004-08.

$PM_{2.5}$

This section explains how we analyzed the trend in anthropogenic $PM_{2.5}$. Estimating $PM_{2.5}$ trends is more complex than analyzing ozone and toxics trends for several reasons. Total $PM_{2.5}$ has been measured routinely only since 1999, so analyzing $PM_{2.5}$ trends prior to 1999 required using other measurements. Analysis of $PM_{2.5}$ is also complicated by the fact that it consists of many components, some man-made, some natural. Thus, we need to analyze the various components, as explained below. And finally, diesel PM, one of the key components of $PM_{2.5}$, cannot be measured directly; as explained in the Diesel $PM_{2.5}$ section below, it must therefore be estimated using elemental carbon as a proxy.

In what follows, we attempt to estimate $PM_{2.5}$ trends since the late 1980s by analyzing the trends in the major components of $PM_{2.5}$ – nitrate, sulfate and carbonaceous $PM_{2.5}$. Nitrate and sulfate have been measured since the early 1990s. Coefficient of Haze (COH), a key measurement which is well-correlated with total carbon, was measured for decades; however, COH measurements ended in 2002. We also have PM10 measurements starting in 1987. $PM_{2.5}$ trends are equivalent to the average of trends in its components.

Table A-4 summarizes the trend information available for these different PM components. Because the PM2.5 measurements have only been available since 1999, whereas the COH measurements were unavailable after 2002, the table shows Bay Area mean concentrations for three periods: (A), the earliest available 5-year periods for PM_{10}, sulfate and nitrate, and parallel years for COH; (B), the earliest 3-year period for $PM_{2.5}$; and (C), the most recent data available. Averages were either 3- or 5-year, a longer period chosen to compensate for fewer data points.

Table A-4. Annual Bay Area mean concentrations (µg/m3 except coefficient of haze units for COH) for various PM measurements in 3 periods.

	Period			Annual Reduction %	
	A	B	C	A to B	B to C
	1988-92	2000-02			
COH	3.81	1.46		8.4%	
		2000-02	2004-08		
total carbon		6.39	5.24		3.9%
	1990-94	2000-02	2003-07		
PM10 nitrate	2.91	1.75	1.41	5.5%	5.2%
	1991-95	2000-02	2003-07		
PM10 sulfate	1.96	1.86	1.60	0.7%	3.7%
	1988-92	2000-02	2003-07		
PM10	31.41	22.57	19.21	3.0%	4.0%
		2000-02	2006-08		
PM2.5		11.94	9.47		3.8%

The last two columns show annual reductions.[93] Consider the reductions from period B to period C first, because $PM_{2.5}$ measurements are available as a benchmark. During this time, there was a reduction in $PM_{2.5}$ of 3.8% per year. This is a lower bound for the annual reduction in anthropogenic $PM_{2.5}$, however, because a fraction of the $PM_{2.5}$ is natural background. Thus, for example, if the background $PM_{2.5}$ were 3 µg/m^3 then the reduction in anthropogenic $PM_{2.5}$ would have been from 11.94 – 3 to 9.47 – 3 or 5.2%.

The major components of $PM_{2.5}$ – nitrate, sulfate and carbonaceous $PM_{2.5}$ – were all reduced by similar amounts from B to C, as was PM_{10}. Note that both sulfate and carbon have natural background: the former from marine air, the latter from forest fires

[93] Computed as follows: If x1 is the concentration in period A and x2 is the concentration in period B and there are y years between them, then the annual reduction was calculated by 1-(x2/x1)^(1/y). For example, PM2.5 went from x1 = 11.94 to x2 = 9.47 in 6 years (2001 to 2007), so the annual reduction is 1-(9.47/11.94)^(1/6) = .0379, or about 3.8%.

and secondary biogenic carbonaceous $PM_{2.5}$. Nitrate, with little natural background was reduced by a larger amount. Thus, the anthropogenic part of these components was reduced by more than 3.8%, consistent with the result for $PM_{2.5}$ as a whole.

The annual nitrate reductions from period A to period B were also around 5% per year, but there was little reduction in sulfate. The 3% annual reduction in PM_{10} was somewhat less than the 4% annual reduction since 2000. But the annual reduction in COH was large, 8.4% annually. Considered as a surrogate for carbonaceous $PM_{2.5}$, it suggests there were major reductions in this component.

Combining this information suggests that the assumption that anthropogenic $PM_{2.5}$ was reduced by 4% per year from 1990 through 2000 is, if anything, somewhat conservative.

To estimate natural background, we have measurements from two coastal national parks – Point Reyes and Redwood, in northern California. Mean annual $PM_{2.5}$ measurements were 5.5 $\mu g/m^3$ for Point Reyes and 3 $\mu g/m^3$ for Redwood National Park from data for 2005-06. At least 1 $\mu g/m^3$ of the difference is a greater Point Reyes ship component.

Taking the lower figure, 3 $\mu g/m^3$, as an estimate of natural background $PM_{2.5}$ and assuming that the reduction in anthropogenic $PM_{2.5}$ was 4% per year, this suggests the 1990 Bay Area mean $PM_{2.5}$ concentration from anthropogenic sources was about 14 $\mu g/m^3$.

Currently, the Bay Area mean $PM_{2.5}$ concentration is about 9.5 $\mu g/m^3$, so the anthropogenic component is about 6.5 $\mu g/m^3$ or somewhat less than half of what it was in 1990. Figure A-5 shows the estimated impact in dollars of $PM_{2.5}$ for 1990 and 2008. The figure is dominated by the costs of mortality; premature mortality is valued at $6.9 million per case, as explained in Chapter 5 of the MPEM Technical Document. Annual estimated deaths in 1990 were 6,200, dropping to about 2,800 annually in 2008.

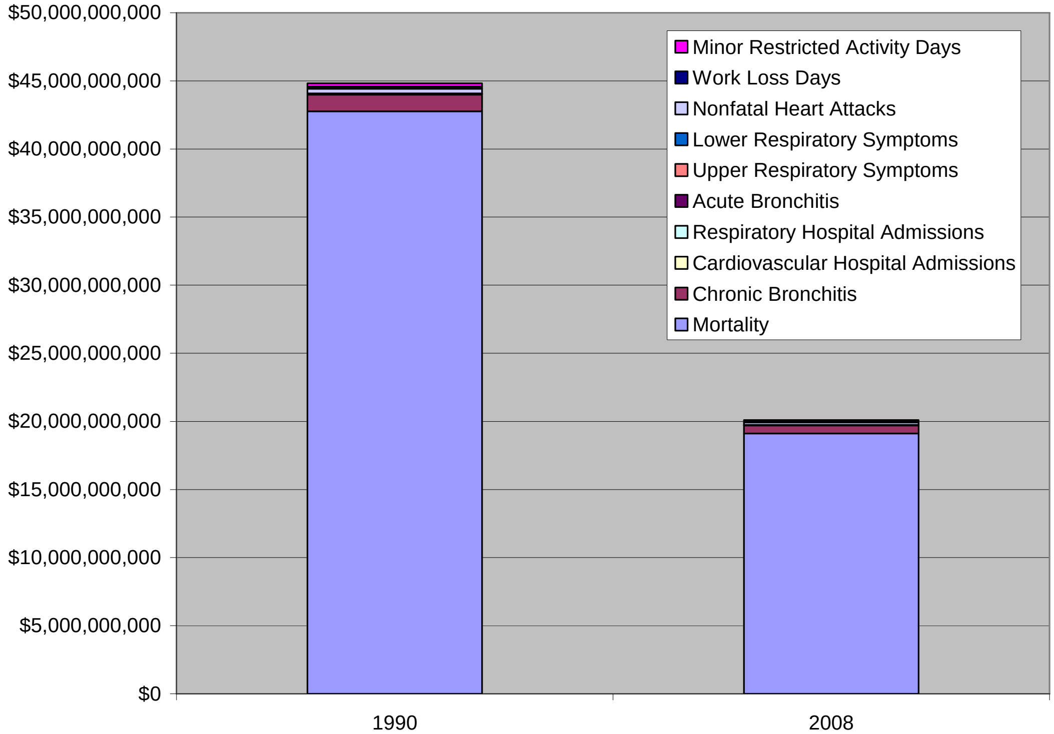

Figure A-5. Estimated annual health burden from PM2.5 exposure of Bay Area residents, 1990 vs. 2008.

Diesel $PM_{2.5}$

Diesel $PM_{2.5}$ cannot be measured directly. Soot, or elemental carbon (EC), is the main constituent, and this has been measured. Roughly 70% of diesel PM is EC and roughly 70% of EC derives from diesel. Thus, to a first approximation, EC concentrations are an estimate of diesel concentrations.

The District has made extensive EC measurements since mid-2004. Figure A-6 shows annual means for site-years with sufficient data in each quarter. Overall, EC concentrations average about 1 $\mu g/m^3$ in populated areas. Point Reyes measurements, from a network of National Park sites, are close to zero, indicating that marine background EC concentrations are very low.

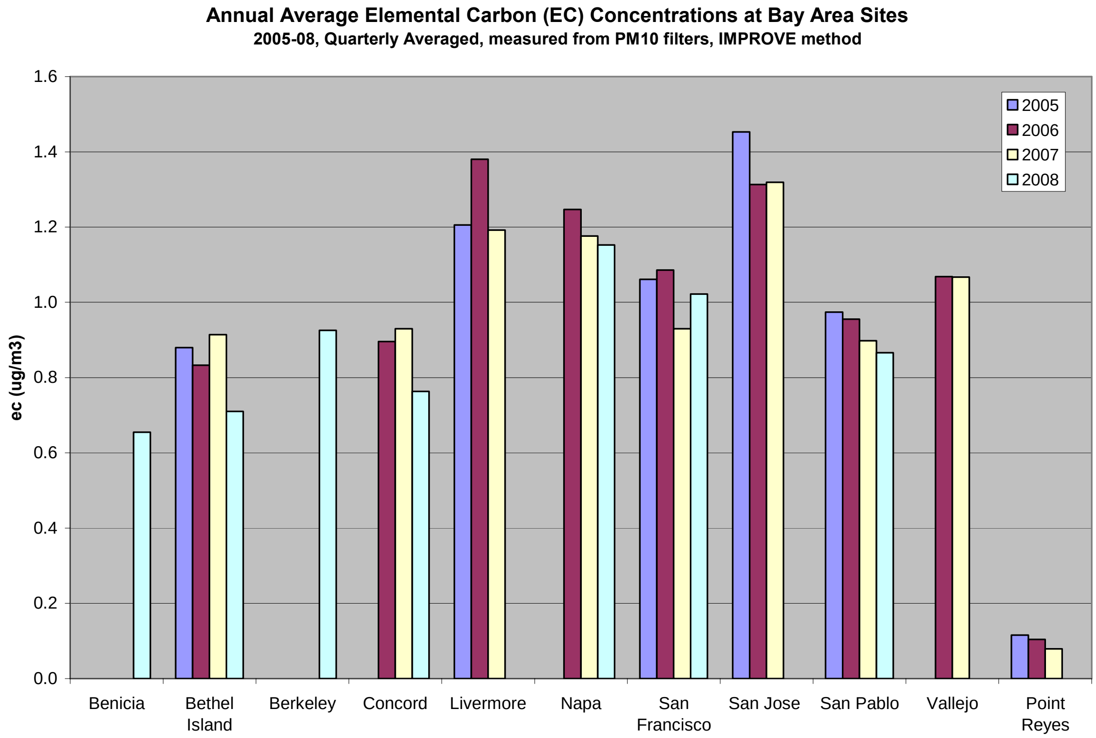

Figure A-6. Annual mean elemental carbon concentrations at Bay Area sites, 2005-08.

There is also data from the toxics modeling conducted for the CARE program, which included diesel. An analysis of concentrations for 2005 yielded a population-weighted diesel concentration of 1.3 $\mu g/m^3$.

To combine these to produce a single estimate, we note that the modeled estimate has the advantage of representing the Bay Area population, but is based on December and July, not the full year. Also, uncertainties in emissions and the modeling process itself cause significant uncertainties in the concentration estimates.

To provide an estimate of earlier diesel concentrations we rely on long-term measurements made with COH instruments. COH measurements are well-correlated with EC as noted earlier. An analysis comparing the measurements at several sites yielded a composite formula: EC = 0.75*COH.

District COH measurements have been collected for many years, with an extensive set commencing in 1967-68. These measurements continued through 2003, when COH monitoring was terminated for most District sites. There were 7 sites with measurements for most of the period and these were used to establish trends.

Figure A-7 shows annual COH means for these sites for years when sufficient data were available. Also shown with a thicker line is a 3-year moving average of these sites. The figure shows an increase in COH from the mid-1970s through 1990 then, starting in

1990, a steady downward trend. The reduction from 1990 to 2003 was large – a factor of 3 - with average COH reduced from 4.0 to 1.3. Applying the formula, this suggests a reduction in EC from 0.75*4 = 3 μg/m^3 to 0.75*1.3 = 1 μg/m^3. Thus, we conclude that average diesel concentrations were reduced from 3 μg/m^3 to 1 μ g/m^3 between 1990 and 2000.

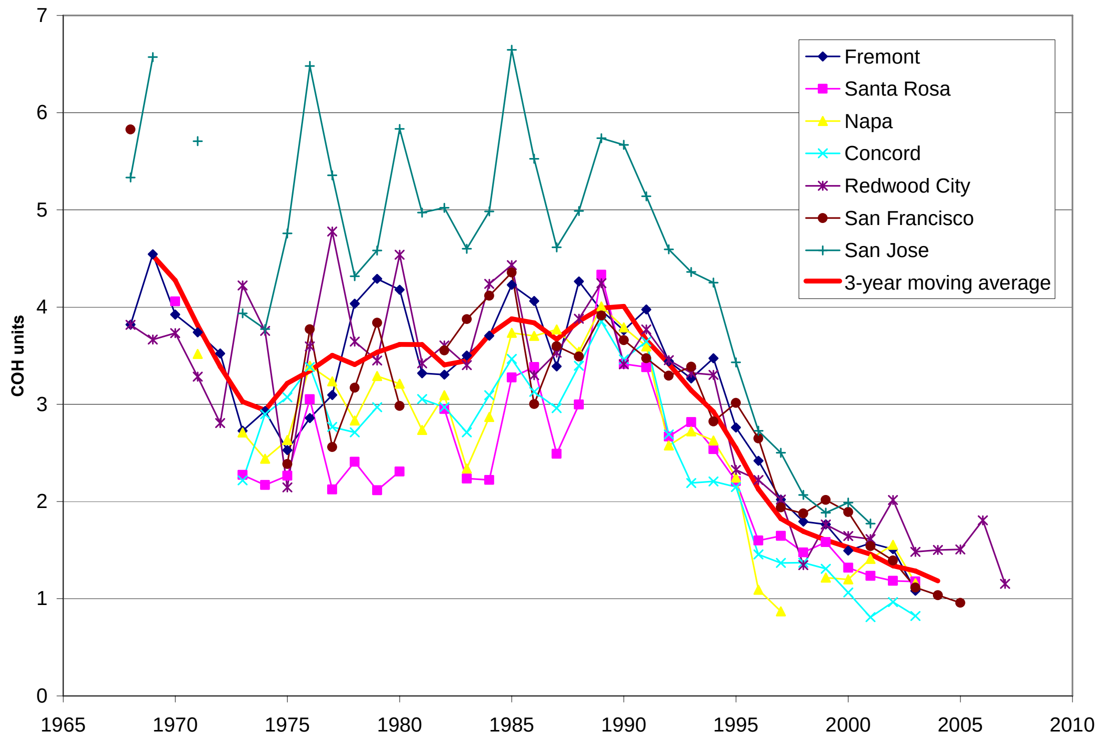

Figure A-7. Annual mean COH measurements for site-years with sufficient data in each quarter. A 3-year moving average is computed from all the measurements within a window of year y-1 to year y+1.

These estimates contain uncertainties. COH is not perfectly correlated with EC which, in turn, is not equal to diesel exhaust. Nevertheless, we believe that the estimates are a reasonable first approximation. For the burden analysis we assume that the current average diesel contribution is 1 μg/m^3 out of the anthropogenic total of 6.5 μg/m^3, and its 1990 contribution was 3 μg/m^3 out of an anthropogenic total of 14 μg/m^3.

Life Expectancy

Figure A-1 above shows that without the air quality improvements that have occurred over the last few decades, there would have been 6,400 deaths per year due to air pollution versus the current 2,800. But this difference would not necessarily be reflected in the raw death rate, because the lower probability of death from air pollution would cause people to live longer, resulting in an older population. Life expectancy can more accurately express the difference in raw death rates. This section compares Bay Area life expectancy today with that of 1990, and what part the reduction in air pollution may have played.

Computing life expectancies requires population and death data by age. We used individual California mortality data from 1989 through 2007. From this the number of deaths by age of Bay Area residents for 1989-91 and 2005-07 was compiled. Age-specific population data was available from the California Department of Finance. Combining these, and using the National Center for Health Statistics approach,[94] we estimated the probability of death at each age for 1990 and 2006.

Figure A-8 shows the results on a log scale. The probability of death has been reduced from 1990 to 2006 at every age. The population-weighted reduction is 40%, so that the probability of dying at a given age today is about 60% of what it was in 1990.

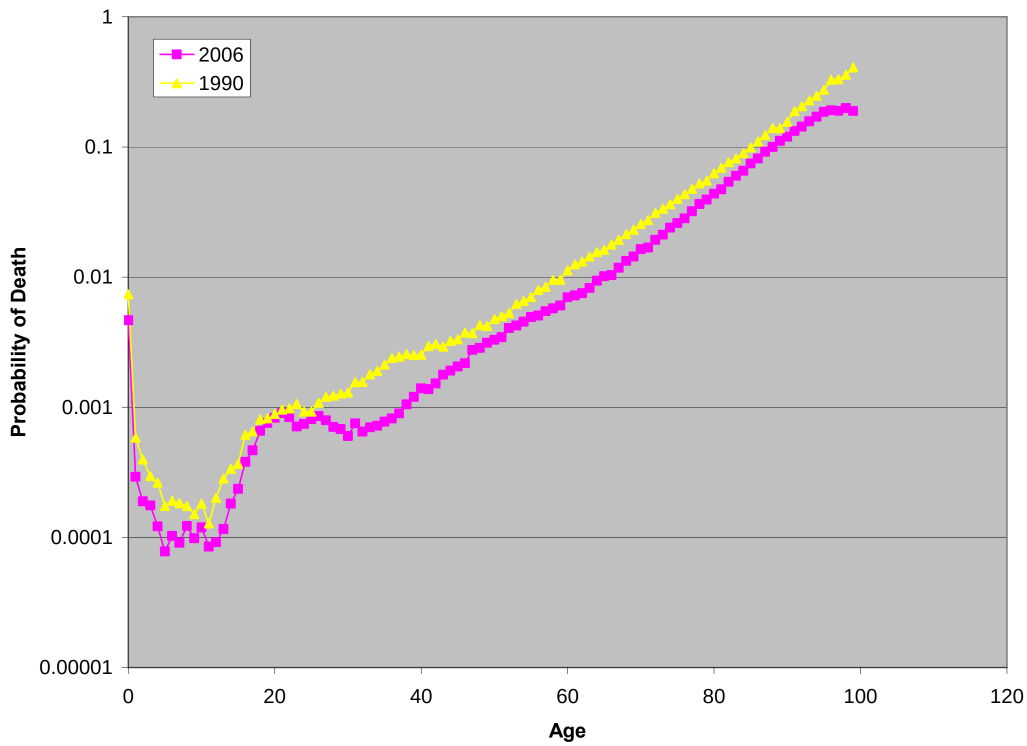

Figure A-8. Probability of death among Bay Area residents, 1990 and 2006. 3-year average deaths vs. population by age.

[94] Arias E. United States life tables, 2000. National vital statistics reports; vol 51 no 3. Hyattsville, Maryland: National Center for Health Statistics. 2002.

These probabilities can be translated into life expectancy. For example, starting with a population group of 100,000, the probabilities of death at each age are applied and the survivors live to the next age and so on. Totaling the number of life-years and dividing by 100,000 yields the life expectancy, the average number of life-years lived.

For 1990, Bay Area life expectancy was 75.7 years. By 2006 it had increased to 80.5 years. How much of this improvement was due to reductions in $PM_{2.5}$? Using CARB's $PM_{2.5}$ factor of 1% reduction in mortality for each 1 μg/m^3 reduction in $PM_{2.5}$ (CARB 2008), the increment in the probability of death from anthropogenic $PM_{2.5}$ dropped from 15% in 1990 to 6.7% in 2006, a reduction of 8.3%.

This factor is specifically for those 30 and older, and for non-accidental mortality. So the number of deaths by age for this group for 2005-2007 was computed. Multiplying the death rate for this group by 1.083 results in a drop in life expectancy to 80.0, or 6 months. Thus, Bay Area residents can expect to live 6 months longer because of the reductions in $PM_{2.5}$ since 1990.

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Appendix B – Public Outreach for the Bay Area 2010 CAP

Air District staff reached out to inform and engage the general public, as well as key stakeholders, about the 2010 Clean Air Plan (CAP) throughout the plan development process. At the outset of the process, staff designed a public outreach strategy to foster sustained engagement and dialogue with a wide range of stakeholders in developing the Plan. Staff identified the following goals to guide CAP public outreach and engagement:

- *Inform* a wide range of stakeholders and members of the public about the scope and schedule of the plan and opportunities for comment.
- *Provide opportunities* for members of the public and stakeholders to offer input on the plan and outreach process.
- *Educate* the public about air quality and why the Air District and the CAP are relevant, by emphasizing the connection between air quality and health outcomes, and explaining the potential benefits of multi-pollutant planning focused on reducing health risk.
- *Engage impacted communities and multilingual communities* in developing the Plan.
- *Promote transparency* throughout the CAP preparation process.
- *Foster buy-in, ownership, and acceptance* of the Plan.

Public outreach for the CAP took place in three phases: introduction to the CAP and the planning process, development of the control strategy, and presentation of the draft and final plan. Primary outreach mechanisms utilized include the CAP website; notices sent to the CAP e-mail list serve; and CAP public workshops and community meetings and the associated materials and comment summaries that staff prepared. Additionally, in the interests of implementing the goals above, staff developed materials and outreach mechanisms to support education and outreach to Air District constituents for whom English is not the primary language, with a focus on Chinese, Vietnamese, and Spanish speakers. Additional outreach took place for the environmental review process and consultation with other air districts. A description of the full range of outreach mechanisms employed over the course of the CAP planning process is provided below.

CAP Web Pages - The CAP pages on the Air District's website features a description of the plan goals and purpose, regulatory framework, meeting schedule, meeting notices and materials, and key technical documents. Technical documents include multi-pollutant planning methodology and key analyses in regard to pollutant emissions and concentrations, exposure, health outcomes, costs, and pollutant weighting factors underlying the plan control strategy. The website has been used primarily to alert the public to meetings and workshops and to post meeting materials and CAP documents for public review prior to each workshop. The main CAP web page is at: www.baaqmd.gov/Divisions/Planning-and-Research/Plans/Clean-Air-Plans.aspx.

E-mail and paper mail database - The database was compiled from an existing outreach database, updated to reflect the most current information for contacts, augmented with additional health, NGO, and regulatory agency contacts, and converted to the extent possible from snail mail addresses to e-mail in keeping with the Air District's interest in reducing waste. It consists of approximately 1075 e-mail contacts with an additional 179 snail mail contacts, representing regional and state regulatory agencies, staff from other air districts, transportation agencies (including CMAs), environmental and health advocates and professionals, community members, representatives from regulated industries, local governments, and others. The list is refreshed and added to by meeting attendance lists and requests received via e-mail and the CAP website. The database was used to notify the public of meetings dates and locations, and to alert the public to meeting materials and planning and CEQA documents posted on the CAP website.

Outreach to Multilingual Communities – Air District staff developed a CAP informational FAQ sheet to educate and inform members of the public about how the CAP relates to air quality and health. The FAQ was translated into Spanish, Chinese, and Vietnamese languages, posted on the CAP website, and distributed at public meetings and workshops. Staff developed and maintained a phone response system in order to respond to any questions from Chinese, Spanish, and Vietnamese language speakers about the CAP. Directions for accessing this system in each of these languages were included on all CAP e-mails and workshop/meeting notices.

Public Workshops and Community Meetings - The Air District held public workshops and meetings at locations throughout the Bay Area during the CAP planning process to facilitate dialogue and collect input on the proposed control strategy and Plan. All meetings were held at accessible locations and in close proximity to transit, whenever possible. Notice of each meeting was provided at least three weeks in advance on the District website and by e-mail and snail mail to the CAP contact database. Public comments received during meetings were recorded, compiled in summaries of public comments and District responses, and posted on the CAP website for public review. As of February 2010, 14 public workshops and community meetings have been held by Air District staff at key intervals throughout the CAP planning process. A table summarizing CAP public workshops and meetings is provided in Table B-1.

Additional public workshops will be held after the release of the draft CAP.

Table B-1. Public workshops on Bay Area 2010 Clean Air Plan.

	Description and Purpose	Date and Location	Attendance
Introduction to the CAP planning process	Kick-off workshop	July 15, 2008 - Oakland	35
	Fall 2008 community meetings	October 6, 2008 - West Oakland *	16
		October 8, 2008 - San Jose *	6
		October 21, 2008 - Petaluma	8
		October 23, 2008 - Pleasanton	7
		October 27, 2008 - San Leandro *	14
		November 15, 2008 - San Francisco * Bayview Opera House	42
Control Strategy Development	Public Workshop: • All Feasible Measures Review / Call for control measure ideas	January 28, 2009 - Oakland	50
	Public Workshops: • Preliminary Control Measures • Draft control measure review • 2005 Ozone Strategy Implementation Update	April 27 2009 - Redwood City	22
		April 29, 2009 - Oakland	23
		April 30, 2009 - Petaluma	11
	Public Workshop: • Multi-pollutant Methodology	June 11, 2009 - Oakland	37
	Public Workshops: • Draft Control Strategy	September 2, 2009 - Mountain View	12
		September 3, 2009 - Oakland	38
	Draft Clean Air Plan	April 6, 2010 - Petaluma	
		April 7, 2010 – Santa Clara	
		April 8, 2010, - Oakland	
	CEQA Scoping Meetings	September 2, 2009 - Mountain View l	12
		September 3, 2009 Oakland	38

*These meetings were held in Community Air Risk Evaluation (CARE) impacted communities to address the District's CARE program and the CAP, with the aim of soliciting input on the CAP planning process from communities most directly impacted by air pollution.

In addition to formal workshops and community meetings, staff made presentations about the CAP to interested stakeholders in other venues as opportunities arose. These presentations were made, often upon request, in order to build partnerships, increase understanding of the scope of objectives of the CAP, and solicit feedback on innovative aspects of the CAP.

Staff pursued opportunities to make presentations about the CAP in other venues, including:

- Richmond resource team meeting, September 25, 2008.
- CAPCOA Engineering Managers symposium, June 16, 2009
- US EPA conference call, July 23, 2009
- California Council for Environmental and Economic Balance:
  - July 13, 2009 and October 6, 2009
- Contra Costa Council: September 4, 2009
- CAPCOA Planning Managers symposium, September 30, 2009
- Urban Heat Island Mitigation Conference, September 21, 2009

Consultation with Neighboring Air Districts: Air District staff held two conference calls to solicit input on the CAP control strategy on September 1, 2009 and September 15, 2009, as described in transport mitigation section in Appendix C.

Collaboration with Regional Agencies: The CAP was developed in collaboration and consultation with MTC, ABAG, and BCDC, the Air District's regional agency partners. MTC staff and ABAG staff provided important input to the Transportation Control Measures, and MTC staff played a key role in developing emission reduction and cost estimates for the TCMs. In addition, the CAP was informed by regional agency plans, including *Transportation 2035: Change in Motion* and *Projections and Priorities 2009*.

Air District Staff made presentations about the CAP at the following regional agency meetings:

Joint Policy Committee:
November 7, 2008
September 18, 2009
March 19, 2010

MTC Planning Committee:
May 8, 2009
July 10, 2009
March 12, 2010

The Draft CAP will be presented to the MTC Planning Committee on March 12, 2010 and to the Joint Policy Committee on March 19. 2010.

Reports to Air District Board of Directors and Board Committees: District staff provided several briefings to the Board of Directors and Board Committees in the course of developing the draft CAP.

BAAQMD Executive Committee:
September 26, 2008
June 29, 2009

BAAQMD Climate Protection Committee:
October 8, 2009

BAAQMD Board of Directors:
September 16, 2009
August 4, 2010
September 1, 2010

CEQA Review: Pursuant to the California Environmental Quality Act (CEQA), the Air District prepared and issued a Notice of Preparation (NOP) and Initial Study (IS) and held two public scoping meetings on September 2 in Mountain View at the Mountain View City Hall and on September 3 at the Metro Center Auditorium in Oakland. The purpose of these meetings was to identify the range of actions, alternatives, mitigation measures, and significant effects to be analyzed in depth during the environmental review. The public comment period for the NOP ended on September 21, 2009.

Appendix C – State Air Quality Planning Requirements

For the past 20 years, the 1988 California Clean Air Act (CCAA), along with subsequent amendments, as codified in the California Health & Safety Code, has guided efforts throughout California to achieve State ambient air quality standards. The basic goal of the CCAA is to achieve health-based State ambient air quality standards by the earliest practicable date. The CCAA requires regions that violate the State ozone standard to prepare attainment plans that identify a strategy to attain the standard. Regional air quality plans are required to achieve a reduction in district-wide emissions of 5 percent per year for ozone precursors (California Health & Safety Code Section 40914).[95] If an air district is unable to achieve a 5 percent annual reduction, adopting a control strategy that includes all feasible measures on an expeditious schedule is acceptable, as an alternate strategy (Sec. 40914(b)(2)).

California classifies ozone nonattainment areas based on their "expected peak day concentration," which is an ozone reading that the region should not exceed more than once per year, on average, excluding exceptional or extreme readings. Legal requirements vary according to the severity of a region's ozone problem. The Bay Area is subject to CCAA requirements for "serious" areas. (Secs. 40921.5(a)(2), 40919).

This Appendix describes CCAA air quality planning requirements and how the Bay Area 2010 Clean Air Plan (CAP) fulfills all requirements.

All Feasible Measures

No non-attainment area in the state has been able to demonstrate a 5% reduction in ozone precursor pollutants each year. Consequently, air districts throughout the state, including the Bay Area, have opted to adopt “all feasible measures” as expeditiously as possible to meet the requirements of the CCAA. The CCAA does not define “feasible,” but the Health and Safety Code provides some direction to assist the District in making this determination. Sec. 40406 defines a related term, Best Available Retrofit Control Technology (BARCT), as “an emission limitation that is based on the maximum degree of reduction achievable, taking into account environmental, energy and economic impacts by each class or category of source.” CARB defines “all feasible measures” in the Transport Mitigation Regulation, Section 70600 *et seq,* Title 17 California Code of Regulations, as “air pollution control measures, including but not limited to emissions standards and limitations, applicable to all air pollution source categories under a district's authority that are based on the maximum degree of reductions achievable for emissions of ozone precursors, taking into account technological, social, environmental,

[95] All references to Section numbers are for the California Health and Safety Code, unless otherwise noted.

energy and economic factors, including cost-effectiveness." Section 40922(a) requires an assessment of the cost effective of each proposed control measure, including a ranking of measures from the least cost-effective to the most cost-effective. Section 40922(b) lists additional criteria that air districts should consider in reviewing potential control measures, including technological feasibility, total emission reduction potential, the rate of reductions, public acceptability, and enforceability.

The process by which the Air District reviewed and evaluated potential control measures in relation to these criteria is described in Appendix F. An overview of the 2010 CAP control strategy is provided in Volume I, Chapter 4; detailed descriptions of control measures are provided in CAP Volume II.

Transport Mitigation Requirements

The CCAA requires CARB to periodically assess transport of ozone and ozone precursors from upwind to downwind regions, and to establish mitigation requirements for upwind districts (Sec. 39610). The CCAA also requires air districts to address transport mitigation requirements in the triennial updates to strategies to achieve the State ozone standard (Sec. 40912).

CARB first adopted transport mitigation requirements in 1990, amended them in 1993, and further strengthened them in 2003. CARB's 2003 amended Transport Mitigation Requirements are in Title 17, California Code of Regulations, Sections 70600 and 70601. The requirements for transport mitigation state that upwind districts "shall include sufficient emission control measures in their attainment plans for ozone…to mitigate the impact of pollution sources within their jurisdictions on ozone concentrations in downwind areas commensurate with the level of contribution." Specifically, the Bay Area is required to:

1) adopt and implement all feasible measures as expeditiously as practicable;

2) adopt and implement best available retrofit control technology (BARCT) on all existing stationary sources of ozone precursor emissions as expeditiously as practicable;

3) implement, by December 31, 2004, a stationary source permitting program designed to achieve no net increase in the emissions of ozone precursors from new or modified stationary sources that emit or have the potential to emit 10 tons or greater per year of an ozone precursor; and

4) include measures sufficient to attain the state ambient air quality standard for ozone by the earliest practicable date within the North Central Coast Air Basin, that portion of Solano County within the Broader Sacramento Area, that portion of Sonoma County within the North Coast Air Basin, and that portion of

Stanislaus County west of Highway 33 during air pollution episodes, provided that:

a) the areas are likely to violate the State ozone standard,
b) the areas are dominated by transport from the Bay Area, and,
c) the areas are not affected by emissions of ozone precursors within their borders.

The 2010 CAP addresses all of the above requirements. The 2010 CAP control strategy, together with the Air District rule development and permitting processes, address the requirement to adopt all feasible measures, including measures sufficient to attain the State ozone standard in specified transport areas, and to implement BARCT on all existing stationary sources. With respect to the "no net increase" requirement, the Air District adopted a 10 ton/year no net increase requirement for ozone precursors in District Regulation 2, Rule 2: New Source Review on December 21, 2004. As adoption of all feasible measures represents the most stringent control strategy that can be accomplished, this requirement is met with the approval of each triennial plan.

In addition, the Air District is required to consult with downwind districts, review the list of control measures in the most recently approved attainment plan (in this case, Bay Area 2005 Ozone Strategy), make a finding as to whether the list of control measures meets the requirements of Section 70600 (b) and include the finding in the proposed triennial plan revision.

To fulfill this consultation requirement, the Air District consulted with downwind air districts to ensure that the CAP control strategy includes all feasible measures. The Air District hosted conference calls with downwind air districts on September 1 and September 15, 2009 to solicit comments and suggestions on the preliminary CAP control strategy. Air District staff also made presentations on the CAP to the CAPCOA (California Air Pollution Control Officers Association) Engineering Managers on June 16, 2009 and to the CAPCOA Planning Managers on September 20, 2009.

Other Requirements

In addition to requirements concerning all feasible measures and transport mitigation, the CCAA requires that strategies to attain the State ozone standard contain other elements, including the following:

<u>Emissions inventory system</u> (Sec. 40918(a)(5)). The Air District maintains an emissions inventory system. The emission inventory is included in the "Sources of Air Pollution – Emission Inventory" section of this document.

A permitting program [Sec. 40919(a)(2)] designed to achieve no net increase in emissions from permitted sources with a potential to emit greater than 15 tons per year of a nonattainment pollutant or their precursors and to require the use of best available control technology (BACT) on new and modified sources with a potential to emit greater than 10 pounds per day. The Air District's permitting program, as spelled out in BAAQMD Regulation 2, Rule 2 — New Source Review — complies with the requirements of Health and Safety Code Section 40919(a)(2). Sufficient offsets have been provided for all permits that have been issued by the Air District. Furthermore, the Small Facility Banking account has sufficient credits to sustain withdrawals into the foreseeable future at the current withdrawal rate. The Air District's no net increase threshold was reduced to 10 tons per year to comply with transport mitigation requirements in December 2004.

Best available retrofit control technology (BARCT) on all existing permitted stationary sources **[**Sec. 40919(a)(3)]. BARCT is implemented through the Air District's rule development, enforcement and permit review programs. Air District staff perform an assessment of BARCT requirements when proposing new rules or rule amendments and ARB reviews Air District rules and proposed rule amendments to insure that BARCT standards are implemented. Additionally, the Air District evaluates existing sources during the annual permit review process to ensure BARCT requirements are being met. Finally, the Air District issues facility advisories, and implements compliance assistance and enforcement programs help to ensure compliance with BARCT standards in rules.

Measures to achieve use of a significant number of low-emission vehicles in motor vehicle fleets [Sec. 40919(a)(4)]. Proposed mobile source control measures MSM A-1, MSM A-2, and MSM A-3 promote the use of low-emission vehicles to reduce motor vehicle fleet emissions. TCM A-1 addresses clean fuel transit and school buses. The Air District's Transportation Fund for Clean Air, Carl Moyer and Low Emission School Bus programs provide funding for projects to promote the purchase and use of low-emission vehicles.

Transportation control measures (TCMS) to substantially reduce the rate of increase in passenger vehicle trips and miles traveled per trip [Sec. 40918(a)(3)]. Pursuant to Sections 40233 and 40717, each TCM must include the following:

- A schedule for implementation
- Identification of potential implementing agencies
- Procedures for monitoring the effectiveness of and compliance with the measures in the plan; and

In addition, Section 40233 directs the Air District to estimate the quantity of emission reductions from transportation sources necessary to attain and maintain State and national ambient air quality standards. Section 40233 requires MTC to prepare and adopt a TCM plan to achieve the specified quantity of emission reductions. The TCM plan is then incorporated into the overall strategy for achieving the State ozone standard. The statute also requires MTC to develop and adopt a revised TCM plan whenever the Air District revises the emission reduction target.

The Air District and MTC complied with the requirements of Section 40233 when preparing the first Bay Area plan for the State ozone standard, the 1991 Clean Air Plan, by adopting a TCM emission reduction target and plan in 1990. Section 40233 leaves it to the Air District's discretion as to whether and when to revise the emission reduction target for transportation sources set in 1990. This triennial update to the strategy for the State ozone standard does not include a revised emission reduction target for transportation sources, and therefore, does not trigger a TCM plan revision. The Air District and MTC have, however, comprehensively reviewed and augmented the TCMs during preparation of the 2010 CAP to maximize their effectiveness.

<u>Indirect source and area source programs</u> [Sec. 40918(a)(4)] Several measures in the 2010 CAP are intended to reduce emissions from indirect sources. LUM 2 calls for the District to develop an indirect source review regulation pursuant to Section 40716. LUM 3 describes updated CEQA guidelines that should also help to reduce emissions from new indirect sources of emissions. Also, TCM D-3 includes actions by the District and partner agencies to promote focused development that should also reduce emissions from indirect sources. Management of area source emissions is addressed through existing Air District regulations for ROG in Regulation 8 and NOx in Regulation 9. In addition, PM is addressed by Regulation 6, including the District's wood smoke rule (Reg. 6, Rule 3, adopted in July 2008) and complementary wood smoke public education program.

<u>Regional public education programs</u> [Sec. 40918(a)(6)] The Air District administers several public education programs that encourage the public to reduce air pollution both year round and on an episodic basis. The Air District's "Spare the Air" public education program, described in TCM C-4, is aimed at curbing emissions from motor vehicles and other ozone precursor sources on days when weather conditions are conducive to high ozone levels. The *Winter Spare the Air* program, described in Chapter 3, complements the regulatory Wood Burning program that reduces emissions of particulate matter from wood burning. Other ongoing educational programs include grassroots resource teams located throughout the Bay Area; a Smoking Vehicle Assistance Program; outreach and presence at public events throughout the year; a suite of youth education programs including the Clean Air Challenge, Cool the Earth and Protect Your Curriculum; and a Speakers Bureau that delivers talks on air quality to a variety of audiences throughout the region.

<u>An assessment of cost-effectiveness of proposed control measures</u> (Sec. 40922). Information regarding cost-effectiveness CAP control measures is provided in Chapter 4 of CAP Volume I.

Periodic requirements include the following:

An annual regulatory schedule (Sec. 40923). The Air District produces a regulatory schedule each December, listing regulatory measures that may be scheduled for adoption or amendment during the following year. A proposed regulatory schedule for years 2010 through 2012 is provided Chapter 4 of the 2010 CAP.

An annual progress report on control measure implementation and, every third year, an assessment of the overall effectiveness of the program (Sec. 40924). The Air District has submitted annual progress reports to CARB nearly every year since 1993. Previous triennial assessments of overall plan effectiveness were submitted in 1994, 1997, 2000, and 2005. The latest triennial assessment is provided in Chapter 3 of the 2010 CAP.

A review and update of the plan every three years to correct for deficiencies and to incorporate new data and projections (Sec. 40925). The 2010 CAP incorporates new data and projections and updates the control strategy.

Appendix D – Ecosystem Impacts of Air Pollution

In addition to impacts on human health, air pollutants can also have impacts on the terrestrial and aquatic ecosystems and the flora and fauna that sustain human life. In many cases, air pollutants such as reactive organic gases (ROG), nitrogen oxides (NOx), sulfur dioxide (SO2), ammonia (NH3), and particulate matter (PM) are ultimately deposited on land and water, where they cause a variety of impacts. Air pollutants can be deposited directly onto the surface of a water body, or they can be deposited on to land and then carried to water bodies through run-off.

This appendix summarizes some of the key ecosystem impacts of air pollution, including damage to crops and vegetation, acid deposition, and eutrophication of waterways. As shown in the table below, multiple pollutants may contribute to each specific impact, and certain pollutants, such as NOX and NH3, may cause multiple impacts.

	Impacts on Terrestrial Systems		Impacts on Aquatic Systems		
	Damage to Crops & Vegetation	Deposition on Land	Acidification	Eutrophication	Water Pollution
ROG	X				
NOx	X	X	X	X	
SO2			X		
NH3		X	X	X	
PM & metals					X

Reactive Nitrogen

Concern about climate change has drawn attention to the consequences of human intervention in the carbon cycle. However, the impact of human intervention in another system of fundamental importance, the nitrogen cycle, has received much less attention. Reactive nitrogen (Nr) is one of the major causes of ecosystems impacts discussed below, including ozone damage to plants, acid deposition on land and on water, nitrogen deposition on land, and eutrophication of water bodies. Human activities produce five times more reactive nitrogen per year than natural processes (EPA Science Advisory Board 2009). The use of synthetic fertilizers is the leading source of anthropogenic Nr, but combustion of fossil fuels in motor vehicles, power plants and other sources is also a major source of Nr.

Nitrogen in its pure form is an inert (non-reactive) gas. However, nitrogen is chemically reactive and exists in many reactive forms. The reactive nitrogen compounds can have beneficial uses, such as fertilizer to increase crop production, but they can also be harmful to ecological systems. Once in a reactive form, nitrogen is easily transported between air, water, and soils in a process known as the "nitrogen cascade." This cascade is very complex, extending from initial emissions through atmospheric transport and chemical transformations; dry-deposition and wet-deposition; and downstream effects that involve plants, animals, fungi, and bacteria interacting in myriad ways. The primary forms of Nr that are released as air pollutants are NH3, NOx, and N2O.

Because it can move so easily from the atmosphere into soils and waterways, and back again, a single nitrogen-containing molecule can have a series of impacts on the environment. While airborne in the form of NOx, reactive nitrogen contributes to formation of ozone in the lower atmosphere, causing respiratory ailments in humans and damaging vegetation. NOx, NH3, and N2O may fall to the surface and contribute to acid deposition, pollution of groundwater and surface water, and eutrophication of estuaries and coastal ecosystems.

Ozone

Ozone is formed by a chemical reaction between ozone precursors, ROG and NOx, in the presence of sunlight. Emissions of these precursors are produced by a wide range of sources and processes, including combustion of fossil fuels, industrial processes, evaporative emissions from fuel tanks, and chemical solvents. Elevated concentrations of ozone can damage agricultural crops, trees and other forms of vegetation. Ozone oxidizes plant tissue, which reduces photosynthesis and interferes with the ability of sensitive plants to produce and store food. Impacts include:

- premature leaf loss, and reduced leaf and root weight;
- increased susceptibility to certain diseases, insects, other pollutants, competition and harsh weather;
- damage to the appearance of urban vegetation, as well as vegetation in national parks and recreation areas; and
- reduced forest growth and crop yields,[96] potentially impacting species diversity in ecosystems.

Acid Deposition and Acidification

Acidification can occur when nitric acid and sulfuric acid are deposited into aquatic or terrestrial ecosystems. When SO2 and NOx are emitted from power plants, motor vehicles, and other sources, they can be transported long distances by prevailing winds, reacting in the atmosphere with water, oxygen, and other chemicals, and eventually falling to earth in the form of dust, acid rain or snow.

When nitric and sulfuric acids are deposited into waterways, such as rivers, streams,

[96] Ozone damage to orchards in the Santa Clara Valley was a major factor in the creation of the Bay Area AQMD in 1955, when agriculture was still the backbone of the economy in the South Bay.

lakes or marshes, the impact of the increased acid on the ecosystem depends on the sensitivity of the water body. Generally, this sensitivity is highest when the soil in the watershed has a limited capacity to neutralize acidic compounds (referred to as "buffering capacity"). In areas where buffering capacity is low, acid rain releases aluminum from soils into lakes and streams. Aluminum is highly toxic to many species of aquatic organisms. [97] Increased concentrations of CO2 in the atmosphere, the primary cause of climate change, also causes acidification of ocean waters, because the CO2 absorbed by oceans dissolves to create carbonic acid. This increased acid content impedes the ability of some marine life to develop shells and skeletal structures.

On land, acid deposition can damage trees, especially at higher elevations, where exposure to acid-heavy clouds and mist is greater. The ability of a forest to cope with acid deposition depends on the buffering capacity of its soil. Acid dissolves and removes the nutrients in forest soils before trees and other plants can use them to grow. At the same time, acid rain causes the release of substances that are toxic to trees and plants, such as aluminum, into the soil. Acid rain is not a problem for water bodies in the Bay Area. However, because SO2 and NOx can travel great distances in the atmosphere before their deposition, pollution emitted in the Bay Area may impact ecosystems in downwind areas, including the Sierra Nevada. According to a National Parks Service report,[98] acid rain and snow is not as serious a problem in the Sierra Nevada as in the eastern U.S. or the Colorado Rockies. However, many high-elevation Sierra lakes have low buffering capacity, so it is important to minimize any future acid deposition.

Nitrogen Deposition on Land

Deposition of reactive nitrogen on land acts as an unintended fertilizer which can have impacts on terrestrial flora and fauna. Of the 225 plant species in California listed as threatened or endangered by the state or federal government, 101 are exposed to levels of nitrogen suspected of causing ecological disruption (CEC 2006). In areas where Nr is deposited on nutrient-poor soil, this can fuel the expansion of invasive, non-native species that choke out native plants. As the flora changes, animal species that depend on the native vegetation may be adversely impacted.

The case of the Bay Checkerspot Butterfly, which has been on the federal endangered species list since 1987, provides an example of the impact of reactive nitrogen on diversity of native flora and fauna. The Checkerspot depends on native grasses, such as plantain, that grow on nutrient-poor serpentine soils. The serpentine ecosystem provides food for both the larval and adult stages of the butterfly. Edgewood Natural Preserve in San Mateo County historically supported a healthy population of Checkerspots. However, nitrogen deposition from vehicles on Interstate 280, which is

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[97] "Acid Deposition Impacts on Aquatic and Terrestrial Ecosystems", http://www.epa.gov/acidrain/effects/surface_water.html

[98] See http://www.nature.nps.gov/air/Pubs/pdf/techInfoEpaDeposition.pdf

adjacent and upwind to the Preserve, has allowed the aggressive, non-native grasses, such as Italian rye grass, to crowd out native grass species in recent years.[99] As a result of habitat reduction, the Checkerspot population at Edgewood is in jeopardy.

Nitrogen Deposition in Water Bodies

When excessive nutrients are introduced to a water body, through fertilizer run-off, atmospheric deposition of nitrogen compounds, or wastewater discharge, this can stimulate excessive plant growth (often referred to as algal blooms), which can in turn degrade water quality. Algal blooms can reduce oxygen content of water, damaging other water-based organisms. This process is called eutrophication. NOx emissions from power plants and motor vehicle exhaust contribute to eutrophication. San Francisco Bay is somewhat protected from the impacts of eutrophication due to the high sediment content of the Bay, which filters out sunlight and impedes phytoplankton growth. However, periodic elevated levels of algal growth (such as "red tides") do occur in the Bay and could become a more serious problem if deposition of excess nutrients is not kept in check. In addition, more than half the nitrogen that fuels algae growth in Lake Tahoe is a result of atmospheric deposition.[100] Thus, emissions of nitrogen compounds in the Bay Area may also contribute to the loss of clarity in Lake Tahoe, a prime aesthetic, recreational, and tourism asset for both California and Nevada.

Other Impacts on Water Systems

According to the San Francisco Estuary Institute's Regional Monitoring Program, although some contaminants are reduced from peak levels seen in earlier decades, the level of contamination in the Bay today is high enough to impair the health of the ecosystem. Pollutants found in waterways increase, or bioaccumulate, through the food chain. Beginning with their ingestion in the water by filter feeders such as clams and oysters, these pollutants eventually make their way up through fish to marine mammals and humans.

Tidal marshes and vegetated areas on the shoreline help prevent the degradation of water quality from non-point source pollution by filtering out contaminants, intercepting run-off, dampening wave action, and reducing bank erosion. However, the ability of marshlands to perform these critical services decline if the health of marsh habitats is compromised.

Deposition of particulate matter, including heavy metals, may also have negative

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[99] Weiss, Stuart, *Final Report on NFWF Grant for Habitat Restoration at Edgewood Natural Preserve, San Mateo County*, CA; October, 2002.

[100] See Suzanne Bohan, "Nitrogen Overdose: Element quietly rivaling CO2 as a global climate threat." *Oakland Tribune,* August 12, 2007. www.creeksidescience.com/files/oaklandtribune_nitrogen_12aug07.pdf

impacts on the Bay and other water bodies. Tire wear is a significant source of zinc, and brake pad wear is a significant source of copper (Stolzenbach 2006). Copper from brake pad wear is washed into streams, rivers and coastal waters where it is toxic to aquatic organisms such as phytoplankton, that serve as the foundation of the food chain, thus affecting the health of entire ecosystems. Elevated copper levels may also be one of the factors contributing to the decline of salmon populations.[101]

Climate Change

In addition to ecosystem impacts from air pollution, climate change due to increasing levels of greenhouse gases in the atmosphere is expected to cause a wide range of detrimental impacts to Bay Area ecology. These impacts will be most damaging to sensitive ecosystems that do not have the ability to rapidly adapt to a changing environment.

When the earth's average temperature changes, even only to a slight degree, it can cause major changes to weather patterns and ecosystems. The Bay Area is already experiencing the impacts of climate change. Examples of ecosystem impacts of climate change include the following.

- Sea levels have risen by as much as seven inches along the California coast over the last century. Rising sea levels may alter, or even submerge, existing wetlands.
- Less winter precipitation is falling as snow, and snow is melting earlier in the year, causing water shortages.
- Spring is arriving earlier, which alters the timing of natural cycles.
- Wildfires are becoming more frequent and intense due to dry seasons that start earlier and end later. This can cause a wide range of direct and indirect ecosystems impacts.
- Higher summer temperatures are causing an increase in ground-level ozone (smog) formation. Higher ozone levels mean more damage to vegetation and crops.

A changing climate will mean warmer temperatures and less rainfall for most of the Bay Area. Plant species that require cooler, moister environments will either migrate to higher elevations or move north if they are able; if they are unable to migrate, they will simply disappear. This may cause assemblages of species that depend on each other for survival, such as broadleaf forests, to break up as stronger species are able to migrate. It is estimated that statewide, up to 1,300 species (two-thirds of California's endemic flora) will either disappear or be greatly reduced from their current ranges.[102] When

[101] For discussion regarding the impact of copper from brake pads on water bodies, see http://www.suscon.org/bpp/#

[102] See: *Taking the Heat* in Bay Nature: Exploring Nature in the San Francisco Bay Area, Jan-March 2009. http://baynature.org/articles/jan-mar-2009/taking-the-heat/taking-the-heat

native plants die out, they are often replaced by weedier replacements that can evolve and adapt quickly.

The Bay Conservation and Development Commission expects sea level in the Bay Area to rise by approximately 4.6 feet by the end of the 21st century. This will inundate most of the Bay's coastal wetlands, leaving very little buffer zone between rising tides and storm waters and the built environment. A wide range of both migratory and resident species, such as the California Tiger Salamander, depend upon San Francisco Bay wetlands for nesting, breeding, and feeding. Loss of these wetlands would be a major blow, particularly to the more specialized, or exotic native species. Generalist species which are more capable of adapting to rapid environmental change, such as crows, raccoons, skunks and coyotes, are likely to increase in numbers.

Recent research has linked increased wildfires in the west to warmer springs and earlier melting of the sierra snowpack, both symptoms of climate change. In recent years, California is experiencing longer, more intense fire seasons, with more destructive fires. Most of the native plants in the California wild lands depend upon intermittent drought and seasonal burning. These species drop seeds which lay dormant in the soil until a wildfire uncovers them and allows them to germinate. With more frequent forest fires, native plants may not have enough time to grow and set seed. A loss of native plant life due to increase occurrence of wildfires could lead to an invasion of more generalist, weedier species.

How the 2010 CAP Helps to Protect Ecosystems

The Bay Area 2010 CAP provides a multi-pollutant control strategy to reduce emissions and ambient concentrations of ozone precursors (ROG and NOx); directly-emitted PM, as well as PM precursors (ROG, NOx, SO2, and NH3); key air toxics; and key greenhouse gases (CO2, methane, N2O). The primary focus of the CAP is to reduce air pollution in order to protect public health. However, ecosystem protection is another important co-benefit of the CAP.

It is beyond the scope of this analysis to directly measure how the anticipated emission reductions from CAP control measures will prevent or mitigate the ecosystem impacts described in this appendix. However, by reducing emissions of ROG, NOx, NH3, SO2, PM, and CO2, the CAP will help to protect the health of terrestrial and aquatic ecosystems and native flora and fauna in the Bay Area, as well as in downwind areas, such as the Central Valley and the Sierra Nevada. It is likely that the emission reductions from the 2010 CAP control strategy will play only a modest role in directly reducing ecosystem impacts. However, for the reasons described in this appendix, the issue of how to reduce the ecosystem impacts of air pollution merits additional attention in future air quality planning efforts.

Sources:

Bay Conservation & Development Commission. Maps of projected sea level rise: www.bcdc.ca.gov/planning/climate_change/index_map.shtml

Creekside Science Center: http://www.creeksidescience.com/nitrogen.html

Reactive Nitrogen in the United States; An Analysis of Inputs, Flows, Consequences, and Management Options, August 2009. U.S. Environmental Protection Agency Science Advisory Board, Integrated Nitrogen Committee

San Francisco Estuary Institute: www.sfei.org/

US EPA website: http://www.epa.gov/acidrain/effects/surface_water.html

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Water Quality Control Plan for the San Francisco Bay Basin. www.swrcb.ca.gov/sanfranciscobay/basin_planning.shtm

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Appendix E – Photochemical Modeling

Although no air quality modeling was required to be performed for the 2010 CAP, results of the Air District's recent air quality modeling helped to inform the development of the CAP. A brief overview of the Air District's modeling and key findings were summarized in CAP Chapter 2. This appendix provides a more detailed description of the Air District's recent modeling work.

BAAQMD Modeling History and Scope

From 1989 to 2006, the Air District's photochemical modeling effort mostly focused on the preparation of the State Implementation Plans for national ozone standards. Because the Bay Area is currently classified as a marginal non-attainment area for national 8-hour ozone standard, the Air District is not required to use photochemical models for attainment demonstration. However, the Air District is committed to continue working with neighboring districts and CARB to study regional ozone transport through the use of photochemical models.

The Bay Area also does not attain the national 24-hour PM2.5 standard. Since a significant percentage of PM2.5 is formed via chemical processes of precursor pollutants affected by sunlight, U.S. EPA is expected to require the use of photochemical models for attainment demonstration in the preparation of the State Implementation Plan for this pollutant. Photochemical modeling is not currently required for demonstrating attainment for State standards.

There are no federal or State requirements to perform photochemical air toxics modeling. The Air District added photochemical air toxics modeling capabilities to its program in 2005 to investigate the nature of toxic concentrations over the entire Bay Area and in sub-regions. Air toxics simulations prior to this date were limited to permit evaluation.

Other applications of photochemical modeling at the Air District include:

- better understanding of ozone and particulate matter formation in the Bay Area;
- assessing the benefit of various proposed and adopted emission control measures;
- weighing alternative emissions control strategies for future planning;
- estimating human exposure to pollutants and associated health impacts;
- analyzing potential impacts of land use development; and

- providing modeling support to District programs and functions such as permit evaluation, rule development, grants and incentives, climate protection, and the CARE Program.

Through the use of photochemical models, the Air District participates in collaborative regional air quality study efforts such as the Central California Ozone Study (CCOS) and the California Regional Particulate Air Quality Study (CRPAQS). Collaborators include U.S. EPA, CARB, the National Oceanic and Atmospheric Administration (NOAA), universities, and neighboring districts, especially the San Joaquin Valley Air Pollution Control District and the Sacramento Metropolitan Air Quality Management District.

Modeling Methodology

An air quality model estimates pollutant concentrations by accounting for pollutant transport, mixing and chemical transformation in the atmosphere, and removal through deposition to the ground. There are two state-of-the-science air quality models that are publicly available and are used by the Air District: U.S. EPA's Community Multiscale Air Quality (CMAQ) model and Environ International Corporation's Comprehensive Air Quality Model with extensions (CAMx). Both of these models are capable of handling multiple pollutants, including ozone, toxics and PM.

Currently, the Air District uses CAMx for simulating ozone and TACs, and CMAQ for simulating PM2.5. In the future, the Air District plans to use CMAQ as the primary model for simulating all three pollutants and CAMx as a back-up model.

Emissions inventory and meteorological inputs to these models are prepared using several specialized computer programs. The anthropogenic emissions input is prepared using U.S. EPA's Sparse Matrix Operator Kernel Emissions (SMOKE) program. The biogenic emissions input is prepared using CARB's Biogenic Emissions Inventory - Geographic Information System (BEIGIS) program. The meteorological input is prepared using the Penn State University/National Center for Atmospheric Research Mesoscale Model version 5 (MM5). These computer programs, along with documentation, are publicly available.

To prepare the anthropogenic emissions inventory input, county-level, source-specific, daily total emissions data are allocated spatially to a predefined grid over the modeling domain. Emissions are then further distributed to each hour of the day and chemically speciated for modeling. Biogenic vegetation emissions are estimated based on leaf area index and ambient temperatures of each grid cell at each hour.

MM5 is applied to simulate hourly wind speed and direction, temperatures, humidity, and solar radiation values needed for the air quality model simulations. Observations are injected in the model to minimize the difference between simulations and observations.

Both meteorological and photochemical models are applied over a relatively large domain to capture the regional impact of meteorology and air quality. For most Bay Area ozone and PM modeling, the domain covers all of Central California and portions of northern California, extending from Redding in the north to the Mojave Desert in the south and from the Pacific Ocean in the west to the Sierra Nevadas in the east.

The Air District has been applying both the CMAQ and CAMx models following the guidelines of U.S. EPA and CARB. Both air quality models and the meteorological model are routinely evaluated against observations using U.S. EPA's and the CARB's model evaluation criteria. Simulations are repeated using various physics and chemistry options of the models until they meet the model evaluation criteria of both U.S. EPA and CARB. Once model performance is deemed satisfactory, the models can be used to evaluate the effects of potential emission reductions.

Ozone Modeling Simulations

This section summarizes results of the Air District's most recent ozone modeling. The Air District used CAMx to simulate two ozone episodes occurring in 1999 and 2000. The 1999 episode was a two-day episode that occurred on July 11 and 12. The maximum 8-hour observed ozone concentrations reached 116 and 122 ppb, respectively, at Concord on these days. The 2000 episode was a three-day episode that occurred from July 31 through August 2. The maximum 8-hour observed ozone concentrations reached 89, 76 and 84 ppb, respectively, at Livermore on these three days. CARB classified the five days included in these two episodes as transport days from the Bay Area to the Central Valley.[103]

The modeling domain for ozone is the Central California Ozone Study (CCOS) domain shown in Figure E-1. First, CAMx was applied for the base case. Model performance met CARB and US EPA modeling criteria. Daily maximum 8-hr ozone levels were somewhat overestimated for some regions, including the Bay Area, and somewhat underestimated for others. These small discrepancies, however, were within accepted tolerances. Next, combined anthropogenic NOx and VOC emissions reductions of 40% were simulated for the Bay Area, Sacramento, and the San Joaquin Valley separately. This level of emissions reduction was discussed at the CARB Northern California SIP/Transport Meeting as representing the maximum feasible statewide emissions controls between 2000 and 2024. This predicted level of emissions reductions includes projected CARB mobile source regulations in combination with other measures.

[103] See "Ozone Transport: 2001 Review" prepared by CARB staff, April, 2001.

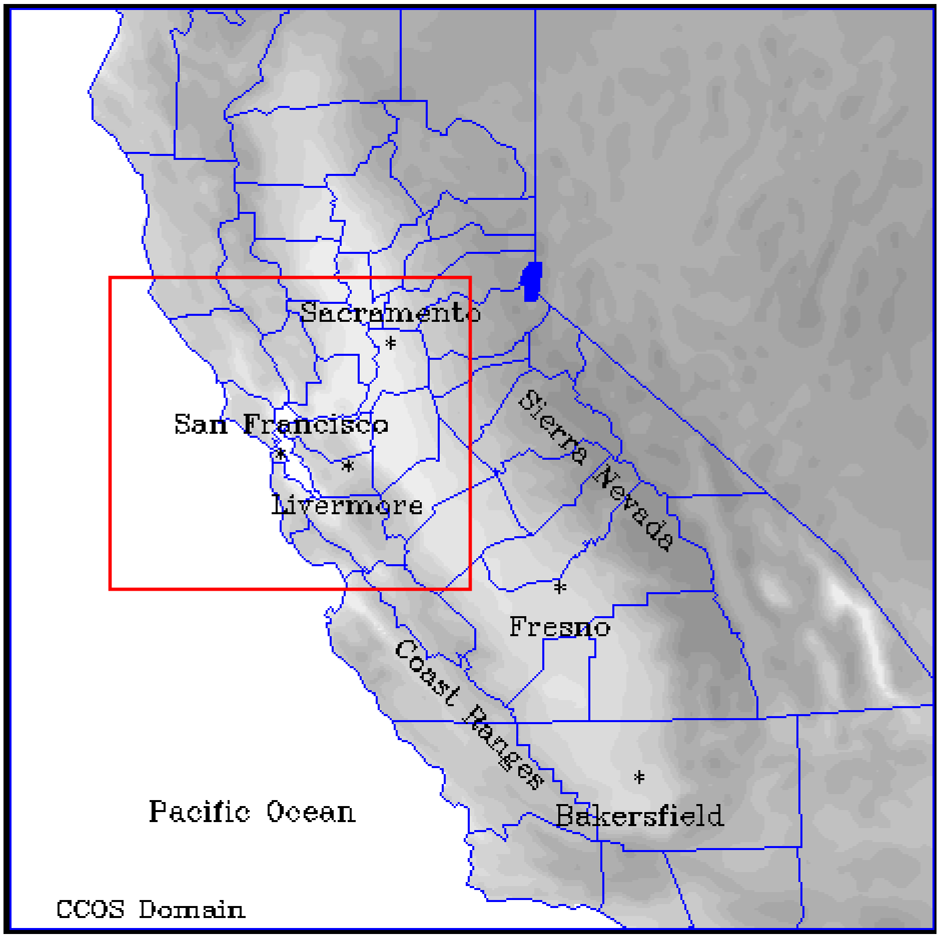

Figure E-1. Ozone and PM2.5 modeling domain (entire figure). Wood smoke modeling domain (inner domain shown in red).

Table E-1 shows the simulated and observed maximum 8-hour average ozone concentrations in the Bay Area, Sacramento, central San Joaquin Valley, and southern San Joaquin Valley. In the simulations with reduced Bay Area anthropogenic emissions, the Bay Area maximum 8-hour ozone levels decreased 13 and 15 ppb for July 11 and 12, and 3, 7 and 5 ppb for July 31 – August 2, 2000, respectively.

Table E-1. Simulated and observed 8-hour maximum ozone concentrations in the Bay Area, Sacramento, and the central and southern San Joaquin Valley. Also shown is the impact of 40% anthropogenic emission reductions on ozone.

July 11, 1999				
	SFB	SAC	C SJV	S SJV
Observation	116	123	123	97
Simulation	126	110	102	83
Simulation with 40% emissions reduction in:				
Bay Area	113	108	101	83
Sacramento	124	100	101	83
San Joaquin Vly	125	109	93	76

July 31, 2000				
	SFB	SAC	C SJV	S SJV
Observation	89	89	103	95
Simulation	105	103	101	100
Simulation with 40% emissions reduction in:				
Bay Area	102	102	99	98
Sacramento	103	97	100	100
San Joaquin Vly	105	103	93	93

July 12, 1999				
	SFB	SAC	C SJV	S SJV
Observation	122	106	109	77
Simulation	135	121	99	84
Simulation with 40% emissions reduction in:				
Bay Area	120	120	99	84
Sacramento	135	109	99	84
San Joaquin Vly	133	120	89	80

August 1, 2000				
	SFB	SAC	C SJV	S SJV
Observation	76	108	109	104
Simulation	107	114	111	96
Simulation with 40% emissions reduction in:				
Bay Area	100	111	109	95
Sacramento	106	105	109	95
San Joaquin Vly	106	114	103	89

August 2, 2000				
	SFB	SAC	C SJV	S SJV
Observation	84	107	106	112
Simulation	93	102	114	98
Simulation with 40% emissions reduction in:				
Bay Area	88	100	112	97
Sacramento	92	96	113	98
San Joaquin Vly	93	102	104	95

Results in Table E-1 give typical mid-summer episodic representations of the relative importance of transport. When Bay Area anthropogenic emissions were reduced, Sacramento and San Joaquin Valley maximum 8-hour ozone levels showed reductions of 1-3 ppb. When anthropogenic emissions were reduced in Sacramento or the San Joaquin Valley, Bay Area maximum 8-hour ozone levels decreased by 1-2 ppb.

In summary, photochemical modeling was used to estimate the impacts of NOx and VOC emissions reductions on ozone concentrations for the Bay Area and its neighboring ozone nonattainment regions. Reducing Bay Area emissions by 40% resulted in significant reductions of up to 15 ppb for Bay Area 8-hour ozone levels. The impacts of reductions in precursor emissions transported from the Bay Area were much smaller than the local impacts of the Bay Area emissions. Reducing the Bay Area emissions by 40% benefited the downwind Sacramento and San Joaquin Valley nonattainment areas by only 1-3 ppb reduced relative to the 8-hour ozone level.

Simulations re: Impacts of Climate Change on Ozone

As discussed in Chapter 1, higher temperatures related to global warming are expected to promote ozone formation through several mechanisms. One major factor is an increase in biogenic emissions of ozone precursors (ROG). The Air District performed simulations to estimate how increased temperatures may affect Bay Area ozone levels. According to the Intergovernmental Panel on Climate Change (IPCC), the current rate of accumulation of greenhouse gases is expected to increase the global average temperature 2 degrees Celsius by 2050.

For the purpose of this modeling, anthropogenic emissions of ozone precursors were held constant, ambient temperature was increased 2 degrees Celsius, biogenic emissions were estimated using the increased temperature, and the simulations described in the Ozone Modeling Simulations section were repeated. The 2 degree increase in temperature increased biogenic emissions by about 20 percent and the maximum 8-hour ozone levels by about 8 ppb in the Bay Area. The uncertainty in these results is large because emissions are constantly changing and the scientific community's understanding of the effect of global changes in emissions and temperatures on regional air quality is still developing. The Bay Area may respond to climate change differently than other parts of the world. Also, changes in temperatures may be accompanied with significantly changing Bay Area wind patterns, which play an important role in ozone formation.

In summary, photochemical modeling was used to estimate the impacts of a 2 degree Celsius increase in Bay Area temperatures on regional ozone levels. The model indicated Bay Area maximum 8-hour ozone levels would increase by about 8 ppb during ozone exceedance days. Assuming the simulated scenario is reasonable, increased ozone levels due to climate change may offset at least 10 years of ozone emissions control efforts in the Bay Area between now and 2050.[104]

[104] See "The effects of climate change on emissions and ozone in Central California" by Su-Tzai Soong, Cuong Tran, David Fairley, Yiqin Jia, and Saffet Tanrikulu. Paper #590 presented in the 101st Annual Meeting, Air and Waste Management Association, June 24-26, 2008 Portland OR.

PM2.5 Modeling Simulations

PM2.5 simulations were performed with the CMAQ model for four months (December-January, 2000-01 and 2006-07). The modeling domain (Figure E-1) included the Bay Area and the entire Central Valley to account for the impact of inter-basin transport. The model was applied on 4-km horizontal grids.

The base case simulation was validated against measurements to ensure that results adequately represented PM2.5 levels in the Bay Area and Delta regions. Simulation results for a typical Bay Area exceedance day, January 4, 2001, are shown in Figure E-2 as an example. This day exhibited light surface-level winds in the Central Valley that entered the Bay Area from the east. The PM2.5 that accumulated around all urban source areas in the modeling domain was composed mainly of primary PM2.5. Most low-lying inland locations were affected by PM2.5 as well, but were usually dominated by secondary PM2.5. Secondary PM2.5 levels were especially high deeper into the San Joaquin Valley, where considerable air mass aging occurred due to lack of ventilation. PM2.5 accumulated in a relatively thin layer near the surface in low-lying valley areas throughout the modeling domain under very stable atmospheric conditions. A plume of PM2.5 downwind of Central California formed over the Pacific Ocean.

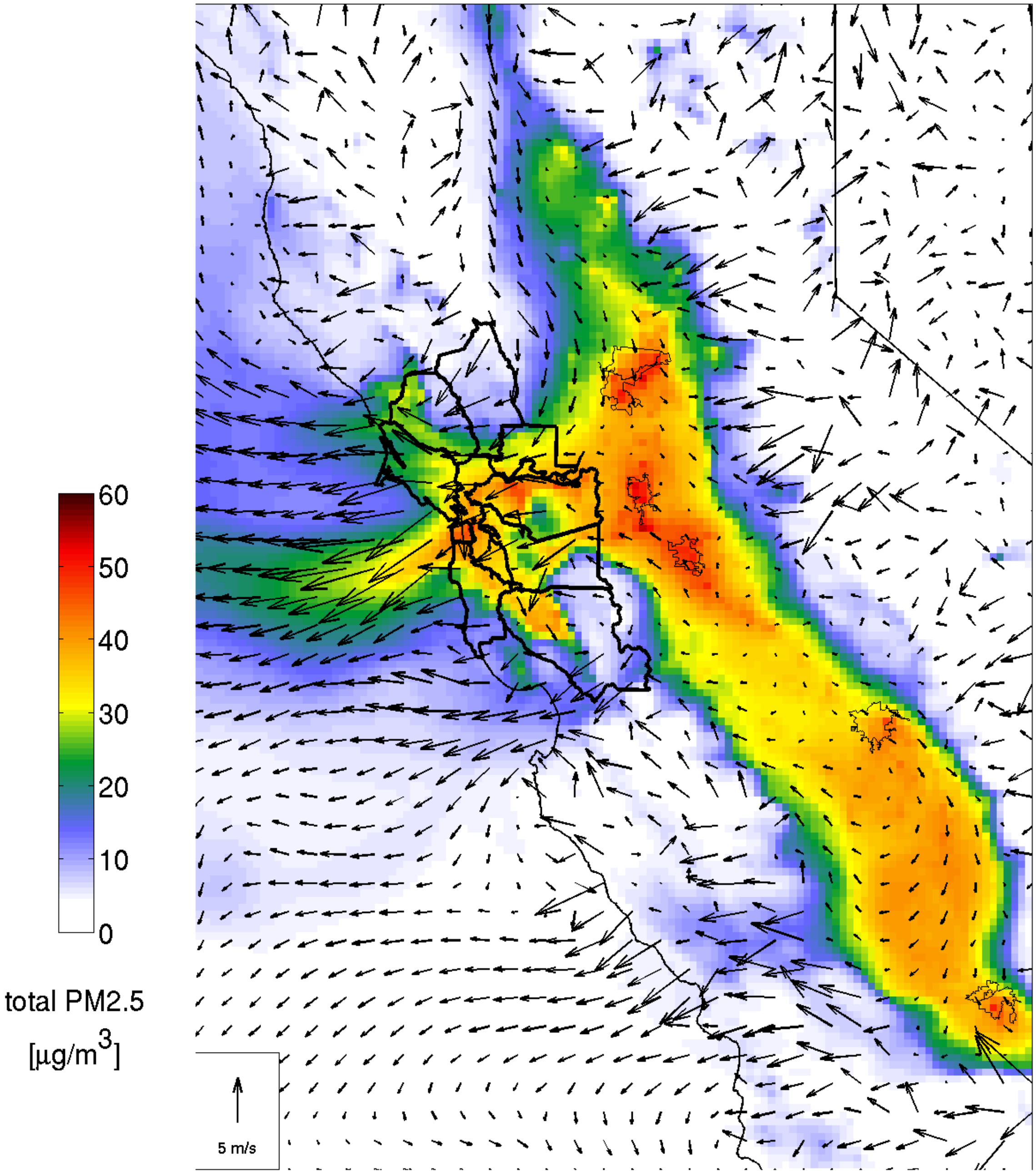

Figure E-2. PM2.5 simulation results for January 4, 2001. Spatial distribution for 24-hour PM2.5 level shown with color scale and 24-hour winds shown with arrow length proportional to speed and pointing along the direction of air flow. Bay Area counties, California boundaries, and city limits for Sacramento, Stockton, Modesto, Fresno, and Bakersfield are shown as black lines.

Figure E-3 shows the spatial distribution of simulated primary and secondary PM2.5 concentrations around the Bay Area. These results were averaged across the 52 simulated days for which measured Bay Area 24-hour PM2.5 levels exceeded 35 µg/m^3. For most of these episodic days, light winds flowed through the Bay Area from the east, and Central Valley conditions were near calm. Primary PM2.5 levels were elevated mainly in and around major Bay Area cities, including Oakland, San Francisco and San Jose; near industrial facilities and highways along the Carquinez Strait; at Travis AFB; and Santa Rosa. Secondary PM2.5, present mostly as ammonium nitrate, was not localized near the sources of its precursor emissions, NO_x and ammonia. Rather, secondary PM2.5 was regionally elevated. A sharp gradient existed, with very high secondary PM2.5 levels in the Central Valley decreasing westward through the Bay Area.

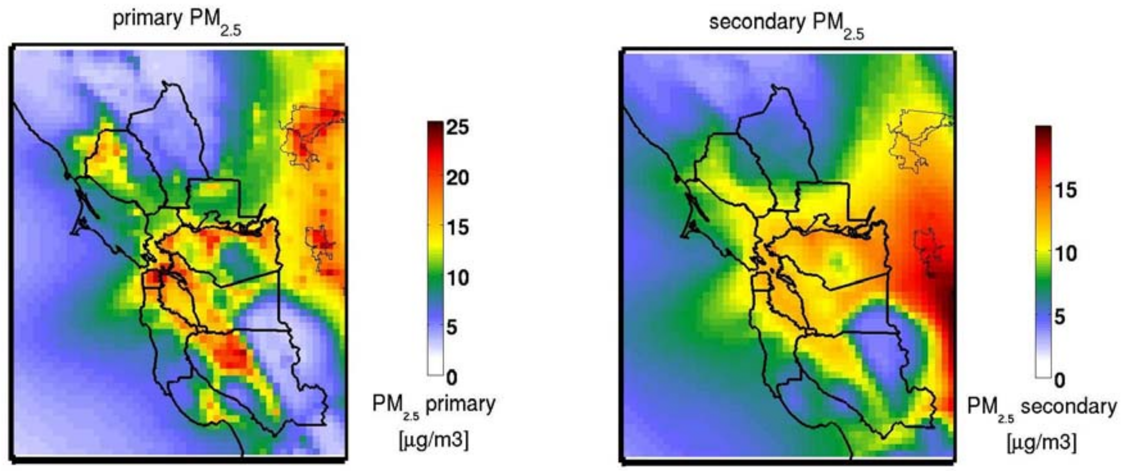

Figure E-3. Spatial distribution of simulated 24-hr primary and secondary PM2.5 levels averaged across the 52 simulated days for which measured Bay Area 24-hr PM2.5 level exceeded 35 µg/m^3. Bay Area counties and the California coastline are drawn using thick black lines. City limits for Sacramento and Stockton are drawn using thin black lines.

Around San Francisco and San Jose, PM2.5 levels were dominated by primary (directly-emitted) PM. For other areas affected by PM episodes, such as the eastern, northern, and southern Bay Area and also the Delta, primary and secondary PM2.5 levels were comparable. Both primary and secondary build-up were required for exceedances to occur in these locations.

PM2.5 sensitivity simulations were performed by reducing emissions at different regions of the modeling domain relative to the base case. First, Bay Area emissions reductions of 20% were simulated for the following five classes of chemical species: NO_x and VOC combined; gaseous sulfur species; ammonia; directly emitted PM; and these four classes combined, comprising all anthropogenic emissions. These reductions were simulated for one episode each from the 2000-01 and 2006-07 winter seasons. Reducing the directly-emitted PM reduced peak PM2.5 levels nearly ten times more effectively than reducing the secondary PM precursors. Reducing primary PM emissions by 20% typically reduced primary PM2.5 levels by 12-20% depending on location, with an average around 16%. Reductions of directly emitted PM were most effective near the PM emissions sources where primary PM2.5 levels were highest. Reducing ammonia emissions by 20% was the most effective of the secondary PM2.5 precursor emissions reductions. Reducing combined NO_x and VOC emissions by 20% was relatively ineffective (0-1%). Reducing sulfur-containing PM precursor emissions by 20% typically had a small impact on Bay Area ambient PM2.5 levels. Under certain conditions, however, reductions of sulfur-containing emissions reduced ambient PM2.5 levels by around 1 $\mu g/m^3$.

Also investigated was the impact of sources outside of the Bay Area on the Bay Area's PM2.5 concentrations by zeroing out the Bay Area's anthropogenic emissions and repeating the above (base case) simulations. Simulated concentrations were averaged across 52 days for which the Bay Area's maximum 24-hour PM2.5 levels were observed to exceed 35 $\mu g/m^3$. Significant amounts of both primary and secondary PM2.5 were found in the Bay Area even when Bay Area anthropogenic emissions were zeroed out. Primary PM2.5 levels were as high as 8 $\mu g/m^3$. Secondary PM2.5 concentrations were as high as 13 $\mu g/m^3$ along the eastern boundary of the Bay Area and about 5-8 $\mu g/m^3$ elsewhere.

In summary, photochemical modeling was used to estimate the impacts of reducing PM and its precursor emissions for the Bay Area and its neighboring PM nonattainment regions. Reducing Bay Area primary (directly emitted) PM2.5 emissions provided far greater reductions in ambient Bay Area PM2.5 levels than reducing Bay Area secondary PM2.5 precursor emissions. Of the precursor emissions reductions simulated, Bay Area ammonia reductions were most effective. The ammonia emissions reductions lowered ammonium nitrate PM2.5 levels only for relatively cold winter days favoring ammonium nitrate buildup. (Ammonium nitrate PM2.5 tends to evaporate faster than it forms at temperatures above around 60 degrees Fahrenheit.) Combined NOx and VOC emissions reductions for the Bay Area were relatively ineffective. NOx emissions reductions were relatively ineffective because ammonium nitrate PM2.5 formation involves the relatively slow and incomplete conversion of NOx to nitric acid. Reducing Bay Area sulfur-containing PM precursor emissions typically had a small impact on Bay Area ambient PM2.5 levels. Under certain conditions, however, reducing Bay Area sulfur-containing emissions did provide around 1 $\mu g/m^3$ reduced Bay Area PM2.5 level. Photochemical simulations were also performed with zero Bay Area anthropogenic emissions to gauge the impacts of transported PM2.5 and precursors. Significant amounts of both primary and secondary PM2.5 were transported into the Bay Area. During Bay Area PM2.5 24-hr exceedance days, transported primary PM2.5 levels averaged as high as 8 $\mu g/m^3$ and transported secondary PM2.5 levels averaged as high as 13 $\mu g/m^3$. The largest transport impacts for both primary and secondary PM2.5 occurred along the eastern boundary of the Bay Area.

Wood Smoke PM2.5 Simulations

Chemical Mass Balance (CMB) analysis has estimated that approximately one-third of Bay Area ambient PM2.5 mass during 24-hour PM2.5 exceedance days is wood smoke from household wood burning.[105] The Air District adopted a wood smoke rule (Regulation 6, Rule 3) in 2008 to reduce wood-burning emissions throughout the region. The wood-smoke rule was first implemented during the 2008-09 winter, during which 11 Spare the Air ("no burn") periods were issued. Simulations using the CAMx model were applied over the Bay Area and surrounding regions (see red box in Figure E-1) to determine the effectiveness of the rule to reduce ambient wood-smoke levels.

The modeling period included 8 of the 11 Spare the Air periods during the winter of 2008-09. Bay Area wood-smoke levels were simulated with and without wood-burning restrictions during these periods. Without burning restrictions during these Spare the Air periods, the simulations indicated that peak wood-smoke levels of up to 10-20 $\mu g/m^3$ would have occurred over the areas that generally have high wood-burning emissions. For many of the remaining populated locations within the Bay Area, wood-smoke levels would have been around 5 $\mu g/m^3$. Peak benefits of the wood-smoke rule were around 10 $\mu g/m^3$ of reduced wood smoke. The 24-hour wood-smoke levels (averaged midnight to midnight) were not reduced to zero for two main reasons. First, the burning restrictions did not begin until noon of the Spare the Air days. Second, carried over wood smoke from previous days still impacted the Bay Area during the Spare the Air periods. Because the burning restrictions reduced carry over, enhanced benefits may be achieved for multiple, consecutive Spare the Air calls. Two consecutive Spare the Air calls during 2008-09 provided the largest simulated reductions of wood-smoke levels.

Maximum simulated benefits of the wood-smoke rule occurred for areas that generally have the highest wood-smoke levels. Often, the areas most heavily impacted by wood smoke are away from the monitoring locations. Simulated wood-smoke levels for the eight simulated Spare the Air days would have averaged around 11, 7, 5, 3, and 3 $\mu g/m^3$ for the Concord, San Jose, San Francisco, Vallejo, and Livermore monitoring locations, respectively, without the burning restrictions. Preliminary wood-smoke simulations suggest that the wood-smoke rule may have been effective at reducing ambient wood smoke levels by 50-75 percent at key PM2.5 monitoring locations. However, this finding is based on an assumption of 100% compliance with the wood-smoke rule, which may not have occurred.

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[105] Chemical mass balance (CMB) analysis is a methodology in which a computer model is used to apportion ambient PM2.5 collected on filters over 24-hour periods at monitoring sites around the Bay Area to a set of source categories. Each filter was analyzed for a range of chemical species. The same species were measured in special studies of emissions from various sources, such as motor vehicles and wood burning. The CMB model finds the mix of these source measurements that best matches the ambient sample, chemical species by chemical species. See report entitled *Sources of Bay Area Fine Particles*.
www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Particulate%20Matter/PM_Report.ashx

In summary, locally-emitted wood smoke accounts for approximately one-third of Bay Area PM2.5 levels during 24-hr PM2.5 exceedance days. The largest reductions in wood-smoke PM2.5 levels were simulated for the locations that generally have the highest peak wood-smoke levels. These locations often are not near any monitor. Therefore, reductions of population exposure to wood smoke resulting from the rule may be significantly greater than indicated by the monitoring data. Multiple, consecutive no-burn days may provide the added benefit of reducing both fresh and carried-over wood-smoke levels.

Air Toxics Modeling

Air toxics species are either directly emitted into the atmosphere from their sources (primary toxics) or are formed through chemical transformation of other pollutants (secondary toxics). Atmospheric oxidants play an important role in the chemical transformation, which is closely related to ozone photochemistry. Therefore, photochemical models provide additional information over engineering models that either ignore secondary toxics formation or estimate secondary toxics concentrations with a simplified chemical mechanism.

Six toxics species were simulated for the air toxics modeling. Five of the species were estimated to account for the bulk of total air toxics cancer risk in the Bay Area: acetaldehyde; benzene; 1,3-butadiene; diesel PM; and formaldehyde. The sixth species, acrolein, was believed to be the ambient toxic with the most serious non-cancer health effects. Air toxics risk assessment required estimates of annual average levels for these six species. Simulations were performed on a 1-km horizontal grid over the Bay Area. Air toxics emissions inventories were estimated for the base year 2005. Because secondary toxics chemistry is very computationally-intensive, toxics simulations were performed for one week in summer and one week in winter, with the exception of diesel PM. To estimate annual average toxics concentrations for these species, the Air District averaged the concentrations obtained for these two weeks. Diesel PM concentrations were simulated for one summer month and one winter month; the average of these two months was used to estimate annual average diesel PM concentrations.

The modeled toxics levels compared reasonably well with ambient measurements. Simulated diesel PM levels were compared against elemental carbon levels measured on filters from the District's routine PM monitoring network. The five other simulated air toxics species were compared against VOC canister measurements taken from about 20 locations throughout the Bay Area. Annual average toxics concentrations were then calculated as averages of the July and December model results. The annual average concentrations for each toxics species were multiplied by their respective unit risk factors and overlaid on Bay Area population data to calculate population-adjusted risk.

Cancer risk was used to define six impacted communities [106] within the Bay Area: Concord; eastern San Francisco; western Alameda County; Redwood City and East Palo Alto; Richmond and San Pablo; and San Jose. These six impacted communities accounted for nearly half of the total Bay Area population-weighted lifetime cancer risk for sensitive groups (those under 18 or over 64 years of age).

Future Directions in Air Quality Modeling

The Air District recognizes that synergies and trade-offs exist in regulating ozone, PM, air toxics, and greenhouse gases. This was the primary reason that the Air District chose to pursue a multi-pollutant approach in developing the 2010 CAP. The results of modeling performed separately for ozone, PM2.5, and air toxics, which are described in the respective sections above, provided critical information used in developing the Air District's MPEM. For purposes of future air quality plans, however, the multi-pollutant framework would benefit greatly from the results of integrated, multi-pollutant modeling performed on a full-year basis. Performing simulations that cover an entire year will enable the Air District to enhance the accuracy of the existing MPEM by eliminating the need to extrapolate episodic modeling results to the full year (as was done for the MPEM used in the 2010 CAP).

Integrated modeling will require a unified modeling platform. The crucial elements of such a platform are: unified, full-year, multi-pollutant emission inventories; a single modeling system; and full-year meteorological fields, as described below.

One key input required for multi-pollutant modeling is a single, comprehensive emissions inventory accounting for all pollutants of interest and their precursors. Currently, relatively independent (though non-conflicting) inventories are used for modeling each pollutant type. Using a single, multi-pollutant emissions inventory, the effects of various proposed control strategies could be evaluated using the same input emissions data. One prerequisite to facilitate full-year modeling is to develop year-round inventories that account for all pollutant types in each season of the year. Traditionally, PM2.5 modeling has focused on the winter months, whereas ozone modeling has focused on the summer months. Year-round inventories for ozone and PM2.5 will facilitate direct estimation of their respective cumulative impacts on public health and evaluation of emission reduction strategies.

The Air District is also moving toward using a single, unified modeling system for all pollutant types. As discussed above, the CMAQ model currently is used for photochemical PM2.5 modeling, whereas CAMx is used for ozone and air toxics

[106] See *Applied Method for Developing Polygon Boundaries for CARE Impacted Communities* (December 2009) available at www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/CARE-Documents.aspx.

modeling. Previous experience has demonstrated that secondary PM2.5 chemistry is better handled by CMAQ, whereas Bay Area ozone episodes are better represented by CAMx. Both models employ a “one atmosphere" approach in which similar physics and chemistry formulations are used to relate changes in emissions to changes in ambient pollutant levels. However, comparison of results from these two modeling systems may not always be directly achievable. Discrepancies may arise because of differences in their numerical algorithms. Use of a single modeling system will help avoid the potential for mathematical artifacts to bias the evaluation of a control strategy across multiple pollutants. The Air District is currently investigating the optimization of CMAQ for all modeling applications.

A final aspect of multi-pollutant modeling is developing meteorological fields that are necessary to drive year-round air quality simulations. Current modeling practices evaluate the effectiveness of emissions controls on PM2.5 and ozone only when elevated levels occur. This approach may place greater weight on acute health impacts over chronic health impacts. A year-round multi-pollutant approach, on the other hand, will ensure that acute and chronic health impacts are weighted appropriately when analyzing potential control measures. The Air District is developing meteorological simulations to match all periods that will be represented in the multi-pollutant, year-round emissions inventories described above.

Appendix F – Evaluation of Potential CAP Control Measures

This appendix summarizes the review of potential control measures for the Bay Area 2010 Clean Air Plan (CAP) performed by Air District staff. Tables providing details about staff review of specific control measures are posted on the web page for the 2010 CAP at: www.baaqmd.gov/Divisions/Planning-and-Research/Plans/Clean-Air-Plans.aspx.

Background

Pursuant to California Health & Safety Code Section 40914, the Bay Area 2010 Clean Air Plan is required to include all feasible control measures to reduce region-wide emissions for each nonattainment pollutant (e.g., ozone precursors). To identify feasible measures for the 2010 CAP, Air District staff reviewed and evaluated 844 potential control measures compiled from a variety of sources.[107] Air District staff sought ideas for new control measures, as well as ways to strengthen existing rules and programs. Sources of potential measures included ideas submitted by the public and Air District staff, other California air district control measures contained in recently-adopted air quality plans, as well as air quality plans from metropolitan areas outside of California. In addition, staff reviewed measures that had previously been considered and rejected during preparation of the Bay Area 2005 Ozone Strategy, to see if the rationale for rejecting a measure at that time is still valid for purposes of the 2010 CAP. The 844 measures reviewed included:

- 368 measures from recently-adopted air quality attainment plans.
- 390 measures from the 2005 Ozone Strategy control measure review process.
- 39 measures suggested by the public.
- 47 measures suggested by Air District staff.

Staff reviewed stationary source, area source, mobile source, and transportation control measures from the following plans:

California Air Quality Attainment Plans

- 2007 Air Quality Management Plan (May 2007, South Coast AQMD)
- Sacramento Regional 8-Hour Ozone Attainment And Reasonable Further Progress Plan (Draft January 2009, Sacramento Metropolitan AQMD)
- 2007 Ozone Plan (April 30, 2007, San Joaquin Valley Unified APCD)
- 2008 Air Quality Management Plan (August 2008, Monterey Bay Unified APCD)

[107] Air District staff and staff of the Metropolitan Transportation Commission (MTC) collaborated in evaluating transportation control measures for the 2010 CAP.

- 2007 Clean Air Plan (August 2007, Santa Barbara APCD)
- Eight-Hour Ozone Attainment Plan For San Diego County (May 2007, San Diego APCD)
- Ventura County 2007 Air Quality Management Plan (May 13, 2008, Ventura APCD)

Out of State Air Quality Attainment Plans

- Houston-Galveston-Brazoria regional SIP (April 2010)
- New York SIP for Ozone (8-Hour NAAQS) Attainment Demonstration for NY Metro Area (August 9, 2007)
- Proposed Maintenance Plan for Southeast Michigan (February 2009)
- Draft Chicago 8-Hour Ozone Attainment Demonstration and Maintenance Plan (December 2008)
- Proposed Georgia's State Implementation Plan for the Atlanta 8-Hour Ozone Nonattainment Area (March 29, 2009)

Control Measure Framework and Evaluation Criteria

Potential control measures were reviewed and evaluated as described below and as summarized in Table F-1. Potential measures were initially screened to identify and eliminate measures that have been either implemented and completed by the Air District, or implemented within the Air District's jurisdiction by the Air Resources Board, US EPA, or another agency.

Remaining measures were evaluated according to the criteria specified in California Health & Safety Code Section 40922, namely:

- Cost-effectiveness
- Technological feasibility
- Total emission reduction potential
- Rate of reduction
- Public acceptability
- Enforceability

In addition to the criteria specified in the California Health & Safety Code, control measures were also evaluated based upon their potential to reduce:

- Emissions of PM, air toxics, greenhouse gases (in addition to ozone precursors), and
- Population exposure to pollutants in one or more of the "impacted communities" identified in the District's CARE program

In reviewing measures based on the evaluation criteria described above, some measures were eliminated for the reasons shown in Table F-1 below.

Measures that are recommended for inclusion in the 2010 CAP fall into three categories:

- Measures incorporated in one of the five control measure categories:
  - Stationary Source Measures
  - Mobile Source Measures
  - Transportation Control Measures
  - Land Use & Local Impact Measures
  - Energy & Climate Measures
- Further Study Measures: This category includes measures which appear to have merit but require more research and information to determine if they are viable for implementation. These measures will be further evaluated, but are not proposed as formal control measures at this time.
- Measures incorporated in draft CAP Leadership Platform: Staff is proposing to include a Leadership Platform in the 2010 CAP to encourage actions by other agencies and/or potential legislation that would be beneficial for air quality. Some potential measures have been included in the draft Leadership Platform.

Please note that Table F-1 indicates that 347 of the potential measures reviewed have been incorporated in the 55 proposed CAP control measures. The reason that these numbers do not match is due to (1) duplication or overlap among the potential measures reviewed, (2) the fact that many of the proposed CAP control measures incorporate multiple actions that have been combined within a single measure. For the same reason, 39 of the potential measures reviewed have been incorporated into the 17 proposed Further Study Measures.

Table F-1. Outcome of all feasible measures review.

Category	Category Definition	# of Measures
Already Implemented by the Air District		219
Already Implemented by Another Agency	Measures that have already been implemented through State, Federal, or regional programs.	116
Measures Deemed Not Feasible	De minimus or no sources exist in the Bay Area.	62
	Not cost-effective.	11
	Not publicly acceptable.	10
	Not applicable to this plan.	13
	Not technologically feasible.	3
	Not enforceable.	3
	Other.	9
	Subtotal: Measures deemed not feasible:	111
Total # Potential Measures Not Incorporated into Draft Control Strategy		**446**
Incorporated into Draft Control Strategy: Stationary Source Measures	Measures implemented through District rule-making: industrial /commercial processes, stationary combustion, petroleum products processing and distribution, and area sources.	45
Incorporated into Draft Control Strategy: Mobile Source Measures	Measures to reduce emissions from on-road and off-road mobile sources by means of cleaner engines or fuels.	76
Category	Category Definition	# of Measures
Incorporated into Draft Control Strategy: Transportation Control Measures	Measures to reduce motor vehicle emissions by reducing vehicle use or traffic congestion.	171
Incorporated into Draft Control Strategy: Land Use and Local Impact Measures	Land use measures to reduce motor vehicle travel and decrease human exposure to air pollutants.	41
Incorporated into Draft Control Strategy: Energy and Climate Measures	Measures to reduce energy use, promote renewable energy sources, and reduce urban heat island effects.	14
Total # Potential Measures Recommended to be Incorporated into Draft Control Strategy		**347**
Included as Further Study Measures	Measures which meet some evaluation criteria but require further analysis to determine if they are potentially viable.	39
Included in Draft Leadership Platform	Measures which will be pursued through advocacy and partnerships as part of the Leadership Platform.	12
Total # Potential Measures Included as Further Study Measures or in Leadership Platform		**51**

Appendix G – Progress Toward 2010 CAP Performance Objectives

Overview

In addition to striving to attain applicable standards for criteria air pollutants, the 2010 Clean Air Plan defines numerical performance objectives related to the plan's goals of protecting public health and protecting our climate. The performance objectives focus on three pollutants: particulate matter less than 2.5 microns (PM2.5), diesel particulate matter (DPM), and greenhouse gases (GHGs). The performance objectives are as follows:

- Reduce PM2.5 exposure by 10% by 2015
- Reduce diesel PM exposure by 85% by 2020
- Reduce GHG emissions to 1990 levels by 2020 and 40% below 1990 by 2035

This appendix analyzes the extent to which the CAP control strategy and related efforts will achieve these objectives. For purposes of this analysis, estimates of anticipated emissions reductions were based on the following:

- implementation of control measures described in the 2010 CAP;
- estimated benefit of rules and measures adopted by the Air District between 2006 and 2009, which are not reflected in the base year 2005 emission inventory;
- expected benefits from recent State actions and current proposed regulations, including air toxics control measures (ATCMs) to reduce emissions from diesel engines, and greenhouse gas measures included in the CARB AB 32 Scoping Plan.

This analysis does not include potential emissions reductions from efforts such as climate action plans that have been developed by many Bay Area cities and counties, or the Sustainable Communities Strategy that will be developed for the Bay Area in response to SB 375 by 2013, or other voluntary, independent actions by Bay Area governments, residents and businesses. These efforts will be vitally important in reducing the region's GHG emissions, but accurately quantifying their effects is not practicable at this time.

Methodology

This analysis relies on the Air District's 2005 baseline emission inventory for PM2.5 and the base year 2007 inventory for greenhouse gases. The baseline and projected inventories for PM and for GHGs are provided in Table 2-9 and 2-12, respectively, in Chapter 2. The baseline emission levels were projected into the future to establish a trend line for future emissions in the absence of additional regulations. Air District staff developed expected benefits from recent state actions and current proposed regulations, as well as the estimated benefits of the proposed control measures in the 2010 CAP. Estimates of benefits from Air District actions since 2005 (or 2007 in the case of GHG emissions) were also developed. The sum of these actions represents the progress towards the performance objectives.

The analysis accounts for emission reductions projected to occur with the implementation of control measures either already adopted or proposed for adoption by the Air District or CARB. Air District measures included herein are the proposed 2010 CAP measures; Regulations 6, Rules 2 and 3; and GHG strategies implemented through local grant programs. CARB measures include the air toxics control measures (ATCMs) adopted as part of the statewide Diesel Risk Reduction Program and the GHG reduction measures included in the AB 32 Scoping Plan, as adopted in December 2008. Estimates of emission reductions for these measures are taken from published staff reports, or in the case of the proposed 2010 CAP measures, from the Air District staff analysis provided in control measure write-ups in Volume II and summarized in Table 4-8 in Chapter 4.

The performance objectives for PM2.5 and diesel PM are expressed in terms of reductions in population exposure to these pollutants; this is the clearest metric for estimating the benefits of reduced pollution. The Air District does not yet have available methodologies to reliably perform an analysis of reduction in regional population exposure. Therefore, this analysis uses expected reductions in emissions as a surrogate for reduction in population exposure. That is, it is assumed that a given reduction in emissions of PM2.5 or diesel PM will yield a corresponding reduction in population exposure to these pollutants. For diesel PM, the assumption of a one-to-one correspondence between reductions in emissions and exposures is consistent with the approach taken by CARB in the risk reduction plan for diesel emissions.

The Air District has inventory and modeling efforts underway to better evaluate future reductions in ambient concentrations and population exposure of Bay Area residents to PM2.5 and diesel PM. The results of these studies will be made available in the years ahead.

PM2.5

The CAP performance objective is to reduce PM2.5 exposure by 10% by 2015. Direct emissions of PM2.5 are estimated to increase from 86 tons per day in 2005 from all sources to 90.2 tons per day in 2015. A ten percent reduction, equivalent to 9.0 tons per day, is needed to meet the performance objective. As shown in Table G-1, a combination of control measures adopted by the Air District between 2006 and 2009, adopted and proposed State regulations, and the proposed 2010 CAP control measures are expected to achieve reductions in direct emissions of PM2.5 of 9.2 tons per day. Figure G-1 plots this data on a graph. Additional reductions in PM2.5 are expected to occur as secondary sources of PM2.5, such as oxides of nitrogen and sulfur, are further controlled; however, estimates of these benefits have not been included in this analysis.

Table G-1. PM2.5 performance objective. (Estimated emissions in tons/day)

Projected 2015 PM2.5 Emissions	90.7
Total Reductions needed 2015	- 9.0
Reductions from Air District Measures 2006-2009	2.2 *
Reductions from State Regulations	5.9
Reductions from 2010 CAP	1.1
Total Reductions	**9.2**

* The emission reduction from Air District measures adopted between the 2006-2009 period is based on adoption of Regulation 6, Rule 2 to reduce emission from charbroilers in restaurants and Regulation 6, Rule 3 to reduce emissions from residential wood-burning.

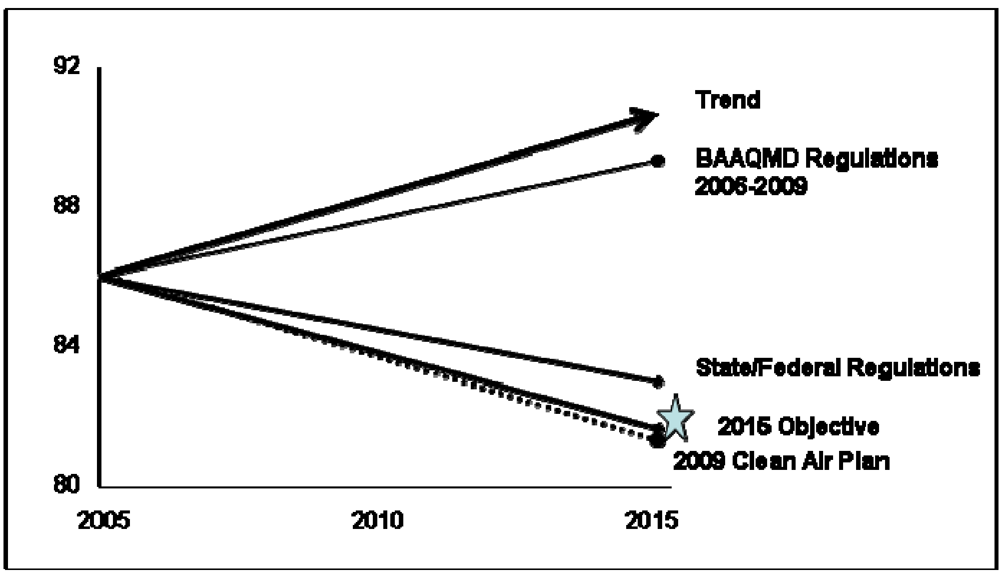

Figure G-1. PM2.5 Performance objective. (Estimated emissions in tons/day)

Diesel PM

The CAP performance objective is by 2020 to reduce diesel PM exposure by 85% from levels experienced in the year 2000.. For the purposes of this analysis, District staff have assumed a one-to-one relationship between reductions in emissions and exposure. Emissions of diesel PM are estimated to have been 14.8 tons per day in 2000 from all sources. An 85 percent reduction of 12.6 tons per day is needed to meet the performance objective. As shown in Table G-2, Air District staff estimates that a combination of control measures adopted between 2006 and 2009, adopted and proposed State regulations and the proposed 2010 CAP control measures will achieve 7 tons per day. Figure G-2 plots this data on a graph.

Table G-2. Diesel PM performance objective. (Estimated emissions in tons/day)

BASELINE DPM Emissions	14.8
Total Reductions needed 2020	- 12.6
Reductions from Air District Measures 2006-2009	<0.1
Reductions from State Regulations	6.4
Reductions from 2010 CAP	0.6
Total Reductions	**7.0**

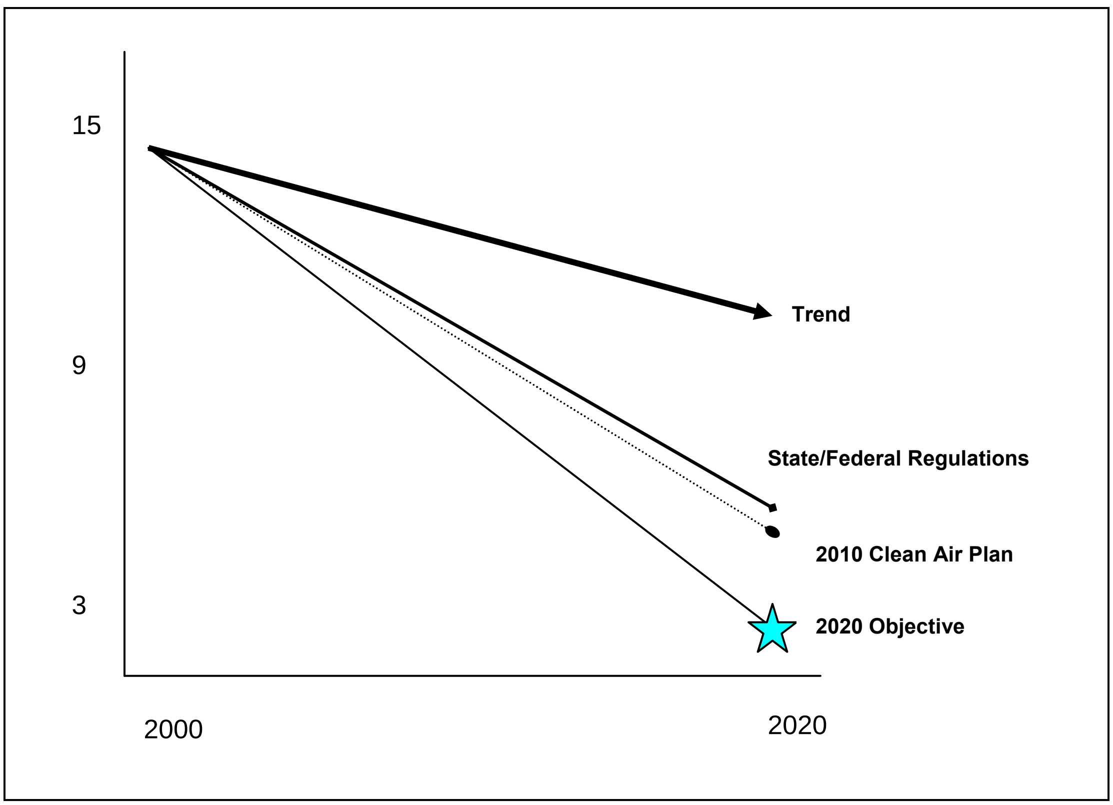

Figure G-2. Diesel PM Performance Objective. (Estimated emissions in tons/day)

Greenhouse Gases

The CAP performance objective is to reduce GHG emissions to 1990 levels by 2020 and 40% below 1990 by 2035. This corresponds with GHG reduction goals established by the State of California. Emissions of GHG in 1990 have been estimated at 273,910 tons per day, and have been projected to increase to 385,650 tons per day in 2020.[108] To meet the performance objectives there will need to be reductions of 111,740 tons by 2020 and 221,306 tons by 2035. As shown in Table G-3, Air District staff estimates that a combination of control measures adopted between 2006 and 2009, adopted and proposed State regulations and the proposed 2010 CAP control measures will achieve 87,980 tons per day in reductions by 2020. It is not possible at this time to predict GHG reductions in the 2020-2035 period. However, if the GHG reductions during the 2010-2020 period continue on the same trajectory through 2035, then GHG reductions would reach 117,000 tons per day by 2035, which is slightly below 1990 levels. Figure G-3 plots this data on a graph.

Table G-3. Greenhouse gases performance objective. (Estimated emissions in tons/day)

Estimated 1990 Levels	273,910
Projected 2020 Levels	385,650
Total reductions needed 2010-2020	111,740
Total reductions needed 2010-2035	221,310
Reductions from Air District Measures 2006-2009	1,230
Reductions from State Regulations through 2020	71,740
Reductions from 2010 CAP through 2020	15,010
Total Reductions through 2020	**87,980**
Additional projected reductions: 2021-2035	29,110
Total Reductions through 2035	**117,000**

108 For purposes of this analysis, GHG emissions are expressed in terms of short tons (2000 lbs.), not metric tons.

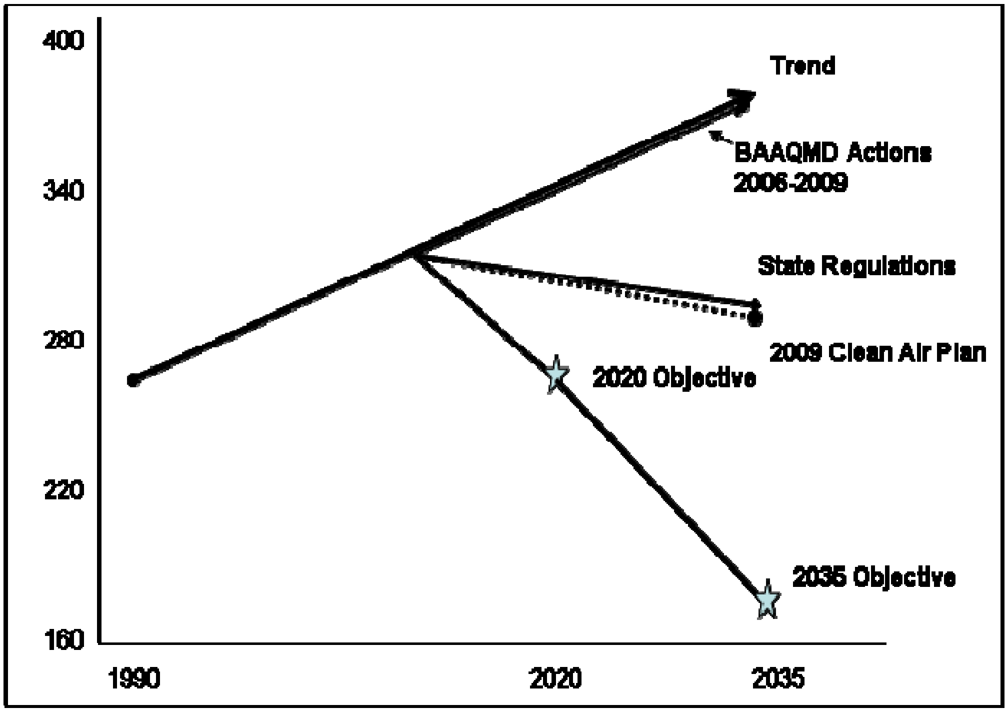

Figure G-3. Greenhouse gases performance objective. (Estimated emissions in 1,000 tons/day)

Discussion of Findings

Our analysis finds that anticipated emissions reductions will enable the Bay Area to reach the performance objective to reduce PM2.5 10% by 2015, but that we will fall short of the diesel PM and the greenhouse gas reduction objectives.

In the case of the diesel PM objective, EPA and CARB set emissions standards for most diesel engines, including trucks, buses, construction equipment, harbor craft, etc. For the past decade, CARB has been adopting and implementing ambitious ATCMs to reduce emissions from all types of diesel engines, both new and existing, with a goal of reducing diesel PM by 85% by 2020. To implement recent changes in State law intended to address the current severe economic recession, CARB has modified compliance timelines for the construction equipment diesel ATCM (i.e., the in-use off-road diesel vehicle regulation). CARB is currently also considering changes to the requirements for in-use on-road trucks and further changes to the in-use off-road diesel vehicle regulation, to account for emission reductions occurring due to the current economic downturn. However, none of the recent or proposed changes to the in-use off-road and in-use on-road regulations would result in fewer reductions of diesel PM by 2020. Combined diesel emissions from all sources should still ultimately be reduced by 85%, although achievement of this objective may not occur by 2020. Nevertheless, the Bay Area should still see a very significant reduction in diesel PM emissions.

In support of the desired 85% reduction of diesel PM emissions by 2020, the Air District will continue to aggressively implement its effort to reduce diesel PM emissions and exposure via enhanced monitoring and analysis of impacted communities, targeted enforcement of CARB regulations in impacted communities, and targeting its grant programs to projects in impacted communities.

The CAP GHG performance objectives goals are based on state goals articulated in AB 32 and Governor's Executive Order S-3-05. This analysis demonstrates that additional measures will be needed to achieve the GHG targets, beyond the measures defined and quantified in the CARB AB 32 Scoping Plan and the 2010 CAP. The additional reductions may be obtained through some combination of State actions that have not yet been fully defined, the Sustainable Communities Strategy that will be developed by Bay Area regional agencies in cooperation with local governments by year 2013, local climate action plans, future Air District actions, and voluntary actions by Bay Area residents and businesses.