SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

South Coast AQMD

Final Socioeconomic Report

2016 AIR QUALITY MANAGEMENT PLAN

March 2017

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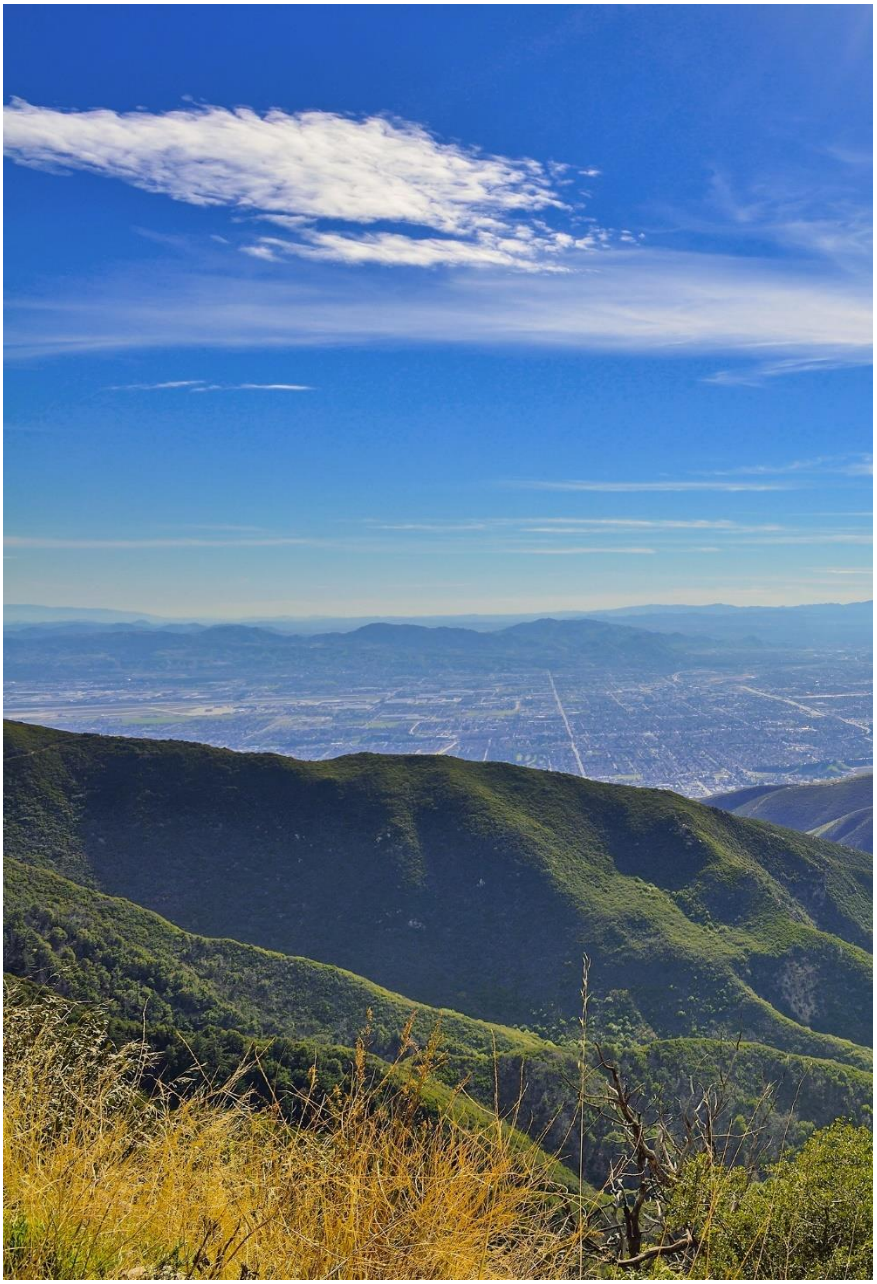

While air quality has improved over the years, the South Coast Air Basin (Basin) still has some of the most polluted air in the nation, exceeding federal public health standards for both ozone and fine particulate matter (PM2.5). The Coachella Valley also exceeds current ozone standards.[1,2] The Basin and Coachella Valley will also be required to meet increasingly more stringent federal and state air quality standards to better protect public health.[3] The Final 2016 Air Quality Management Plan (AQMP) is a regional blueprint designed to achieve federal air quality standards in the Basin and Coachella Valley by seeking emission reductions from stationary and mobile sources through regulations and incentives[4] to help accelerate the deployment of zero and near-zero emission technologies.

The estimated costs and benefits of the proposed measures in the Final 2016 AQMP[5] are expected to alter, to various degrees, the economic decisions made by households, businesses, and other economic actors. Some businesses would see production costs go up while other businesses would benefit from a greater demand for their services and technologies. For consumers who consider purchasing or replacing vehicles or certain household appliances, the proposed control strategies would also change or widen the range of product choices that differ in fuel types, energy efficiencies, effective unit prices, and thus potential payback periods.

In order to inform decision-makers and stakeholders about the potential costs and benefits of the Final 2016 AQMP and how the associated socioeconomic impacts would affect communities within the region, a Final Socioeconomic Report has been prepared. Based on recommendations made by Abt Associates in 2014 to improve the socioeconomic assessment, a concerted effort among SCAQMD staff, scientific advisors, sister agencies, and the public was made to conduct an enhanced analysis that not only utilizes state-of-the-art methods, but is more accessible and transparent to the general public. While many of Abt Associates' recommendations have been implemented, staff will continue to update and refine its methodologies for subsequent AQMPs and socioeconomic assessments for clean air rules and programs.[6]

The key findings in the Final Socioeconomic Report are based on analyses conducted using two major modeling tools: the Regional Economic Models, Inc. (REMI)'s Policy Insight Plus, a policy simulation program for regional macroeconomic impacts, and the U.S. Environmental Protection Agency's

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[1] The Basin is an over 10,000 square mile area comprised of Orange County and the urban portions of Los Angeles, Riverside, and San Bernardino Counties. The Coachella Valley is a sub-region of Riverside County in the Salton Sea Air Basin that is bounded by the San Jacinto Mountains to the west and the eastern boundary of the Coachella Valley to the east.

[2] The Basin is required to meet the following standards: 2008 8-hour ozone standard of 75 parts per billion (ppb) in 2031; 2012 annual PM2.5 standard of 12.0 micrograms per cubic meter (µg/m^3) in 2021 or 2025 depending on nonattainment classification; 2006 24-hour PM2.5 standard of 35 µg/m^3 in 2019; 1997 8-hour ozone standard of 80 ppb in 2023; 1979 1-hour ozone standard of 120 ppb in 2022.

[3] In 2015, U.S. EPA revised the 8-hour ozone standard to 70 ppb. If the Basin retains the classification as an extreme nonattainment area, the attainment deadline for this latest standard would be 2037.

[4] The Draft Financial Incentives Funding Action Plan for the 2016 AQMP provides more information regarding how incentive programs are expected to be implemented as well as potential funding sources and opportunities. The document can be found at http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/draftfinancialincentivefunddec2016.pdf.

[5] The Draft Final 2016 AQMP was released on December 2, 2016 and can be found here: http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/draft-final-aqmp/clean/2016finaldraftaqmpdec2016(clean).pdf.

[6] See Chapter 8 for more details regarding the implementation of Abt Associates' recommendations for enhancing the report and future enhancements to be made.

environmental Benefits Mapping and Analysis program (BenMAP). Total incremental costs, inclusive of the cost of incentives, were compiled for proposed control measures with quantified emission reductions. Modeled air quality data for the Basin, together with mathematical functions and parameters based on the most updated epidemiological and economic studies, were used in BenMAP to quantify public health benefits due to reduced exposure to air pollution. Public health benefits were combined with incremental costs to estimate a range of regional jobs and other macroeconomic impacts from implementing the Final 2016 AQMP. Projected changes in health risk and monetized public health benefits were also used to analyze how implementation of the Final 2016 AQMP may affect environmental justice (EJ) in the Basin, as evaluated by a number of alternative metrics.

Key Findings in the Final Socioeconomic Report

- ***Two-thirds of the Final 2016 AQMP's nearly $16 billion[7] total incremental cost is associated with control strategies seeking reductions from mobile source emissions, the principal contributor to the Basin's air quality challenges.***

Living in a region with over 20,000 miles of highways and major surface streets, 450 miles of passenger rail, six commercial airports, and the two largest marine ports in the nation, Basin residents are exposed to emissions from a multitude of mobile sources each day. Reducing emissions from mobile sources is generally the most cost-effective way to reduce regional and local air pollution health impacts. Two-thirds or about $10 billion of the Final 2016 AQMP's total incremental cost is related to mobile source control strategies, and these strategies are expected to lead to more than 80 percent of the emission reductions needed to attain the 8-hour ozone standard by 2031.[8] The remaining $5.7 billion is associated with reducing stationary source emissions in the Basin.

TABLE ES-1: COST SUMMARY OF THE FINAL 2016 AQMP[9]

Measures	Present Worth Value (Billions of 2015 dollars)					Percent of Total Incremental Cost
	Remaining Incremental Cost		Incentives		Total Incremental Cost	
Stationary Source	$4.3	+	$1.4	=	$5.7	36%
Mobile Source	-$3.3	+	$13.2	=	$10.0	64%
All Sources	**$1.1**	**+**	**$14.6**	**=**	**$15.7**	**100%**

Note: Numbers may not sum up due to rounding.

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[7] Expressed in 2015 dollars for present worth value, with a discount rate of four percent.

[8] Since nitrogen oxide (NOx) emissions also lead to the formation of PM2.5, the NOx reductions needed to meet the ozone standards will likewise lead to improvement of PM2.5 levels and attainment of PM2.5 standards.

[9] Costs are characterized as incremental costs, not as the total cost of a particular control equipment or program. Specifically, they represent the cost difference between a "business as usual" path and an alternative path as proposed by the Final 2016 AQMP. See Table 2-1 in Chapter 2 for more cost details for each measure.

Over 90 percent or $14.6 billion of the Final 2016 AQMP's total incremental cost is attributed to publicly funded incentive programs that eligible industries and consumers can use to offset the cost of purchasing cleaner technologies. Due to incentives and expected fuel savings, consumers are expected to see total cost savings of $2.3 billion. While some industries would similarly benefit from incentives and long-term cost-savings, private industries as a whole are expected to incur $3.4 billion in incremental costs.

- ***By implementing the Final 2016 AQMP, the risk of premature deaths among Basin residents and numerous other health risks associated with air pollution would be reduced. As a result, the four-county region is expected to gain a total public health benefit of $173 billion.***

Air pollution continues to be linked to increases in death rates (mortality) and increases in illness and other health effects (morbidity). Implementing the Final 2016 AQMP would lower many health risks associated with exposure to air pollution. These decreases in health risk are estimated to result in an average of 1,600 premature deaths avoided per year. Reductions in numerous other non-fatal health conditions were also estimated annually, including about 2,500 fewer asthma-related emergency department visits, about 700 fewer hospital admissions related to asthma, cardiovascular, or respiratory conditions, and more than 200,000 fewer person-days of work and school absences. These public health benefits have an estimated value of $173 billion, cumulatively from 2017 to 2031.[10]

TABLE ES-2: MONETIZED PUBLIC HEALTH BENEFITS OF THE FINAL 2016 AQMP

	Present Worth Value (Billions of 2015 dollars)
Mortality-related benefits	$170.8
Short-Term Ozone Exposure	$6.1
Long-Term PM2.5 Exposure	$164.7
Morbidity-related benefits	$2.4
Grand Total	**$173.2**

Over 95 percent of the estimated public health benefits are associated with a lower risk of premature deaths due to reduced long-term exposure to PM2.5, and the rest are associated with ozone mortality and avoided incidence of various respiratory and cardiovascular symptoms and of work and school absences. Although not quantified in the Final Socioeconomic Report, additional public welfare benefits exist relating to how clean air promotes visibility and prevents damage to agriculture, local ecology, buildings, and other materials.

[10] It should be emphasized that, as with any scientific studies and evaluations, there are various sources of uncertainty surrounding the estimated public health benefits, including the uncertainty embedded in data inputs, uncertainty of the magnitude of various health effects of exposure to air pollutants, and uncertainty of valuation. Given the significant contribution of mortality-related benefits, several sensitivity analyses were conducted, including one regarding the valuation parameters used. See Chapter 3 for more details as well as other sensitivity analyses.

- ***Projected job change from implementing the Final 2016 AQMP is expected to have minimal impact on regional job growth.***

The four-county regional economy currently generates more than a trillion dollars in GDP and supplies more than 10 million jobs.[11] Without implementing the Final 2016 AQMP, baseline jobs in the region are expected to grow at an annualized rate of 1.02 percent from 2016 to 2031.[12] Based on the four different scenarios analyzed, total jobs in the region are projected to grow between 1.01 and 1.04 percent annually over the same period, a small variation from the expected baseline growth in an economy with over 10 million jobs. Scenarios are based on a combination of two important factors: 1) whether public health benefits are taken into account and 2) whether incentive funding is assumed to be financed from existing state revenues allocated for the region or from existing unallocated federal funds.

TABLE ES-3: FOUR JOB SCENARIOS OF FINAL 2016 AQMP IMPLEMENTATION

	Health Benefits Included	No Health Benefits Included
Federal Revenues	**Best-Case Scenario:** • **1.04%** Annualized Job Growth between 2016 and 2031 • An additional **29,000 jobs gained** annually to an economy with over 10 million jobs	• **1.02%** Annualized Job Growth between 2016 and 2031 • An additional **6,000 jobs gained** annually to an economy with over 10 million jobs
State Revenues	**Primary Scenario:** • **1.04%** Annualized Job Growth between 2016 and 2031 • An additional **14,000 jobs gained** annually to an economy with over 10 million jobs	**Worst-Case Scenario:** • **1.01%** Annualized Job Growth between 2016 and 2031 • **9,000 jobs foregone** annually from an economy with over 10 million jobs

As seen in Table ES-3, when health benefits are included with incremental costs, an average of 12,000 jobs are expected to be gained annually under the state-funded primary scenario; whereas, more jobs, or an annual average of 29,000, are expected to be gained under the federally-funded best-case scenario.

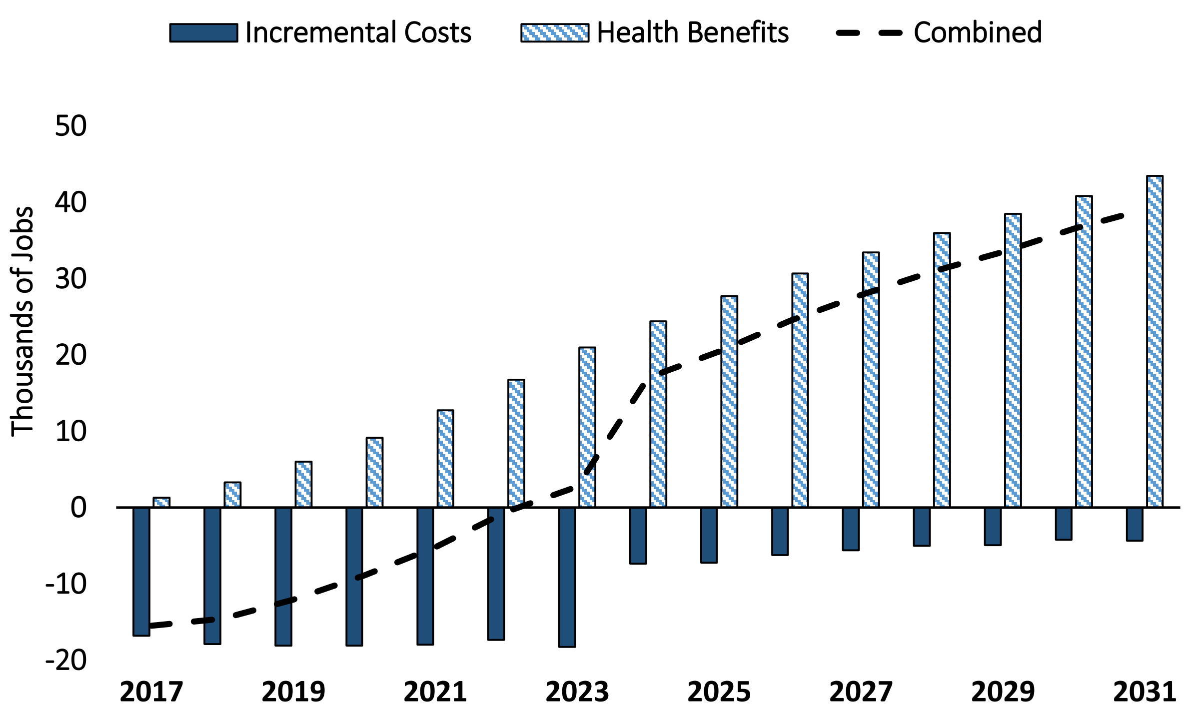
[11] U.S. Bureau of Economic Analysis, 2015 GDP and 2014 total job estimates (including payroll jobs and self-employment) for Los Angeles-Long Beach-Anaheim and Riverside-San Bernardino-Ontario metropolitan areas.

[12] The baseline scenario analyzed in this report is derived from the 2016 Growth Forecast, which is a long-term demographic and job forecast developed by the Southern California Association of Governments (SCAG 2016). SCAG's growth forecast was used to guide the development of its 2016 Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS), and it was also used by SCAQMD to develop the baseline emissions inventory for the Final 2016 AQMP and thus for air quality model projections. This growth forecast assumes that the four-county region would continue receiving federal highway funding to make the necessary infrastructure investments for implementing the 2016 RTP/SCS.

Job gains are smaller under the primary scenario because needing to use large amounts of existing state-funding allocated for the region for incentives implementation would divert funds away from local spending on other programs. As a result, this would dampen the positive job impact. In an economy with over 10 million jobs, however, a gain of 14,000 or 29,000 jobs a year would not have lasting effects on the region's long-term job outlook. Under either scenario, the annualized job growth rate between 2016 and 2031 would increase to 1.04 percent, which represents a 0.02 percentage point uptick in expected job growth of 1.02 percent without implementation of proposed control measures.

In the beginning years under the primary scenario, state government jobs would be most adversely impacted, followed by construction, retail trade, and the healthcare and social assistance sectors. Over time, as the proposed strategies are implemented and public health benefits are realized, healthcare related spending would be reduced, worker productivity would increase, and the region would become a more attractive place to live and work. As more economic migrants are enticed to the region, the labor supply would increase, creating more local demand for goods and services in the region. As the regional economy grows larger, more job opportunities would become available, as seen in Figure ES-1.

FIGURE ES-1: NET JOB IMPACTS OF THE FINAL 2016 AQMP IMPLEMENTATION PRIMARY SCENARIO



Of the 14,000 jobs expected to be gained on average each year under the primary scenario, they are expected to distribute differently among the 21 sub-county regions analyzed. The Central sub-region of Los Angeles County is expected to see the largest gain of jobs. An additional 2,100 jobs would be added each year to its projected average baseline of 1,239,000 jobs. The sub-region of Riverside Other in Riverside County would see 40 jobs foregone on average each year during the same period from its projected average baseline of about 413,000 jobs.

Even in the worst-case scenario where existing state funds for local spending must be used to finance incentives and no public health benefits are accounted for, the projected 9,000 jobs foregone annually would correspond to a 0.01 percentage point slowdown for the region's annualized job growth, from 1.02 percent to 1.01 percent, between 2016 and 2031.

Four CEQA alternatives were analyzed as alternative pathways to achieving attainment goals, and they were projected to have a similarly small job growth impact.[13]

- ***Overall inequality of health risks are expected to decrease in the Basin, with greater per-capita public health benefits accrued in Environmental Justice (EJ) communities versus non-EJ communities.***

Many Basin residents live, work, and play in areas with poorer air quality than others, and are often more economically disadvantaged. The EJ analysis was significantly enhanced in the Final Socioeconomic Report to assess the impacts of implementing the Final 2016 AQMP by answering these two important questions:

1. How does implementing the Final 2016 AQMP impact the inequality of health risks that already exist in the Basin?
2. Do more health benefits accrue in EJ versus non-EJ communities as a result of implementation of the Final 2016 AQMP?

Our analysis found that the overall health risk inequality in the region decreases, whether in terms of the risk of dying prematurely among adults or the risk of children having to go to emergency room for asthma exacerbations. Furthermore, while the entire Basin is expected to benefit from health risk reductions due to clean air, EJ communities are expected to gain greater per capita public health benefits versus non-EJ communities. Monetized benefits range between $1,900 and $2,000 per capita in EJ communities, approximately $300 to $400 higher than for non-EJ communities. These results are consistent across all alternative EJ definitions tested.[14]

Concluding Remarks

Overall, the implementation of the Final 2016 AQMP is expected to result in nearly $16 billion of incremental cost, while generating public health benefits of $173 billion. Even when uncertainties in health benefits valuation are taken into account, the range of public health benefits—$66 billion to $273 billion, cumulatively from 2017 to 2031—is still well above the estimated total cost. Moreover, over 90 percent of the anticipated incremental costs, mostly related to capital expenditures, would be financed by publicly funded incentive programs. In an economy with more than a trillion dollars in regional GDP and more than 10 million jobs across the four counties, these costs and benefits were projected to result in relatively minor job impacts and would not alter the region's long-term job growth. Additionally, overall health risk inequality is expected to decrease in the Basin. While all residents would benefit from reductions in air pollution-related health risk, a higher per capita benefit is anticipated to accrue in EJ communities, as a result of implementing the Final 2016 AQMP.

[13] See Chapter 4 for more information of job impacts under the four scenarios discussed. Sub-regional distribution of job impacts is discussed in Chapter 5. Chapter 7 discusses CEQA alternatives.

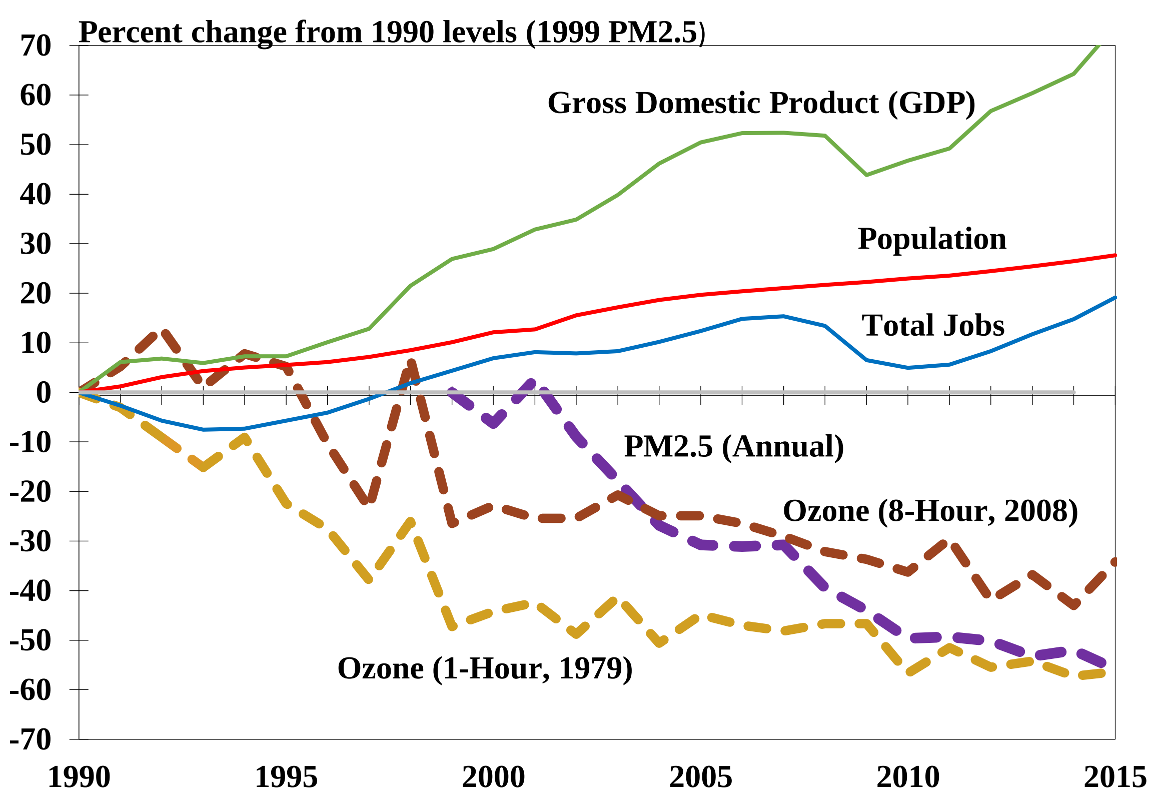
[14] See Chapter 6 for more information of the Environmental Justice Analysis.

Chapter 1: Introduction

Air quality in the South Coast Air Basin (Basin) has improved significantly over the years, and air quality control programs at the local, state and federal levels have played an important role. These improvements are demonstrated in Figure 1-1, which shows the air quality trends since 1990, including percent changes in the 8-hour ozone concentrations, the 1-hour ozone concentrations, and the annual average concentrations of fine particulate matter (PM2.5) since measurements began in 1999.

Concurrent economic trends, including percent changes in regional gross domestic product, total jobs and population, are also depicted in Figure 1-1. The 2007-2009 economic recession, precipitated by the housing market collapse and ensuing worldwide financial crisis, dealt a severe blow to the regional economy and employment. Since then, the slow pace of economic recovery in the nation amid global headwinds continues to cast uncertainties on the sustainability of this recovery. Despite these issues, California has been one of the nation's silver linings in recent years, and the economy of the four-county region—Los Angeles, Orange, Riverside and San Bernardino—is expanding again, with clearly rebounding jobs and output numbers that have exceeded pre-recession peaks.

FIGURE 1-1: AIR QUALITY HAS IMPROVED AMID POPULATION INCREASES AND RISE IN ECONOMIC ACTIVITY (SCAQMD FOUR-COUNTY REGION, 1990-2015)



Economic growth and other human activities generally result in increased air pollutant emissions (i.e., anthropogenic emissions). However, the increased utilization of low-emitting and more energy efficient technologies have nonetheless resulted in decreased ozone and PM levels. Thus, advances in technology demonstrate that it is possible to maintain a healthy economy while improving public health through air quality improvements. This reality has been demonstrated in the past, and with concerted efforts by all stakeholders, can continue into the future.

Challenges to Attaining Air Quality Standards

While substantial progress and improvements in air quality have been made, the region still does not meet all federal and state air quality standards set to protect public health. The Final 2016 Air Quality Management Plan (AQMP) is designed to provide a path to clean air goals and address federal Clean Air Act (CAA) requirements for ozone and PM2.5 standards.

The CAA requires areas not attaining the national ambient air quality standards (NAAQS) to develop and implement an emission reduction strategy that will bring the area into attainment in a timely manner. For ozone and PM2.5, the area is given a classification that describes the degree of nonattainment. This classification dictates specific planning requirements under the CAA, including the time provided to attain the standard. The CAA requires attainment of the standard to be achieved as "expeditiously as practicable," but no later than the attainment years listed in Table 1-1 below.

TABLE 1-1: AIR QUALITY STANDARDS AND LATEST ATTAINMENT YEAR

Standard	Concentration	Classification	Latest Attainment Year
2008 8-Hour Ozone	75 ppb	Extreme	2031
2012 Annual PM2.5	12.0 μg/m^3	Moderate	2021
		Serious	2025
2006 24-Hour PM2.5	35 μg/m^3	Serious	2019
1997 8-Hour Ozone	80 ppb	Extreme	2023
1979 1-Hour Ozone	120 ppb	Extreme	2022

Note: "ppb" stands for parts per billion and "μg/m^3" stands for microgram per cubic meter.

The most significant air quality challenge in the Basin is to reduce nitrogen oxide (NOx) emissions[1] sufficiently to meet the upcoming ozone standard deadlines. Although the existing air regulations and programs will continue to lower NOx emissions in the region, an additional 43 percent of NOx emission reductions in the year 2023 and an additional 55 percent in the year 2031 are necessary to attain the 8-hour ozone standards.[2] Since NOx emissions also lead to the formation of PM2.5, the NOx reductions

[1] NOx emissions are a precursor to the formation of both ozone and secondary PM2.5.

[2] Estimates are based on the inventory and modeling results and are relative to the baseline emission levels for each attainment year (see Final 2016 AQMP for detailed discussion).

needed to meet the ozone standards will likewise lead to significant improvement of PM2.5 levels and attainment of PM2.5 standards.

Latest Scientific Evidence Relating Ozone and PM2.5 Exposure to Public Health

Ambient air pollution is a major public health concern. Ozone and PM2.5 are the two pollutants being targeted to meet federal air quality standards in the Final 2016 AQMP and they continue to be linked to increases in illness (morbidity) and increases in death rates (mortality).[3]

In 2013, the U.S. Environmental Protection Agency (U.S. EPA) released the latest Integrated Scientific Assessment (ISA) of ozone and related photochemical oxidants (U.S. EPA 2013). It was concluded in the assessment that there was a causal relationship between short-term ozone exposure and respiratory effects, and a likely causal relationship between long-term ozone exposure and respiratory effects. Short-term ozone exposure was also determined to have likely causal relationships with mortality and cardiovascular effects. U.S. EPA additionally identified groups with increased risk from ozone exposure such as outdoor workers, individuals with asthma, children, elderly adults, and people with certain vitamin deficiencies. As a result of these findings, in 2015, the U.S. EPA revised the 8-hour ozone standard to 70 ppb from 75 ppb. While the Basin needs to attain the 2008 standard of 75 ppb in 2031, the attainment deadline of the 2015 standard of 70 ppb is anticipated to be 2037 if the Basin retains the classification as an extreme nonattainment area.

With regard to particulate matter, the 2009 ISA[4] released by the U.S. EPA concluded that both mortality and cardiovascular effects had a causal relationship with both short- and long-term PM2.5 exposures (U.S. EPA 2009). Respiratory effects were also likely to have a causal relationship with short- and long-term exposure to PM2.5. Numerous studies showing the causal relationship between PM2.5 and negative health effects have been closely scrutinized with the data being reanalyzed by additional investigators. The re-analyses confirmed original findings, and there were additional studies reviewed in the 2009 ISA that confirmed and extended the range of the adverse health effects of PM2.5 exposures. As a result, in 2012, the U.S. EPA revised the PM2.5 annual average standard to 12.0 $\mu g/m^3$, which the Basin needs to attain in 2025 as a serious nonattainment area.

In a systematic literature review commissioned by the South Coast Air Quality Management District (SCAQMD), Industrial Economics, Inc. (IEc) found 27 studies published since 2012 that assessed the relationship between mortality and PM2.5 exposure that were conducted in the U.S. or Canada. Four studies focused on effects of PM2.5 exposures on populations within California or within the Los Angeles metropolitan area specifically. Collectively, these newer studies provided additional evidence to support the U.S. EPA's determination of a causal association between PM2.5 exposure and mortality due to both short- and long-term exposure (Industrial Economics, Inc. 2016a).

[3] See Appendix I of the Final 2016 AQMP for a discussion of these studies.

[4] The 2009 PM ISA is currently being updated, with draft materials being circulated for public input.

Legal Requirements for Socioeconomic Analysis

Both the SCAQMD Governing Board and the California Health & Safety Code require preparation of a socioeconomic analysis whenever the SCAQMD adopts or amends emission reduction rules or regulations. Although these requirements do not apply to preparation of the AQMP, the SCAQMD nonetheless elects to perform a separate socioeconomic analysis of the AQMP in order to further inform public discussions and the decision-making process associated with adoption of the Plan.

In so doing, SCAQMD staff is guided by a Governing Board Resolution adopted in 1989. That resolution directed staff to prepare an economic analysis of all emissions reduction rules proposed for adoption or amendment. The analysis was to include the following elements: identification of affected industries, cost effectiveness of control, and public health benefits in any such analysis.

Staff is additionally guided by the California Health & Safety Code requirements for socioeconomic analyses prepared during the rulemaking process. In particular, Health and Safety Code Section 40440.8 lists relevant impacts to be considered in a socioeconomic analysis. These impacts include:

1. The type of industries affected by the rule or regulation.
2. The impact of the rule or regulation on employment and the economy in the Basin.
3. The range of probable costs, including costs to industry, of the rule or regulation.
4. The availability and cost-effectiveness of alternatives to the rule or regulation.
5. The emission reduction potential of the rule or regulation.
6. The necessity of adopting, amending, or repealing the rule or regulation in order to attain state and federal ambient air standards.

Health and Safety Code Section 40728.5 identifies similar impacts to be discussed in a socioeconomic analysis and additionally states that efforts shall be made to minimize any adverse impacts.

Finally, staff may also consider Health and Safety Code Sections 39616 and 40920.6 during its preparation of the socioeconomic analysis. Section 39616 requires the SCAQMD to ensure that any market-based incentive strategy it adopts results in equivalent or greater emission reductions at equivalent or less cost and overall job impacts – i.e., no greater job losses or significant shifts from high-paying to low-paying jobs – when compared to command-and-control regulations. Section 40920.6, requires that incremental cost effectiveness – i.e., the difference in costs divided by difference in emission reductions – be performed whenever more than one control option is feasible to meet control requirements.

Economic Outlook for Industries Potentially Affected by the Final 2016 AQMP

Nearly 18 million people currently reside in the counties of Los Angeles, Orange, Riverside and San Bernardino. The four-county regional economy generates over one trillion dollars of gross domestic product and employs more than 8 million workers, with a four to six percent unemployment rate among the four counties.[5,6,7] The region currently supplies about 7.5 million payroll jobs.[8] Between July 2012 and July 2016, total payroll jobs in the region have increased at an annualized rate of nearly 2.5 percent.[9] In the long-term, based on projections by the Southern California Association of Governments (SCAG), total jobs in the region are forecasted to grow at an annualized rate of one percent between 2016 and 2031.[10]

The Final 2016 AQMP includes control strategies for emission reductions from both stationary and mobile sources to attain upcoming NAAQS. Stationary source control measures are proposed by SCAQMD whereas the braoder mobile source control measures are proposed by the California Air Resources Board (CARB), with SCAQMD's local mobile source measures proposed mainly to facilitate local implementation of CARB's mobile source control strategy. These strategies are comprised of both command-and-control regulations and incentive programs[11], as well as further deployment of advanced clean technologies. These proposed control strategies could potentially affect both public and private sectors, but are expected to mainly impact the nine private sector industries as listed below:

- Oil & Gas Extraction
- Utilities
- Construction
- Manufacturing
- Nurseries, Wholesale Garden
- Transportation & Warehousing
- Equipment Leasing and Rental
- Waste Management
- Restaurants

Figure 1-2 shows the regional job outlook between 2016 and 2031 for the potentially affected industries, based on SCAG projections.

Both SCAQMD and CARB's mobile source strategies would primarily affect passenger transportation and the "goods movement" sector, the core of which constitutes freight transportation and warehousing. The goods movement sector plays a pivotal part in the regional economy. It provides the critical service of

[5] California Department of Finance, State/County Population Estimates as of January 1, 2016.

[6] U.S. Bureau of Economic Analysis, 2015 GDP estimates for Los Angeles-Long Beach-Anaheim and Riverside-San Bernardino-Ontario metros.

[7] California Economic Development Department (EDD), preliminary estimates as of October 2016, civilian employment only. A five-percent unemployment rate is generally considered as "full employment" by the Federal Reserve.

[8] EDD Current Employment Survey (CES) estimates as of November 2016 for Anaheim-Santa Ana-Irvine, Los Angeles-Long Beach-Glendale metro divisions, and Riverside-San Bernardino-Ontario MSA. Does not include self-employed, family workers, and private household employees.

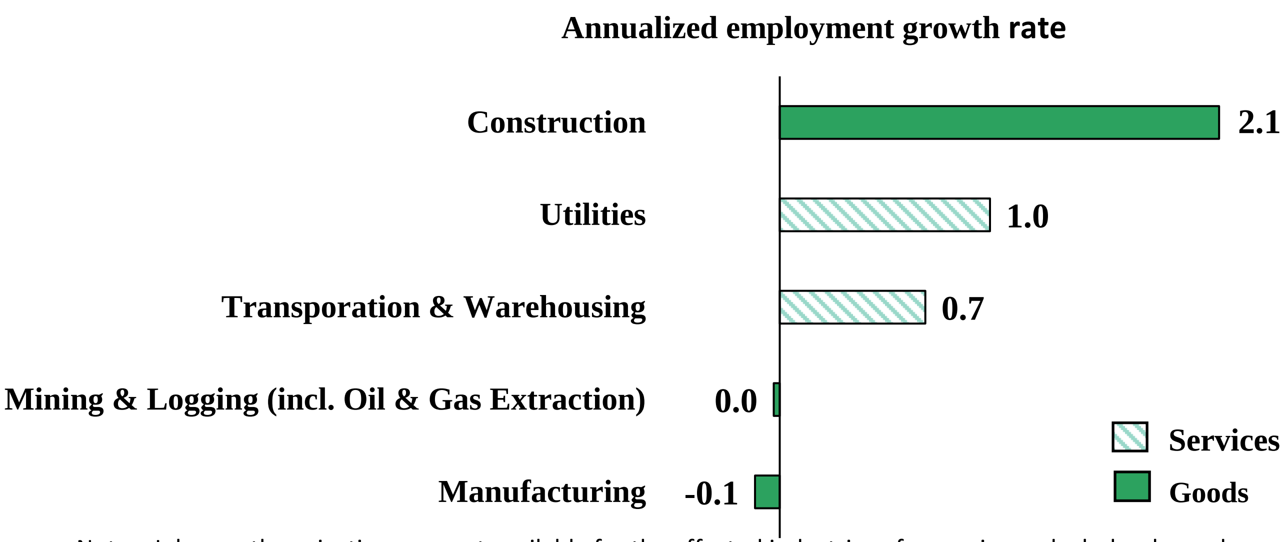
[9] Edd, current employment statistics (CES), July 2012 and July 2016.

[10] Based on SCAG's Growth Forecast in the 2016 Final Regional Transportation Plan/Sustainable Communities Strategy.

[11] The Draft Financial Incentives Funding Action Plan for the 2016 AQMP provides more information regarding how incentive programs are expected to be implemented as well as potential funding sources and opportunities. The document can be found at http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/draftfinancialincentivefunddec2016.pdf

delivering goods between the region's seaports and airports and businesses across the nation. It also serves the fast-growing consumer demand for retail products purchased online.[12] The strong dollar and demand for imports, coupled with increases in e-commerce and the competition among the retailers to shorten delivery time, especially to large urban markets, puts a growing number of high-cube distribution centers in the Inland Empire at a strategic economic advantage. The transportation and warehousing sector currently provides 291,300 payroll jobs or 4 percent of all payroll jobs in the region.[13] Over the next 15 years, the sector as a whole is expected to grow at an annualized rate of 0.7 percent. Much of this job growth will be concentrated in the Inland Empire. Currently, average pay in this sector ranges from $38,000 in Riverside County to $56,000 in Los Angeles County, which are respectively seven percent below the average wage in Riverside County and about the average wage in Los Angeles County.[14]

FIGURE 1-2: CONSTRUCTION LEADS PROJECTED JOB GROWTH WHILE MANUFACTURING DECLINES



Notes: Job growth projections are not available for the affected industries of nurseries and wholesale garden, equipment leasing and rental, and waste management, and restaurants.
Source: Staff analysis of SCAG's growth forecast in the 2016 Final RTP/SCS Plan.

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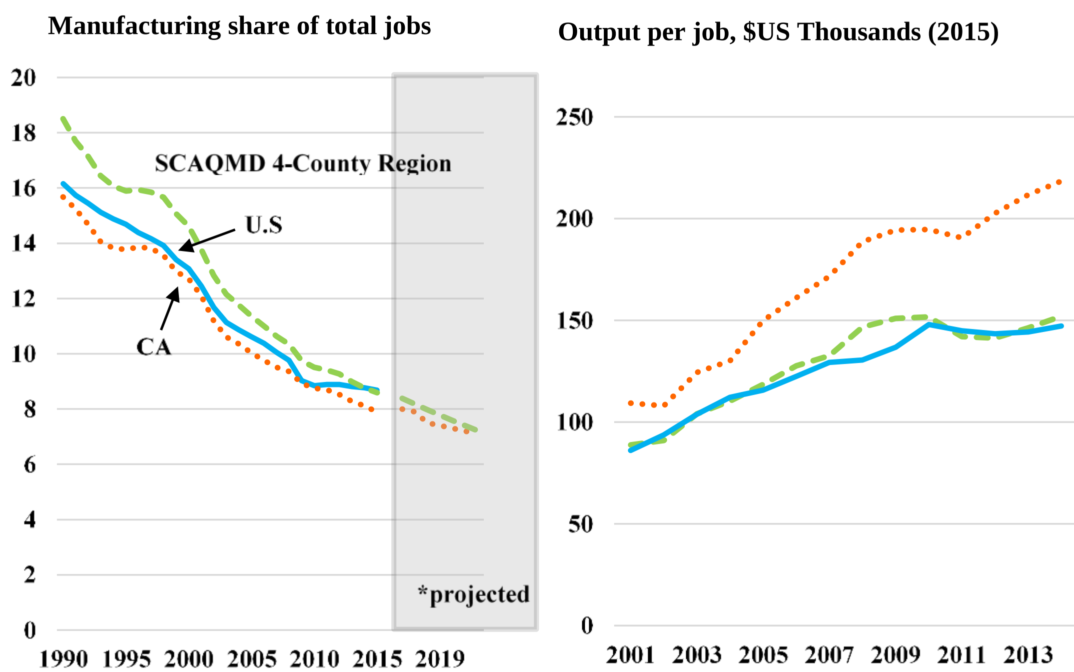
[12] According to the 2013 market research by eMarketer, online retail in the U.S. grew by 16.4 percent from 2012 to 2013 and totaled $262.3 billion in sales; by 2017, it was expected to reach $440 billion (Jones 2013).

[13] Based on EDD's CES for November 2016. All current job numbers listed below are from this source unless otherwise noted and unlike the BEA total jobs estimate that includes self-employment, CES estimates represent "payroll" jobs only

[14] Historical wage data from California Employment Development Department's Quarter Census of Employment and Wage (QCEW) database for 2015 Q3 wages. All the wage data in this section is from this source unless otherwise noted and is reported for the county with the lowest average annual wage in a specific industry and the county with the highest. The average wage represents the average of all industries covered by QCEW in both private and public sectors. According to EDD, the average annual pay is affected by the ratio of full-time to part-time workers; the number of workers who worked for the full year; and the number of individuals in high-paying and low-paying occupations. When comparing average pay levels between geographic areas and industries, these factors should be taken into consideration. For example, industries characterized by high proportions of part-time workers will show average wage levels appreciably less than the pay levels of regular full-time employees in these industries. The opposite effect characterizes industries with low proportions of part-time workers, or industries that typically schedule heavy weekend and overtime work. Average wage data also may be influenced by work stoppages, labor turnover, retroactive payments, seasonal factors, bonus payments, and so on.

The manufacturing sector would be affected by stationary source measures targeting NOx and Volatile Organic Compound (VOC) emissions, which include both command-and-control regulations and incentive programs to accelerate facility modernization. In the meantime, transportation equipment manufacturers in the region and nationwide would benefit from the incentive programs proposed to accelerate the deployment of zero and near-zero emission technologies, as part of the mobile source control strategies. The manufacturing sector in the region currently provides 608,100 payroll jobs or about 8 percent of all payroll jobs in the region; however, the sector's total job count is expected to mirror the nationwide trend and continue its long-term decline (see Figure 1-3). Manufacturing jobs are projected to decrease by an annualized rate of 0.1 percent over the next 15 years. More than half of the projected manufacturing job losses would occur in Los Angeles County where the industry is concentrated.

FIGURE 1-3: OUTPUT PER WORKER INCREASES DESPITE STEADY DECLINE IN MANUFACTURING JOBS



Data Sources: SCAG, U.S. Bureau of Labor Statistics and U.S. Bureau of Economic Analysis.

Despite the industry's shrinking workforce, its output per worker has increased over time, rising from $89,000 to $152,000 (in 2015 dollars) over the 2001 to 2014 time period (see Figure 1-3).[15] Currently, the average pay in the sector ranges from $50,000 in Riverside County to $69,000 in Orange County, paying about a quarter more than the average wages in these counties. Both chemical manufacturers and refineries are expected to be impacted by stationary source measures. Chemical manufacturing pays slightly higher with average pay ranging from $58,000 in Riverside County to $70,000 in Orange County. Petroleum manufacturing pays substantially higher, ranging from $75,000 in Riverside County to $117,000 in Los Angeles County.

[15] Output from the U.S Bureau of Economic Analysis and employment data from the U.S. Bureau of Labor Statistics.

Transportation equipment manufacturing and its related industries will be key partners in the joint effort to reduce mobile source emissions, as it plays a pivotal role in the research, development and deployment (RD&D) of advanced clean transportation technologies, whether they apply to light-duty passenger cars or heavy-duty commercial trucks. Funding programs can help lower the upfront financial barriers for deploying cleaner technologies and realize long-term benefits such as fuel-savings. Long-term cost-savings can potentially become greater over time as the sector shifts towards producing not only the hardware but the software that will be needed to help increase fuel efficiency. Past funding programs have incentivized several truck engine manufacturers to develop and demonstrate that ultra-low NOx technologies (0.02 g/bhp-hr) are technically feasible. These technologies have provided the basis for CARB's Low-NOx Engine Standard control measure for heavy-duty vehicles, proposed as part of the State Implementation Plan (SIP). Currently, the transportation equipment manufacturing industry in coastal counties provides 61,400 payroll jobs or nearly one percent of payroll jobs in the region and is projected to decline by 0.1 percent annually from 2016 to 2031. The average wage in this sector ranges from $41,000 Riverside County to $88,000 in Los Angeles County, which is about the overall average wage in Riverside County and nearly 60 percent higher than the average wage in Los Angeles County.

Restaurants would be affected by a NOx measure that proposes the installation of cleaner cooking equipment. Restaurants are one of the region's major small business employers with nearly all establishments employing fewer than 100 people.[16] It currently provides 594,000 payroll jobs and accounts for about eight percent of payroll jobs in the region. However, restaurants typically offer lower paying jobs—the recent annual compensation is on average about $17,000 in Riverside County to $20,000 in Los Angeles County, more than 60 percent below the average wages in these counties.

Energy producers, who are broadly considered to include the oil and gas extraction industry and the utilities sector, would also be affected by the proposed control measures. Oil and gas extraction is a highly capital intensive industry. While the industry's total output was as high as $1.4 billion in 2012,[17] it provides only a few thousand payroll jobs[18] in the region and pays on average six-figure wages that are similar to or higher than in the petroleum manufacturing industry. The industry sector of utilities currently provides 21,000 payroll jobs in the region. It offers high paying jobs in all counties with average pay ranging from $90,000 in San Bernardino to $101,000 in Orange County, which is 130 and 80 percent higher than the average wage in the respective counties. Job growth for energy producers is projected to remain relatively flat between 2016 and 2031.

Additionally, the industry of waste management and remediation service would be impacted by a VOC/PM2.5 measure. The industry currently provides 18,000 payroll jobs[19] and average pay ranges from $54,000 in San Bernardino County to $61,000 in Orange County, which is about 30 and eight percent more than the average wage in their respective counties. Construction, the fastest growing industry in the Basin, is expected to be directly affected by mobile source strategies incentivizing the conversion to cleaner equipment and a stationary source strategy regulating the VOC content of coatings, solvents, adhesives,

[16] Based on the establishment-by-size data for the four counties from the U.S. Census Bureau's 2014 County Business Patterns Database.

[17] Bureau of Economic Analysis.

[18] CES data do not provide job estimates for the oil and gas extraction industry; however, this industry belongs to the broader sector of mining and logging, with current number of jobs estimated at about 5,100. Moreover, the QCEW data indicated that, in Los Angeles County alone, the oil and gas extraction industry supplied approximately 2,000 jobs in the third quarter of 2015.

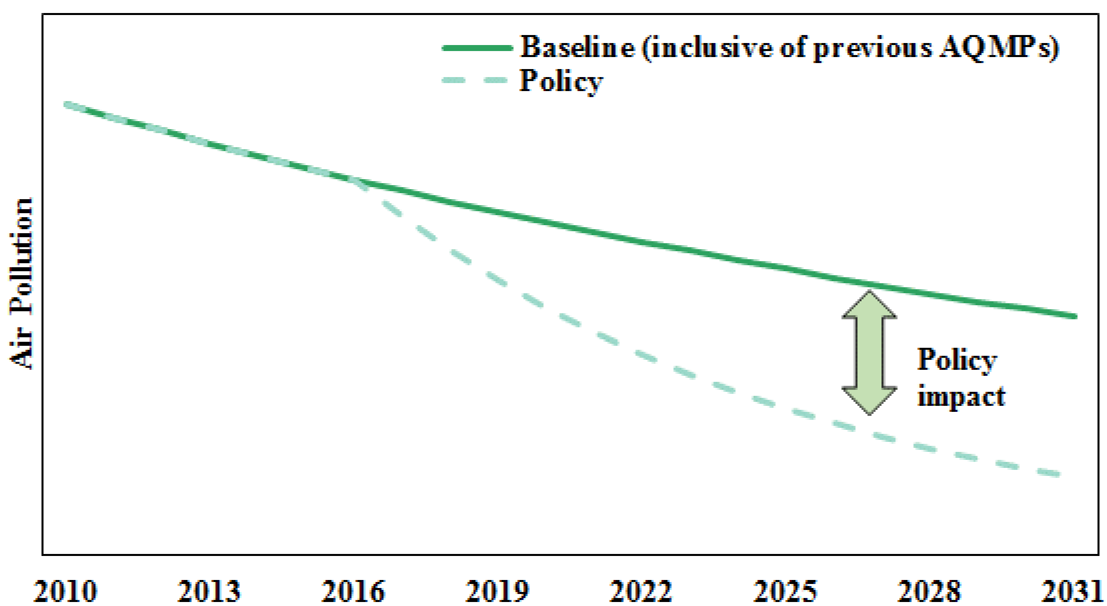
[19] Unlike other current job estimates, this figure is based on the QCEW 2015 third quarter data.

and sealants. In the meantime, however, construction could potentially benefit from additional revenues from installing control equipment. Currently, the construction industry provides 317,800 payroll jobs or about four percent of payroll jobs in the region. The industry is expected to grow at an average annualized rate of about two percent from 2016 to 2031. The average pay in the sector ranges from $50,000 in Riverside to $63,000 in Orange County, about 25 and 15 percent higher than the average job in the respective counties. Finally, the proposed control measures would also affect segments of the retail and wholesale trades (e.g., nurseries and wholesale garden suppliers), as well as commercial and industrial machinery and equipment rental and leasing.

Baseline Definition for Socioeconomic Assessment

A fundamental component in the practice of socioeconomic analysis is the definition of the baseline for analysis. The "baseline" is often referred to as the expected path (of pollution concentrations, the regional economy, etc.) without the implementation of a plan i.e. "policy". The difference between the baseline and policy scenario is the policy impact (an example of this is illustrated in Figure 1-4).

FIGURE 1-4: ILLUSTRATIVE EXAMPLE OF BASELINE AND POLICY SCENARIOS



For the purpose of this socioeconomic analysis, the impacts of the Final 2016 AQMP, which is implemented in the policy scenario,[20] are evaluated with respect to the baseline scenario, which is a projection of the regional economy *without* the implementation of the control measures described in

[20] "Policy scenario" is used interchangeably with "control scenario" throughout the report, particularly in the discussion of regional air quality modeling as an input to the quantification of public health benefits.

Final 2016 AQMP.[21] The baseline scenario is inclusive of any effects that have not yet occurred but are projected to occur as a result of all existing plans, regulations, and policies, including those adopted and implemented pursuant to previous AQMPs. Specifically, all SCAQMD rules adopted as of December 2015 and all CARB rules adopted by November 2015, are incorporated into the baseline, while rules after these dates are not (for more information see Final 2016 AQMP Appendix III-B).[22]

The baseline scenario analyzed in this report is derived from the 2016 Growth Forecast, which is a long-term demographic and job forecast developed by SCAG (SCAG 2016). SCAG's growth forecast was used to guide the development of its 2016 Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS), and it was also used by the SCAQMD to develop the baseline emissions inventory for the Final 2016 AQMP and thus for air quality model projections. This growth forecast assumes that the four-county region would continue receiving federal highway funding to make the necessary infrastructure investments for implementing the 2016 RTP/SCS. For this reason, the baseline scenario for both emission inventory and socioeconomic analysis purposes includes implementation of the 2016 RTP/SCS.

The socioeconomic analysis herein attempts to address any deviations from the baseline as the Final 2016 AQMP is fully implemented in terms of benefits of cleaner air, incremental costs of control strategies, and spillover impacts of direct benefits and costs. These deviations represent the socioeconomic impact of the Final 2016 AQMP, and they do not overlap with any cost, benefit, and macroeconomic impacts analyzed for the 2016 RTP/SCS. The impacts of the 2016 RTP/SCS are separately summarized and discussed in Appendix IV-C of the Final 2016 AQMP. Similarly, the air quality improvements projected in the Final 2016 AQMP do not overlap with any emission reductions attributable to the 2016 RTP/SCS or any of its components such as the Transportation Control Measures (TCMs). TCMs are included in the Final 2016 AQMP for air quality conformity purposes (for more information see Chapter 4 and Appendix IV-C of the Final 2016 AQMP).

This baseline definition is employed consistently throughout the socioeconomic analysis both for quantifying costs and benefits, and for determining regional macroeconomic impacts from implementation of the Final 2016 AQMP control strategies. The costs evaluated in this socioeconomic analysis are the total incremental cost expected to be incurred due to Final 2016 AQMP control strategies. Any costs associated with TCMs and TCM-type projects included in SCAG's 2016 RTP/SCS are excluded from this analysis. Public health benefits reflect air quality improvements attributable to the Final 2016 AQMP control measures. Any benefits associated with TCMs and TCM-type projects included in SCAG's 2016 RTP/SCS are excluded from this analysis. The regional macroeconomic impact model, REMI PI+ v1.7, baseline forecast is updated with the job and population forecasts from SCAG (2016), ensuring that the baseline used for costs and benefits analyses is consistent with that used for macroeconomic modeling (for more information see Appendix 4 of this report).

The socioeconomic analysis horizon is from 2017 to 2031, where 2017 is expected to be the year when the Final 2016 AQMP is adopted and 2031 is the last year of the planning horizon, at which time the federal 8-hour ozone standard will need to be attained (see the Final 2016 AQMP for the attainment demonstration). SCAG forecasts jobs and population in the four-county region to grow by 16 percent and 11 percent, respectively, from 2016 (base year for job growth) to 2031. The County of Riverside is

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[21] These "without" (baseline) and "with" (policy) scenarios are different than "before" and "after" scenarios, because they control for changes over time.

[22] This includes the reduction in RECLAIM trading credits (RTCs) by 12 tpd by year 2022, which was adopted by the SCAQMD Governing Board in December 2015.

projected to grow at the fastest pace: jobs are projected to increase by 36 percent and population by 22 percent over the period of 2016 to 2031.

It should be noted that the receipt of federal highway funding for transportation investment in the region hinges on adopting an appropriate plan to achieve the federal air quality standards (i.e., the highway sanction clause in the CAA). Ultimately, failure to attain these standards could have undesirable economic consequences for the region if it results in the inability to have an approvable plan or results in a failure to implement the plan. However, this outcome is not incorporated into the baseline as the purpose of this socioeconomic analysis is to evaluate the impact of the Final 2016 AQMP, not the impacts of a scenario where the region is penalized for failure to attain NAAQSs.

Current Socioeconomic Analysis Program

SCAQMD staff continually seeks to improve its analysis of socioeconomic impacts by expanding the scope of analysis, as well as the methods and tools utilized. Over the years, the SCAQMD socioeconomic analyses have evolved as shown in Figure 1-5. The evolution has been informed by two major reviews of the socioeconomic assessment procedures and guided by the Scientific, Technical and Modeling Peer Review (STMPR) Advisory Group members, who are economists from academia, other government agencies (SCAG, CARB, and U.S. EPA), the Center for Continuing Study of California Economy (CCSCE), and other economic research and consulting firms. The first comprehensive review was conducted by the Massachusetts Institute of Technology (MIT) in 1992 (Polenske, et. al 1992). This review found that the SCAQMD surpassed most other agencies in analytical methods and recommended further enhancements, which included using alternative approaches in certain areas and working with the regulated community and socioeconomic experts to refine its socioeconomic assessment.

In 2014, Abt Associates, Inc. (Abt) conducted the second comprehensive review of the SCAQMD's socioeconomic assessments (Abt Associates 2014). This review found that the SCAQMD socioeconomic assessment is more comprehensive in both breadth and depth relative to those conducted by the majority of other agencies considered in Abt's evaluation effort. Abt also found that SCAQMD staff uses sound methodologies to analyze costs, health benefits, and economic impacts. For further enhancements, Abt provided a list of major and minor recommendations.

The key recommendations concerned multiple areas. First, Abt recommended that SCAQMD clearly define the baseline and policy scenarios, specifically, whether SCAG's TCMs and their associated benefits and costs are considered as part of the AQMP policy scenario. Second, while Abt supported the continued use of REMI for economic impact analysis, it recommended that SCAQMD staff: 1) use other modeling tools and analysis for small industry sectors and small businesses; 2) improve the REMI amenity inputs; and 3) keep abreast of the U.S. EPA's development of methods for applying benefits in economy-wide models. In addition, Abt advised that SCAQMD improve the uncertainty analyses, expand the environmental justice (EJ) analysis, and institute a systematic process to review and update recent literature in specific areas. Finally, in the interest of transparency, Abt recommended that the SCAQMD: 1) involve the scientific advisory group; 2) increase public outreach; 3) make the peer review process clearer; and 4) enhance documentation and clarity to consider different types of audiences.

Between the two reviews, there have been a number of major enhancements to the SCAQMD socioeconomic assessment. In 2000, towards the goal of expanding its analysis tools, SCAQMD staff commissioned BBC Research and Consulting to examine approaches to assess impacts of proposed regulations on a spectrum of facilities and to evaluate impacts of rules after their adoption. The study results indicated the need to employ a variety of external data sources, construct internal time series data, and explore data sharing opportunities with other governmental agencies.

Beginning in 2000, published economic statistics at the industry level have moved away from the Standard Industrial Classification (SIC) system to the North American Industrial Classification System (NAICS) to include new and emerging industries such as information technologies, among others. In 2006, all the potentially affected point source facilities in the 2002 emission inventory were re-designated with appropriate NAICS codes. The American Community Survey (ACS) continuously samples population to provide up-to-date demographic statistics to supplement information not provided by decennial censuses. There are ACS one-year, three-year, and five-year estimates for various purposes. The 2006 to 2008 estimate was used to expand the four-county geography to 21 sub-regions from the previous 19 regions.

Since 2007, SCAQMD staff has used the Environmental Benefits Mapping and Analysis Program (BenMAP) to assess health benefits associated with reductions in exposure to criteria pollutants. BenMAP is currently maintained and used by the U.S. EPA to assess health benefits of federal rules. It is a geographic information system (GIS) application which integrates epidemiological studies with air quality and demographic data, as well as economic valuation methodologies to quantify health effects associated with pollutant concentration and economic values associated with these effects.

In preparation for development of the socioeconomic assessment of the Final 2016 AQMP, SCAQMD staff has consulted with the AQMP Advisory Group, the STMPR Advisory Group, SCAG, CARB, California Department of Finance, and U.S. EPA staff, as well as independent consultants to discuss possible and future refinements to data collection, modeling, and other aspects of socioeconomic of analyses. In 2015, SCAQMD staff continued to refine its socioeconomic analysis as recommended by Abt. During 2015, staff held multiple study sessions with SCAG staff and consultants and came to consensus on the most suitable approach to define the baseline for the socioeconomic analyses. Three Requests for Proposals were issued relative to analysis of health benefits, environmental justice, and small scale economic impacts. A contract was issued for a third-party evaluation of macroeconomic modeling of public health and other non-market benefits. Based on a stakeholder request that was documented in the Abt report, but not recommended in the Abt report, another contract was issued for analysis of the health impacts of unemployment in the SCAQMD region. The findings of the latter two contracts were published and made available to the public (Lahr 2016; Tekin 2015).[23]

In addition, an Ad Hoc Governing Board Committee on Large Compliance Investments and Regulatory Uncertainty was formed in 2015 to evaluate recent concerns raised by the business community regarding investing in pollution control technologies only to have them become stranded assets as a result of later rule amendments. In 2016, the 2016 AQMP--Socioeconomic Assessment EJ Working Group was formed to further engage stakeholders to help staff enhance the impact analyses on EJ communities.

In addition to enhancements made to the costs, benefits, macroeconomic impact, and EJ analyses, other Abt recommendations are also implemented throughout this report. They include improving the

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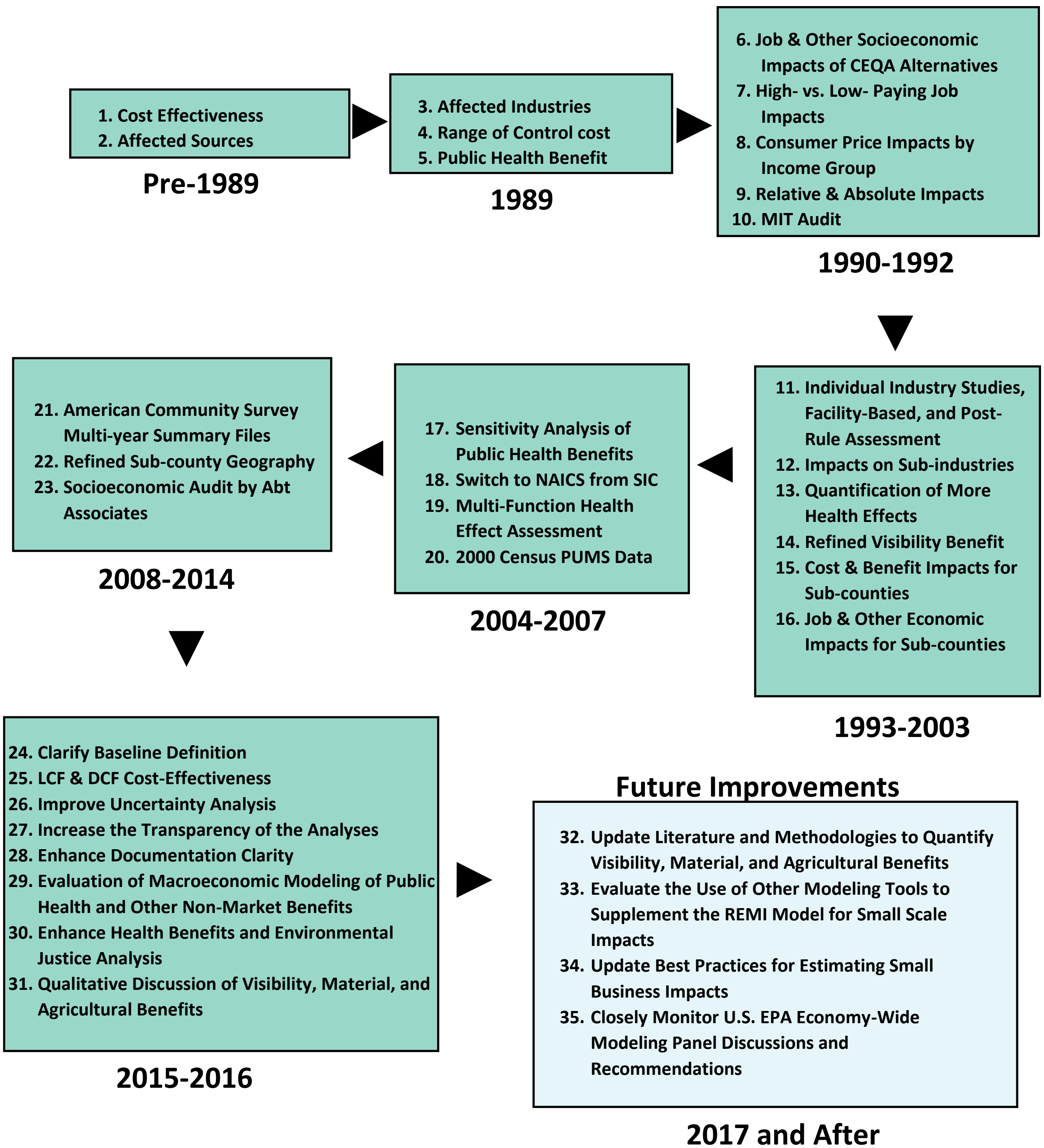
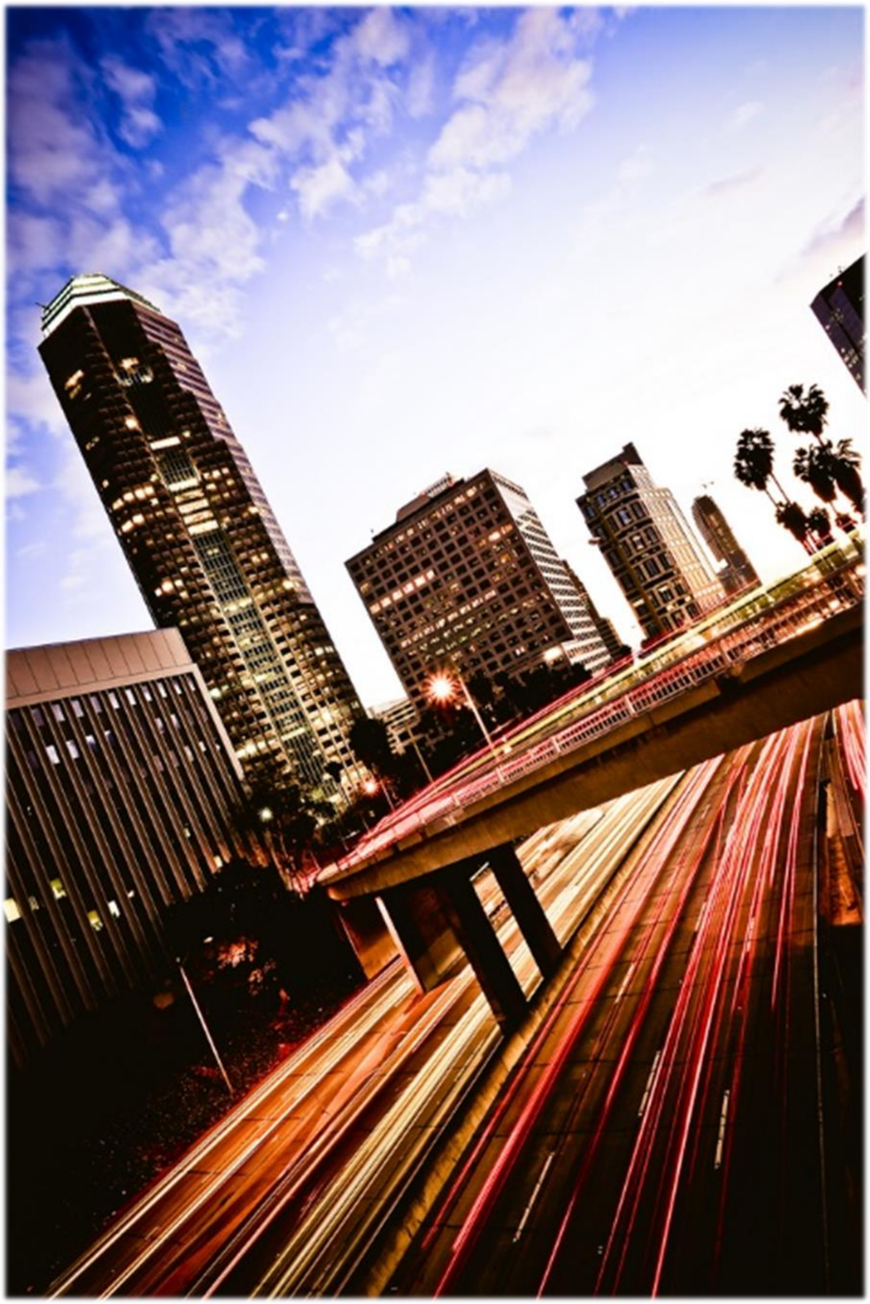
[23] The Evaluation of Macroeconomic Impacts of Non-Market Benefits can be found here: http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/lahr_evalmacroeconimpacts_041716.pdf
The Final Report on Unemployment and Health can be found here: http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/unemploymentandhealth_dec2015_012616.pdf

uncertainty analyses, increasing the transparency of the analyses, increasing public outreach, making the peer review process more transparent, and enhancing documentation and clarity to consider different types of audiences. The implementation of the Abt recommendations will be discussed in detail in the ensuing chapters and summarized in the closing chapter.

FIGURE 1-5: EVOLUTION OF SOCIOECONOMIC ANALYSIS



Chapter 2: Incremental Costs



The Final 2016 AQMP control strategies will seek emission reductions from stationary and mobile sources through command-and-control regulations and incentives to help accelerate the deployment of cleaner equipment. The cost analysis herein quantifies the incremental cost associated with the additional actions needed to achieve sufficient emission reductions for attaining the federal ozone and PM2.5 standards.

What is Quantified in the Estimated Costs of Final 2016 AQMP Measures?

Estimated costs associated with the Final 2016 AQMP are characterized as incremental costs, not as the total cost of a particular control equipment or program. Specifically, they represent the cost difference between the baseline path and an alternative path as proposed by the Final 2016 AQMP to reach the attainment targets. As an illustrative example, if a piece of low-emission replacement equipment costs $5,000, and without the proposed actions identified in the control strategies, it can be reasonably expected that an affected facility would normally purchase a conventional model as a replacement for $2,000, then the *total incremental cost* associated with purchasing the low-emission model would be $3,000 ($5,000-$2,000=$3,000). Suppose a $1,500 cash rebate is available, then the affected facility will not incur the total incremental costs, but the *remaining incremental cost* of $1,500 ($3,000 price difference between models - $1,500 rebate=$1,500).[1]

Present Value (PV) of Total Incremental Costs
= PV of Remaining Incremental Costs + PV of Incentives

Note that only the remaining incremental costs will be directly incurred by the affected entities, including businesses and consumers. The incentive funds may be financed by different levels of government from their existing revenue sources, or by introducing additional sources of revenue through new or increased taxes and fees. In the Final Socioeconomic Report, it is assumed for modeling purposes that the federal or state government will be responsible for financing the entire incentive amount from their existing funds (see Chapter 4). Total incremental costs are calculated as the sum of incremental capital costs (e.g., equipment purchases and installation costs) and future incremental recurring costs over the equipment's expected lifetime that are associated with operation and maintenance (e.g., filter replacement and fuel costs/savings).[2] The present value, or interchangeably present worth value (PWV), of incremental capital costs is calculated by multiplying the unit cost of equipment by the number of affected units and discounting them from the year of capital spending back to 2017, or when a number of control strategies are expected to begin implementation.[3] The present value of incremental recurring costs are calculated by multiplying recurring costs or savings over the lifetime of the equipment by the number of affected units and discounting back to 2017. The present value of incentives are also discounted back from the

[1] These do not represent market prices and are for illustrative purposes only.

[2] CTS-01 (Coatings, Solvents, Adhesives, and Lubricants) has a reformulation cost associated with Rule 1168—Adhesive and Sealant Applications and is calculated by multiplying the price difference between compliant/non-compliant products and the annual sales of the product (in tons).

[3] A discount rate of four percent is used in the Final Socioeconomic Report. See Appendix 2-A for more discussion on the discount rate.

year of capital spending to 2017. All present worth values are expressed in 2015 dollars. More details about the assumptions of cost estimates for each control measure can be found in Appendix 2-A.

Similar to previous AQMPs, the Final 2016 AQMP contains control strategies with quantified emission reductions, as well as control measures with to-be-determined (TBD) emission reductions. It is important to note that NAAQS are expected to be attained with the quantified emission reductions alone. For the cost analysis in this report, incremental costs are estimated for the control strategies with quantified emission reductions only. Some of the control strategies with TBD emission reductions may serve as contingency measures to make up for any unexpected emission reductions shortfall. However, many of these control strategies include emergent technologies. Therefore, their emission-reducing potential may still need to be evaluated and their cost-effectiveness, and in some cases their costs too, remain highly uncertain or unknown at this time. Nonetheless, the inclusion of these TBD control strategies can provide strategic flexibility in the future. For example, as cleaner technologies develop, they can potentially become more cost-effective than the proposed control strategies with quantified emission reductions. As a result, SCAQMD may consider the more cost-effective option at the time of rule or program implementation. Appendix 2-A includes a discussion of each TBD control measure proposed by SCAQMD.

In addition, control measures that recognize co-benefit ozone and/or VOC emission reductions from other programs will not have incremental costs. Specifically, ECC-01, ECC-02, and ECC-04 recognize co-benefit credits from other *existing* programs that aim to promote energy efficiencies and greenhouse gas reductions. Similarly, CARB's "Further Deployment of Cleaner Technologies: On-Road Light Duty Vehicles" measure is primarily designed to reduce greenhouse gas emissions and therefore it is recognized as providing the co-benefit of NOx and VOC reductions that are expected to be implemented even if the Final 2016 AQMP is not adopted. Finally, the costs associated with the *existing* Carl Moyer projects (part of MOB-14) will not be considered as part of the incremental cost of Final 2016 AQMP. These existing Carl Moyer projects are included for the purpose of recognizing their associated emission reductions for the SIP submittal. These emission reductions are included in the baseline emission inventory. Therefore, they do not count toward the quantified public health benefits that will be discussed in Chapter 3.

Cost Summary of Final 2016 AQMP Measures

As seen in Table 2-1, the total present worth value was estimated to be $15.7 billion for the total incremental costs associated with the Final 2016 AQMP control measures, and the amortized amount was close to an average of $850 million per year between 2017 and 2031. The estimated annual cost of the Final 2016 AQMP is less than one tenth of a percent (0.07 percent) of the $1.3 trillion worth of annual gross domestic output in the region.

The discount rate used in this analysis for discounting and amortization corresponds to a real interest rate of four percent. As a sensitivity test, a real interest rate of one percent—which is closer to the prevailing real interest rate—was used. Assuming a real interest rate of one percent, the amortized cost of the Final 2016 AQMP was estimated at $628 million per year between 2017 and 2031. It should be noted that the amortization was performed for the upfront costs, mainly for expenditures related to capital outlay, over the equipment lifetime. However, many categories of equipment have an expected lifetime that will extend well beyond 2031. Therefore, the amortized annual average between 2017 and 2031 does not reflect the entire present worth value of the total incremental costs. The amortized annual average can be considered as the expected spending per year between 2017 and 2031, if the affected entities would be able to finance their upfront costs and pay off the loan over the equipment lifetime with an equal amount of annual installments.

TABLE 2-1: ESTIMATED COSTS OF FINAL 2016 AQMP MEASURES

Control Measures	Implementation Period for Cost Analysis	Present Value of Remaining Incremental Cost ($Million)		Present Value of Incentives ($Million)		Present Worth Value of Total Incremental Cost ($Million)	Amortized Annual Average 2017-2031 ($Million)
SCAQMD Stationary Source							
ECC-03 (Residential Building Energy Efficiency)	2018-2031	$246.6	+	$406.9	=	$653.5	$37.8
CMB-01 (Transition to Zero & Near-Zero Emission Technologies)	2018-2031	$1,883.0	+	$275.5	=	$2,158.6	$89.8
CMB-02 (Zero and Near-Zero Appliances)	2018-2031	$699.0	+	$503.5	=	$1,202.4	$51.6
CMB-03 (Emission Reductions from Non-Refinery Flares)	2020	$113.4	+	$0.0	=	$113.4	$6.3
CMB-04 (Restaurant Burners and Residential Cooking)	2018-2031	$320.6	+	$192.4	=	$512.9	$30.7
CMB-05 (NOx Reductions from RECLAIM Assessment)	2026-2031	$856.4	+	$0.0	=	$856.4	$19.3
CTS-01 (Coatings, Solvents, Adhesives, and Lubricants)	2018-2031	$31.6	+	$0.0	=	$31.6	$3.0
FUG-01 (Improved Leak Detection and Repair)	2022	$26.5	+	$0.0	=	$26.5	$2.5
BCM-10 (Emission Reductions from Greenwaste Composting)	2020-2031	$7.0	+	$0.0	=	$7.0	$0.6
BCM-01 (Further Emission Reductions from Commercial Cooking)	2025	$143.1	+	$0.0	=	$143.1	$10.8
BCM-04 (Manure Management Strategies)	2020-2031	$16.4	+	$0.0	=	$16.4	$2.0
Total for SCAQMD Stationary Sources		**$4,343.5**	+	**$1,378.2**	=	**$5,721.7**	**$254.6**
SCAQMD Mobile Source Measures							
MOB-10 (SOON Provision for Construction/Industrial Equipment)	2017-2022	$7.2	+	$63.4	=	$70.6	$4.6
MOB-11 (Extended Exchange Program)	2018-2022	$0.0	+	$66.2	=	$66.2	$6.7
MOB-14 (Emission Reductions from Incentive Programs)	2017-2023	$26.7	+	$460.1	=	$486.7	$43.1

Control Measures	Implementation Period for Cost Analysis	Present Value of Remaining Incremental Cost ($Million)		Present Value of Incentives ($Million)		Present Worth Value of Total Incremental Cost ($Million)	Amortized Annual Average 2017-2031 ($Million)
Total for SCAQMD Mobile Sources		**$33.9**	+	**$589.7**	=	**$623.5**	**$54.4**
CARB Mobile Source Measures Affecting South Coast							
On-Road Light-Duty							
Advanced Clean Cars 2	2026-2031	($2,648.0)	+	$0.0	=	($2,648.0)	($90.8)
On-Road Heavy-Duty							
Low NOx Engine Standard - California Action	2023-2027	$154.3	+	$0.0	=	$154.3	$11.7
Low NOx Engine Standard - Federal Action	2024-2031	$281.9	+	$0.0	=	$281.9	$15.1
Advanced Clean Transit	2018-2031	($521.5)	+	$312.2	=	($209.2)	($6.6)
Last Mile Delivery	2020-2031	$411.5	+	$0.0	=	$411.5	$29.2
Further Deployment of Cleaner Technologies: On-Road Heavy Duty*	2017-2031	$0.0	+	$4,191.5	=	$4,191.5	$269.8
Off-Road Federal & International							
More Stringent National Locomotive Emission Standards	2024-2031	$308.2	+	$0.0	=	$308.2	$12.0
Tier 4 Vessel Standard	2025-2031	$133.7	+	$0.0	=	$133.7	$3.9
At-Berth Regulation Amendments	2022	$90.4	+	$0.0	=	$90.4	$5.2
Further Deployment of Cleaner Technologies: Federal and International*	2017-2031	$120.3	+	$3,707.0	=	$3,827.2	$221.0
Off-Road Equipment							
Zero-Emission Off-Road Forklift Regulation Phase I	2023-2030	($134.8)	+	$0.0	=	($134.8)	($8.5)
Zero-Emission Ground Support Equipment	2023-2031	$3.3	+	$0.0	=	$3.3	$0.2
Small Off-Road Engines	2022-2031	$20.4	+	$0.0	=	$20.4	$2.1
Low-Emission Diesel Fuel Requirement	2023-2031	$867.7	+	$0.0	=	$867.7	$86.9
Further Deployment of Cleaner Technologies: Off-road Equipment*	2017-2031	($2,453.2)	+	$4,435.5	=	$1,982.2	($18.8)

Control Measures	Implementation Period for Cost Analysis	Present Value of Remaining Incremental Cost ($Million)		Present Value of Incentives ($Million)		Present Worth Value of Total Incremental Cost ($Million)	Amortized Annual Average 2017-2031 ($Million)
Other CARB SIP Measure Affecting South Coast							
Consumer Products Program	2023-2031	$70.1	+	$0.0	=	$70.1	$7.0
Total for CARB Measures Affecting South Coast		**($3,295.7)**	+	**$12,646.2**	=	**$9,350.5**	**$539.3**
Grand Total for All Quantified Costs		**$1,081.7**	+	**$14,614.0**	=	**$15,695.7**	**$848.3**

* Based on Table 4-20 of the Final 2016 AQMP. Other CARB measures are based on data provided by CARB staff.
Note: 1) Numbers are expressed in 2015 dollars and may not sum up due to rounding.
2) A discount rate of four percent was used for both discounting and amortization.
3) Numbers in parentheses indicate cost-savings, mainly associated with fuel-savings

More than $9 billion, of the Final 2016 AQMP's total incremental cost can be attributed to CARB's mobile source measures, which target on-road light and heavy-duty sources like cars, trucks, and buses as well as off-road sources like trains, ocean-going vessels, planes, and construction equipment.[4] This amount represents the net total of costs estimated for most of the CARB control measures and cost-savings anticipated from the remaining CARB measures, which include Advanced Clean Cars 2, Advanced Clean Transit, and Forklift Regulations. CARB's mobile source control strategies, while contributing to 60 percent of total cost, are expected to be generally more cost-effective and would lead to more than 80 percent of the emission reductions needed to attain the 8-hour ozone standard by 2031. This large share reflects the large amount of NOx emissions generated from mobile sources, which contributed about 88 percent of the region's total NOx emissions in 2012 and would continue to be the single largest category of emission sources if no further controls are implemented.

The SCAQMD's local mobile source measures are proposed mainly to facilitate local implementation of CARB's "Further Deployment" measures. The total incremental cost of three local mobile source measures, for which additional NOx emission reduction potentials were identified, was estimated to be $624 million in present worth value, with an amortized annual average of $54 million between 2017 and 2031. Two of these three measures focus on turning over older in-use construction and industrial diesel engines (MOB-10) and increasing market penetration of electric or low-emission gas powered lawn and garden equipment (MOB-11). The third measure (MOB-14) recognizes the expected emission reduction credits from existing and future projects enabled by Carl Moyer funds.

[4] The incentive amount and incremental costs for CARB's "Further Deployment" measures were based on Table 4-20 of the Final 2016 AQMP. Cost estimates for the remaining CARB control measures were derived from data provided by CARB staff. In CARB's Mobile Source Strategy, Appendix A: Economic Impact Analysis (2016a), incremental costs are not presented in present worth values. Costs from CARB that apply to the four-county region have been converted to present worth values in this analysis.

The SCAQMD's stationary source measures were estimated to cost $5.7 billion, with an amortized annual average of $255 million between 2017 and 2031. About 24 percent of these costs are associated with incentive programs that are built into a number of control strategies, including those for cleaner space and water heaters (CMB-02), restaurant burners (CMB-04), as well as enhancements in building efficiency (ECC-03) and the transition to zero and near-zero technologies at industrial facilities (CMB-01). Traditional command-and-control regulations focus on reducing NOx and/or VOC emissions from composting (BCM-10), non-refinery flares (CMB-03), fugitive leaks (FUG-01), and coatings, solvents, lubricants, and adhesives (CTS-01). The proposed NOx-reducing measures also include further amendments to the market incentive program RECLAIM (CMB-05). BCM-01 and BCM-04, which specifically target PM2.5 emission controls for under-fired charbroilers and from manure management respectively, are included as contingency measures in the event that the NOx and VOC control measures fail to produce sufficient PM2.5 co-benefits.

Among the $15.7 billion of total incremental cost, over 90 percent or $14.6 billion is associated with incentive-based measures or measures that include an incentive component for the purposes of accelerating further deployment of zero and near-zero emission technologies. The majority of incentive funds—about $10 billion—will be used to accelerate further deployment of cleaner transit systems, trucks, cars, as well as various types of off-road equipment, in order to achieve the large amount of NOx emission reductions needed from mobile sources. The $10 billion of incentives associated with the "Further Deployment" measures is an upper limit of the most likely funding necessary if no other actions are taken to achieve the associated emission reductions. There are other implementation approaches for the "Further Deployment" measures in addition to incentives programs. For example, operational efficiency improvements and deployment of connected vehicles, autonomous vehicles, and intelligent transportation systems could lead to emission reduction benefits and reduce the amount of incentives needed to achieve these emission reductions.

While production costs may rise initially for industries deploying cleaner technologies, incentive programs can help by offsetting a portion of the initial capital spending to shorten the payback period. This would further accelerate market penetration and promote wider adoption of low-emission technologies across industries. This is critical to lowering costs in the long-run as demand ramps up and local supply chains are developed. Accelerating the deployment of cleaner technologies may also increase benefits over time. For example, three measures focusing on advanced clean cars, advanced public transit, and zero-emission forklifts are expected to result in cost savings, mainly due to fuel savings.

Distribution of Final 2016 AQMP Costs Across Economic Sectors

The total incremental cost of the Final 2016 AQMP is expected to affect various parts of the regional economy. Many private industries and the public sector are expected to incur costs, although the amount borne by each party would vary. Table 2-2 shows the sectoral distribution of the Final 2016 AQMP's total incremental cost. As mentioned above, over 90 percent of the total cost is associated with publicly funded incentive programs that eligible industries and consumers can use to offset the cost of purchasing cleaner technologies. Due to incentives and expected fuel savings, such as increased energy efficiency and the use of renewable energies for residential buildings, consumers are expected to see total cost-savings of $2.3 billion.

TABLE 2-2: INCREMENTAL COSTS OF THE FINAL 2016 AQMP BY SECTOR

Sector	Present Value of Incremental Cost ($Millions)	Share (Percent)
Agriculture, Forestry, Fishing, and Related Activities	$16	0
Oil and Gas Extraction	$131	1
Utilities	$664	4
Construction	$39	0
Manufacturing	$558	4
Nurseries, Wholesale Garden	-$32	(0)
Other Wholesale and Retail Trades	$1	0
Transportation & Warehousing	$791	5
Equipment Leasing and Rental	-$34	(0)
Administrative and Waste Management Services	$390	(2)
Health Care and Social Assistance	$1	0
Restaurants	$464	3
All Industries	$1,181	8
Subtotal of Private Industries	**$3,392**	22
Consumers	-$2,311	(15)
Government Spending	$14,615	93
Total	**$15,696**	**100**

Note: 1) Numbers are expressed in 2015 dollars and may not add up due to rounding.
2) Numbers in parentheses indicate cost-savings, mainly associated with fuel-savings.
3) An 'All Industries' category is included for measures with across-the-board cost impacts (i.e., CMB-01 & CMB-02).
4) Government spending captures mainly incentive funds, but it also includes expected control costs incurred by public agencies.

While some industries will benefit from incentives and long-term cost-savings, private industries as a whole are expected to incur $3.4 billion in incremental costs. Some control measures are expected to affect all industries, because widely used emission source equipment is being targeted. For example, all industries using traditional combustion for the production of facility power, heating, and steam production will be affected by a NOx control measure (CMB-01) incentivizing the transition to cleaner equipment. CMB-02 also seeks broad base NOx emission reductions from and commercial space and water heating.

Energy producers, who are broadly considered to include the utilities sector and the oil and gas extraction industry, are expected to incur a total incremental cost estimated at about $0.8 billion in combination, with $0.7 billion incurred by the utilities sector alone. The $0.8 billion total cost includes the cost associated with CMB-05 which would seek further NOx emission reductions from all RECLAIM sources, including energy producers.[5] It also includes the cost associated with CMB-01 affecting facilities belonging

[5] Note that, due to data limitations for the time being, the incremental cost estimated for CMB-05 was based on the 2014 NOx RECLAIM amendments. The cost distribution among the industries reflect the estimated distribution as a

to a wide variety of industries including energy producers. CMB-03 would also affect energy producers because it would require non-refinery facilities to install newer flares or to capture flare gas for beneficial uses, such as renewable energy generation.[6] In addition, this sector would incur additional costs from FUG-01 which seeks installation of advanced leak detection devices. While energy producers are expected to incur more than half of the cost estimated of all private industries. The cost-related job impact is expected to be proportionally small because, this sector is more capital intensive.

Both SCAQMD and CARB's mobile source strategies will primarily affect passenger transportation and the "goods movement" sector, the core of which constitutes freight transportation and warehousing. As shown in Table 2-2, transportation and warehousing, among all private industries, is expected to incur an estimated incremental cost of $791 million. The relatively moderate cost impact, as compared to the large amount of emission reductions from mobile sources, is mainly due to the incentive funds that will be used to lessen the financial impact to this industry sector.

SCAQMD and CARB recognize the importance of the goods movement sector to the regional economy, as well as the financial constraints faced by many small business operators that make up the majority of this sector.[7] Situated among the world's largest seaports and airports, the region's goods movement sector provides the critical service of delivering goods securely and promptly to and from businesses across the nation. In 2015, the U.S. waterborne trade totaled $1.6 trillion in value, of which nearly a quarter moved through the Ports of Los Angeles and Long Beach; in the same year, about one tenth of the $1 billion worth of total U.S. airborne trade traveled through the airports in the Basin.[8] Over the next 15 years, jobs in the transportation and warehousing sector are expected to grow at an annualized rate of 0.7 percent.[9] Much of this job growth will be concentrated in the Inland Empire region. The SCAQMD and CARB will work closely with industry stakeholders during the implementation stage to further fine-tune the mobile source strategies and explore and identify the most affordable and cost-effective pathway to reducing mobile source emissions.

The manufacturing sector is expected to incur an estimated incremental cost of $558 million. Some measures will impact this sector more broadly as in the case of CMB-01 which incentivizes the transition to zero and near-zero technology at industrial facilities. Other measures may potentially affect only a small number of manufacturing industries. For example, FUG-01 (leak detection and repair) and CMB-05 (RECLAIM) are expected to affect the petroleum and coal products manufacturers, including refineries, in addition to energy producers. As mentioned in Chapter 1, the number of total manufacturing jobs is expected to mirror the nationwide trend and continue its long-term decline. This long-term decline is not expected to be affected by any potential effect from the proposed control strategies

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result of the 2014 amendments and may not reflect the actual distribution of any future amendments to NOx RECLAIM.

[6] The potential economic benefits of energy conversion are not taken into account.

[7] For example, according to data presented by the California Trucking Association at the October 31, 2014 meeting of the 2016 AQMP White Paper Working Group "A Business Case for Clean Air Strategies," In 2006, more than half of California registered trucks belonged to fleets with five or fewer trucks, including one third being solo operators. The data source cited was the California Department of Motor Vehicles' 2006 data.

[8] Staff analysis based on data compiled by the U.S. Census Bureau (U.S. Merchandise Trade, Selected Highlights: Report FT 920).

[9] Based on SCAG's Growth Forecast for its 2016 RTP/SCS.

The restaurant industry is expected to incur up to $464 million in estimated incremental costs. Restaurants will be mainly impacted by a NOx measure (CMB-04) which would require the installation of low-NOx burners in retail and quick service establishments utilizing commercial cooking ranges, ovens, and fryers. As mentioned earlier, BCM-01 is a PM2.5 contingency measure to control emissions from under-fired charbroilers, and its associated cost of $143 million may be potentially incurred by both small and large restaurants; currently, however, this cost is not expected to occur if ozone measures are implemented.

Restaurants are one of the major small business employers in the region. While currently providing 594,000 payroll jobs in the region, nearly all restaurants employ fewer than 100 people.[10] Moreover, restaurants typically offer lower paying jobs and many of their employees subsist on minimum wage.[11] Therefore, affordability for small businesses and the job impact on economically disadvantaged workers will need to be carefully taken into consideration during the implementation stage of these control strategies.

Unlike other industries, the administrative and waste management sector is expected to experience a total cost-savings of about $390 million. This sector is expected to incur gross incremental costs mainly due to a VOC/PM2.5 measure (BCM-10) which would require the use of emerging organic waste processing technology while restricting the direct land application of chipped and ground uncomposted greenwaste. Landscapers, who also work in this industry and primarily for small operations, may incur incremental costs associated with voluntarily upgrading to cleaner gardening equipment (MOB-11). However, this sector will also experience significant fuel savings from diesel industrial engines and commercial lawnmowers and turf equipment proposed by the CARB control "Further Deployment of Cleaner Technologies: Off-Road Equipment measure."[12] As a result, this sector will experience net cost-savings. Cost-savings estimated for the sectors of nurseries, wholesale garden and equipment leasing and rental are also due to fuel savings and building energy efficiencies.

Lastly, the construction industry is expected to incur an estimated incremental cost of up to $39 million for converting to cleaner equipment through SCAQMD's SOON program (MOB-10) and a VOC measure (CTS-01) to reduce emissions from chemical products like architectural adhesives and sealants used in construction. In the meantime, however, construction could potentially benefit from additional revenues that stem from installing control equipment and other activities that are expected to occur in other industries due to the proposed control strategies.

Incremental Costs over Time

Figure 2-1 illustrates the incremental costs of control measure equipment and programs attributable to each implementation year. Unlike the costs reported previously, these costs are not discounted to their present worth values, nor are they amortized over the equipment life.

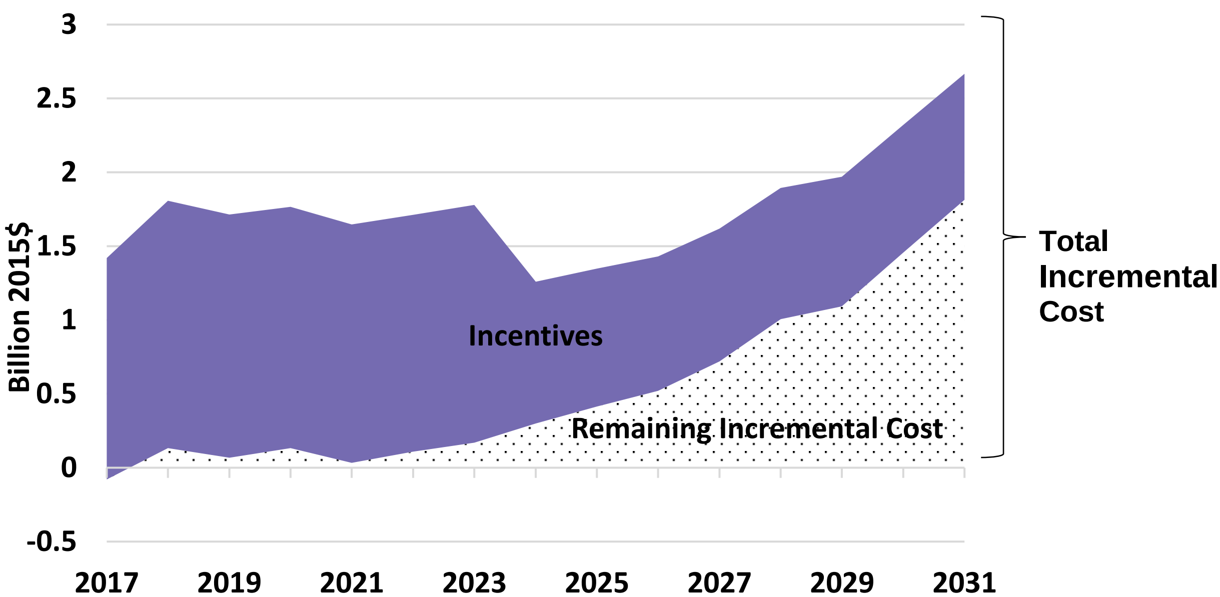
The total incremental cost increases over time, due to each successive year of the Final 2016 AQMP which will require a greater amount of more costly equipment and activities in order to achieve attainment of

[10] Based on establishment by size data for 4-County region from the U.S. Census 2014 County Business Patterns Database.
[11] Recent annual compensation ranged from an average about $17,000 in San Bernardino to about $20,000 in Los Angeles (source: EDD QCEW database for 2015 Q3).
[12] Based on Table 4-20 of Final 2016 AQMP.

the NAAQS. The cost per year remains approximately constant from 2018 through 2022, as most of the incentive funding is expected to be available and similar equipment and programs are assumed to phase in over that time period to attain the 1997 8-hour ozone standard in 2023. The largest amount of incremental cost occurs towards the end of the analysis horizon, with the greatest cost year being the last year of attainment demonstration (2031), or the year when the 2008 8-hour ozone standard needs to be attained.

The total incremental cost increases from about $1.4 billion in 2017 to about $2.7 billion in 2031. The total incremental cost in 2017 consists of about $1.5 billion in incentives and $0.08 billion of fuel savings from more efficient equipment. In 2031, the total incremental cost consists of about $0.9 billion in incentives and $1.8 billion remaining incremental cost. It should be noted that the $850 million annual cost discussed earlier came from amortized costs over the life of the equipment and represents an annual average of the amortized costs between 2017 and 2031. In Figure 2-1, capital costs were reported in the expected year of capital spending instead of being amortized over the equipment life.

FIGURE 2-1: INCREMENTAL COSTS OVER TIME



Small Business Analysis

The SCAQMD defines a "small business" in Rule 102 for purposes of fees as one which employs 10 or fewer persons and which earns less than $500,000 in gross annual receipts. The SCAQMD also defines "small business" for the purpose of qualifying access to services from SCAQMD's Small Business Assistance Office (SBAO) as a business with annual receipts of $5 million or less or with 100 or fewer employees.

In addition to SCAQMD's definition of a small business, the federal Small Business Administration (SBA) and the Federal Clean Air Act Amendments (CAAA) of 1990 also provide definitions of a small business. The CAAA classifies a business as a "small business stationary source" if it: (1) employs 100 or fewer employees, (2) does not emit more than 10 tons per year of either VOC or NOx, and (3) is a small business as defined by the SBA. The SBA definitions of small businesses vary by six-digit NAICS codes. In general terms, a small business must have no more than 500 employees for most manufacturing and mining industries, and no more than $7 million in average annual receipts for most non-manufacturing industries.

Table 2-3 provides information on the share of small businesses in each industry potentially impacted by the Final 2016 AQMP.[13] Small business impacts will be assessed in further detail during the rulemaking process, when more facility-specific data will be available. Furthermore, as part of Abt's 2014 recommendations, staff will evaluate the use of other modeling tools such as partial equilibrium modeling to supplement the REMI analysis when assessing for small scale impacts.

TABLE 2-3: SMALL BUSINESS SHARE OF AFFECTED INDUSTRIES, 2014

		Size of Employment		
Industry Sector	**Number of Establishments**	**Less than 10 Employees**	**Less than 100 Employees**	**Less than 500 Employees**
Oil and Gas Extraction	222	64%	95%	99%
Utilities	493	48%	87%	99%
Construction	26,678	79%	99%	100%
Manufacturing	20,403	58%	94%	99%
Nurseries, Wholesale Garden	314	71%	100%	100%
Transportation & Warehousing	10,994	71%	96%	99%
Equipment Leasing & Rental	1,002	67%	99%	100%
Waste Management	744	57%	94%	100%
Restaurants	33,249	47%	99%	100%
All Private Industries	**418,463**	**75%**	**98%**	**100%**

[13] Employment by establishment-size data from the U.S. Census Bureau's County Business Patterns for the Los Angeles-Long Beach-Anaheim and Riverside-San Bernardino metros.

Cost-Effectiveness Analysis

Based on the estimated total incremental costs for each measure and the projected emission reductions throughout the associated project life, cost-effectiveness was calculated for each control measure proposed in the Final 2016 AQMP.[14] Following the 2014 Abt recommendations, cost-effectiveness based on both discounted cash flow (DCF) and levelized cash flow (LCF) methods were reported in Table 2-4 to facilitate comparisons with cost-effectiveness reported by other agencies and organizations.[15] It should be noted that, each cost-effectiveness value listed in Table 2-4 was calculated based on emission reductions of the primary target pollutant for attaining the ozone and PM2.5 NAAQS. However, many control measures also achieve reductions of other air pollutants. For example, many of the mobile source NOx control measures would additionally result in VOC and greenhouse gas emission reductions which are not reflected in the cost-effectiveness calculated in this section.

It is observed that, the stationary source measures for NOx are expected to cost between $10,000 and $50,000 per ton of emissions reduced, as calculated using the DCF method ($15,000 to $77,000 using LCF). Most of the mobile source measures would cost between $4,000 and $50,000 per ton of NOx reduced (using DCF, and between $6,000 to $69,000 using LCF), with many of them under $10,000 per ton. Additionally, a few mobile source measures proposed by CARB are expected to lead to long-term cost-savings due to lower fuel costs and operation and maintenance expenditures. However, two of CARB's mobile source measures are expected to incur a high cost per ton of NOx emission reduction. Under the "Last Mile Delivery" measure, a mix of battery electric and fuel cell trucks were assumed, and the latter technology carries a high per unit cost and a high cost to build up the infrastructure. Under the "Low-Emission Diesel Fuel Requirement" measure, the portion of the heavy-duty fleet that chooses to continue operating on internal combustion engines, instead of adopting the expectedly more cost-effective zero and near-zero emission technologies, is anticipated to incur additional costs due to the proposed requirement to utilize low-emission diesel fuel.

The limited and strategic use of VOC controls has cost-effectiveness values well below $10,000 per ton, regardless of the method used. These values are consistent with estimations for previous VOC regulations. Finally, cost-effectiveness of the contingent PM2.5 control measures were estimated to be $12,000 per ton of PM2.5 reduced and $19,000 per ton of NH3 reduced, respectively, as calculated using the DCF method ($14,000 and $23,000 respectively when calculated using LCF).

[14] Consistent with the estimation of total incremental cost, which accounts for capital cost of equipment and operation and maintenance costs throughout the equipment life, the project life of a control measure is calculated from the year the first pieces of equipment are expected to be installed to the year the last pieces of installed equipment are expected to be retired. The expected emission reductions were calculated based on the average emission reductions per unit of equipment over the equipment life or provided by CARB staff based on the Vision model. However, most of the expected emission reductions throughout the project life relied on linear interpolation based on the projected emission reductions in 2023 and 2031, as the equipment was generally assumed to be evenly phased in over the implementation period. If the project life would extend beyond 2031, the post-2031 emission reductions were assumed to stay constant as in 2031, except in the case where the estimated emission reductions per unit were used for year-by-year projections.

[15] A comparison of DCF and LCF methods, as well as more information for the methodology used, can be found in Appendix 2-B.

As mentioned in the 2014 Abt Report, the main difference between the DCF and LCF methods lies in how the costs are expressed. DCF utilizes the present value, or a stream of all present and future costs discounted to and summed up in the same initial year. In comparison, LCF amortizes all costs, incurred at present or in the future, into a yearly expenditure of equal amount over the project life. As the same amount of money is usually considered to be more valuable now than in the future (i.e., the financial concept “time value of money”), the same amount of cost is therefore lower when discounted to its present value than when amortized to the present and each future period of the project life. This is why a cost-effectiveness value as calculated using DCF is always lower than that calculated using LCF. In other words, the methodological choice is to some degree analogous to the choice of measurement units: the same length can be expressed as one inch or 2.54 centimeters, and the smaller (or greater) number should not be taken to indicate a shorter (or longer) length. Similarly, a cost-effectiveness value calculated using the DCF method should not be compared with another cost-effectiveness value calculated using the LCF method. In the interest of transparency and comparability and based on Abt’s recommendation, staff had begun providing both values since the rulemaking process that led to the 2015 NOx RECLAIM amendments.

TABLE 2-4: COST-EFFECTIVENESS OF FINAL 2016 AQMP MEASURES

Control Measures	Primary Target Pollutant	DCF (2015$/ton)	LCF (2015$/ton)
SCAQMD Stationary Source Measures			
ECC-03 (Residential Building Energy Efficiency)	NOx	$49,000	$77,000
CMB-01 (Transition to Zero & Near-Zero Emission	NOx	$39,000	$73,000
CMB-02 (Zero and Near-Zero Appliances)	NOx	$26,000	$49,000
CMB-03 (Emission Reductions from Non-Refinery Flares)	NOx	$10,000	$15,000
CMB-04 (Restaurant Burners and Residential Cooking)	NOx	$42,000	$68,000
CMB-05 (NOx Reductions from RECLAIM Assessment)	NOx	$17,000	$28,000
CTS-01 (Coatings, Solvents, Adhesives, and Lubricants)	VOC	$5,000	$6,000
FUG-01 (Improved Leak Detection and Repair)	VOC	$4,000	$4,000
BCM-10 (Emission Reductions from Greenwaste Composting)	VOC	$1,000	$1,000
BCM-01 (Further Emission Reductions from Commercial	PM2.5	$12,000	$14,000
BCM-04 (Manure Management Strategies)	NH3	$19,000	$23,000
SCAQMD Mobile Source Measures			
MOB-10 (SOON Provision for Construction/Industrial	NOx	$5,000	$8,000
MOB-11 (Extended Exchange Program)	NOx	$6,000	$8,000
MOB-14 (Emission Reductions from Incentive Programs)	NOx	$19,000	$31,000
CARB Mobile Source Measures Affecting South Coast			
On-Road Light-Duty			
Advanced Clean Cars 2	NOx	($771,000)	($1,072,000)
On-Road Heavy-Duty			
Low Nox Engine Standard - California Action	NOx	$8,000	$10,000
Low Nox Engine Standard - Federal Action	NOx	$8,000	$11,000
Advanced Clean Transit	NOx	($431,000)	($663,000)
Last Mile Delivery	NOx	$206,000	$296,000
Further Deployment: On-Road Heavy Duty	NOx	$12,000	$19,000
Off-Road Federal & International			
More Stringent National Locomotive Emission Standards	NOx	$6,000	$9,000
Tier 4 Vessel Standard	NOx	$4,000	$6,000
At-Berth Regulation Amendments	NOx	$15,000	$22,000
Further Deployment: Federal and International	NOx	$5,000	$11,000
Off-Road Equipment			
Zero-Emission Off-Road Forklift Regulation Phase I	NOx	($26,000)	($34,000)
Zero-Emission Ground Support Equipment	NOx	$50,000	$69,000
Small Off-Road Engines	NOx	$2,000	$3,000
Low-Emission Diesel Fuel Requirement	NOx	$203,000	$236,000
Further Deployment: Off-road Equipment	NOx	$6,000	$12,000
Other CARB SIP Measure Affecting South Coast			
Consumer Products Program	VOC	$5,000	$5,000

Note: All numbers are rounded to thousands. Negative values (in parentheses) indicate cost-savings. Each cost-effectiveness value was calculated for the primary target pollutant only and does not take into account additional emission reductions of other pollutants that would be simultaneously achieved.

Chapter 3: Public Health and Other Benefits

The Final 2016 AQMP contains a suite of control strategies that are designed to attain the 80 ppb 8-hour ozone standard in 2023 and the 75 ppb 8-hour ozone standard in 2031. They are devised to also attain the 12.0 $\mu g/m^3$ annual PM2.5 standard and the 35 $\mu g/m^3$ 24-hour PM2.5 standard. Attaining the ozone and PM2.5 standards will result in various benefits including better public health, improved visibility, and avoided damage to animals, crops, vegetation, and buildings.

One of the major recommendations of the 2014 Abt independent review of past socioeconomic analyses was to update the literature and methodology for benefits analysis (Abt Associates 2014). This report prioritizes the implementation of this recommendation in the area of public health benefits for two reasons. First, public health benefits usually account for the majority of quantified benefits associated with improved air quality.[1] Second, the primary ambient air quality standards were set to provide public health protection, whereas the secondary standards, in some cases less stringent than the corresponding primary standard,[2] were set to provide public welfare protection in other areas mentioned above. Moreover, Abt recommended that these analyses be updated with more current methodologies, which cannot be done in time for this report.

SCAQMD staff has worked closely with Industrial Economics, Inc. and its scientific advisors to provide an updated health benefits literature review and fine-tune the methodology used to quantify public health benefits and address the associated uncertainties in estimates. Despite these efforts, a full assessment of public health benefits in dollar terms is not possible until further advances occur in human health sciences, physical science, and economic disciplines that will allow monetary estimates to be made for currently unquantifiable areas. Public welfare benefits of the Final 2016 AQMP are quantified as explained above; however, these benefits are scientifically documented and are qualitatively discussed towards the end of this chapter.

Projected Emission Reductions and Changes in Pollutant Concentrations

Regional air quality modeling indicates that significant NOx reductions with additional strategic, limited VOC reductions will lead to the attainment of ozone standards. As shown in Table 3-1, the proposed control strategies were projected to significantly reduce NOx emissions by 124 and 128 tons per day (tpd) and strategically reduce VOC emissions by 64 and 72 tpd, in 2023 and 2031 respectively. These control strategies were also projected to generate sufficient PM2.5 co-benefits that will lead to attainment of the annual PM2.5 standard by 2025.

[1] For example, quantified public health benefits of the 2007 AQMP amounted to $16 billion for year 2023, compared to other quantified public welfare benefits of about $6 billion (in 2000 dollars). Similarly, quantified public health benefits of the 2012 AQMP amounted to $1.7 billion for year 2023, compared to other quantified public welfare benefits of $0.66 billion (in 2005 dollars).

[2] For annual PM2.5 standards, the secondary standard is 15.0 $\mu g/m^3$ whereas the primary standard is 12.0 $\mu g/m^3$.

TABLE 3-1: PROJECTED EMISSION REDUCTIONS BY POLLUTANT

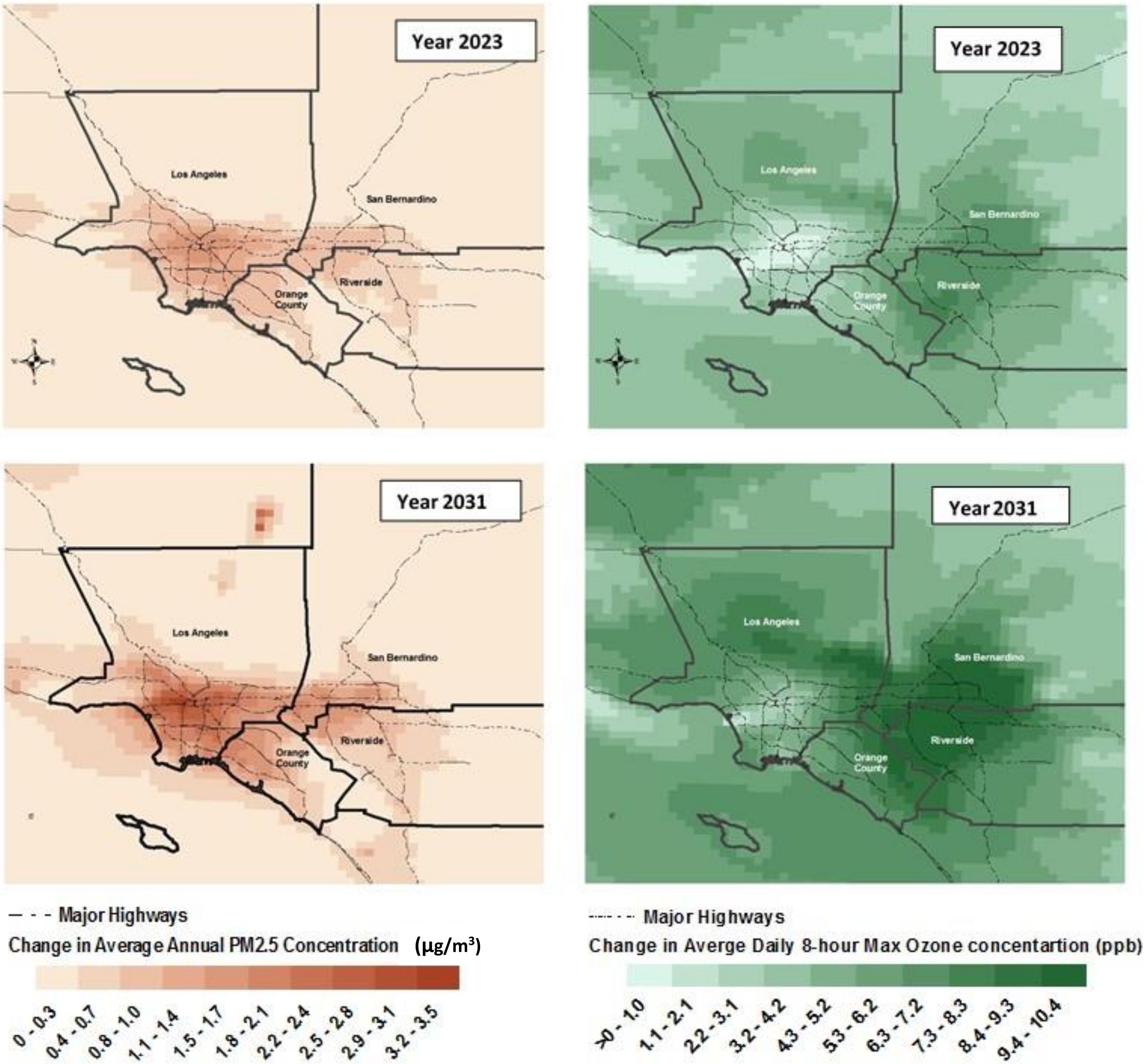
NOx Emissions (tpd)	**Year 2023**	**Year 2031**
Baseline Inventory	262	223
Reductions from Final Control Strategies	124	128
Remaining Emissions	138	95
VOC Emissions (tpd)	**Year 2023**	**Year 2031**
Baseline Inventory	379	362
Reductions from Final Control Strategies	64	72
Remaining Emissions	314	290

Note: Projected emission reductions are the average of the summer planning period (May 1 to September 30). The NOx emission reductions reported in this table reflect the latest regional air quality modeling results.

Although each attainment demonstration is performed with respect to the worst air quality site, the benefit assessment herein analyzed the changes in the projected air pollutant concentrations between the baseline scenario (without Final 2016 AQMP) and the control or policy scenario (with Final 2016 AQMP) in each air quality modeling grid of four kilometer by four kilometer. Thus, the quantified public health benefits discussed in this report are based on where projected air quality changes are expected to occur. Figure 3-1 shows the modeled changes in ozone and PM2.5 concentrations based on control measures proposed in the Final 2016 AQMP, which will move beyond the already adopted regulations and already implemented programs to the level needed to attain the federal ozone and PM2.5 standards. Air quality modeling methods account for background concentrations of pollutants and thus concentrations projected in the control scenarios are above backgound concentration levels.[3]

[3] Background concentrations of chemical species are calculated with a global chemistry transport model (Model for Ozone and Related chemical Tracers, MOZART). Species concentrations from this model are fed into the modeling domain along the model boundaries. Temporally- and spatially-dependent MOZART data are used to capture the variability in background concentrations throughout the entire modelling year. Biogenic and Anthropogenic emissions from within the modeling domain are simulated with the MOZART-derived boundary conditions to estimate pollutant concentrations within the Basin. Therefore, the PM concentrations modeled for future years in this analysis are above the background levels.

FIGURE 3-1: MODELED CHANGES IN PM2.5 AND OZONE CONCENTRATIONS, 2023 AND 2031



Note: Ozone concentarations are the summer planning period average of daily 8-hour maxima, whereas PM2.5 concentrations are the annual average of 24-hour means.

Quantified Public Health Benefits

Numerous epidemiological as well as controlled laboratory studies have demonstrated a positive association between ambient air pollution exposure and increases in illness and other health effects (morbidity endpoints) and increases in death rates from various causes (mortality endpoints) (U.S. EPA 2009; U.S. EPA 2013). Groups that are most sensitive to the effects of air pollution are children, elderly persons, and people with certain respiratory and heart conditions.

Table 3-2 summarizes the causal determinations documented in the U.S. EPA Integrated Science Assessments (ISAs), based on the current weight of evidence regarding ozone and PM2.5 exposure (U.S. EPA 2009; U.S. EPA 2013).[4] Exposure to other pollutants, such as NO2 and SO2, has also been found to cause adverse respiratory effects.[5] However, based on the recommendation by Industrial Economics, Inc., this analysis does not quantify these effects to avoid potentially double counting benefits with reduced PM2.5 exposure (Industrial Economics and Thurston 2016b). Similarly, due to concerns of potentially double counting over the same health endpoint, not all causal or likely causal relationships listed in Table 3-2 are quantified in this report.

TABLE 3-2: SUMMARY OF U.S. EPA'S CAUSAL DETERMINATIONS FOR OZONE AND PM2.5 EXPOSURE

Health Category	Causal Determination	Quantified?
Short-Term Exposure to Ozone		
Mortality	**Likely to be a causal relationship**	**Y**
Cardiovascular Effects	**Likely to be a causal relationship**	N
Respiratory Effects	**Causal relationship**	**Y**
Central Nervous System Effects	*Suggestive of a causal relationship*	N
Effects on Liver and Xenobiotic Metabolism	*Inadequate to infer a causal relationship*	N
Effects on Cutaneous and Ocular Tissues	*Inadequate to infer a causal relationship*	N
Long-Term Exposure to Ozone		
Mortality	*Suggestive of a causal relationship*	N
Cardiovascular Effects	*Suggestive of a causal relationship*	N
Respiratory Effects	**Likely to be a causal relationship**	N
Reproductive and Developmental Effects	*Suggestive of a causal relationship*	N
Central Nervous System Effects	*Suggestive of a causal relationship*	N
Cancer	*Inadequate to infer a causal relationship*	N

[4] Descriptions for Weight of Evidence for Causal Determinations are provided in Appendix 3-A.

[5] See the Final 2016 AQMP Appendix I for a discussion of health effects of ambient air pollution.

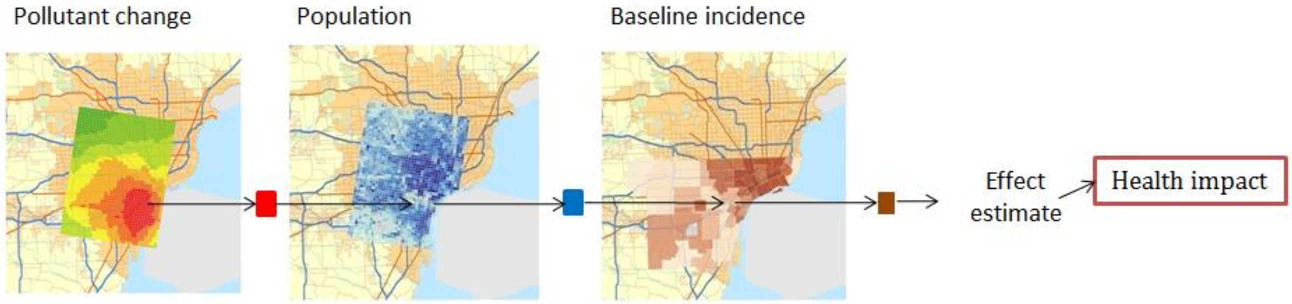
TABLE 3-2: SUMMARY OF U.S. EPA'S CAUSAL DETERMINATIONS FOR OZONE AND PM2.5 EXPOSURE (CONT'D)

Health Category	Causal Determination	Quantified?
Short-Term Exposure to PM2.5		
Mortality	**Causal relationship**	**Y**[1]
Cardiovascular Effects	**Causal relationship**	**Y**
Respiratory Effects	**Likely to be a causal relationship**	**Y**[2]
Central Nervous System Effects	*Inadequate information to assess*	
Long-Term Exposure to PM2.5		
Mortality	**Causal relationship**	**Y**
Cardiovascular Effects	**Causal relationship**	N
Respiratory Effects	**Likely to be a causal relationship**	**Y**
Reproductive and Developmental Effects	*Suggestive of a causal relationship*	N
Cancer, Mutagenicity, Genotoxicity	*Suggestive of a causal relationship*	N

[1] Health effects of short-term PM2.5 exposure on all-cause mortality is quantified and discussed separately due to concerns for potential double-counting with mortality effects due to long-term exposure.
[2] Effects of PM2.5 exposure on new onset of wheeze among adult populations are quantified but not monetized, due to lack of valuation method.
Source: U.S. EPA ISAs (2009; 2013)

The first step of a public health benefits analysis is the health effects quantification. Appropriate concentration-response (C-R) functions need to be selected, which numerically characterize the causal and likely causal relationships between exposure to a pollutant and various health endpoints. Specifically, the C-R function used in this analysis relates changes in ambient air pollution concentration with changes in mortality or morbidity incidence, the magnitude of which also depends on the baseline incidence rate and the population exposed to a specific health risk being analyzed (see Figure 3-2 for a graphic illustration).

FIGURE 3-2: HEALTH EFFECTS QUANTIFICATION



Source: U.S. EPA BenMAP Community Edition User's Manual.

C-R functions were determined based on a systematic review of the epidemiological literature, where studies were evaluated for quality and applicability according to numerous criteria (Industrial Economics and Thurston 2016a; Industrial Economics and Thurston 2016b). These criteria included: peer-review, date of the study, geography and population characteristics, and study design. Thus, the C-R functions applied in this analysis were found from recent, peer-reviewed articles, derived from local studies of the Basin or studies that report separate estimates using sub-samples pertaining to the Basin, where feasible. The 2016 RTP/SCS population forecast was provided by SCAG for each air quality modeling grid. When feasible, local health data based on public administrative records were utilized to obtain baseline incidence rates. Appendix 3-B describes in detail the input data and methodology used, as well as analytical assumptions such as cessation lags for mortality effects associated with long-term PM2.5 exposure that will have implications for monetizing health benefits. The public health benefit analysis is implemented using U.S. EPA's Environmental Mapping and Analysis Program – Community Edition (BenMAP-CE).[6]

Table 3-3 reports the health effect estimates for each health endpoint by pollutant. In total, it was estimated that more than 1,400 premature deaths will be avoided in 2023, and more than 2,700 in 2031, or an average of about 1,500 avoided premature deaths per year due to improved air quality as a result of implementing the Final 2016 AQMP control measures. Figure 3-3 shows that mortality risks will be reduced in each of the four counties, with the largest number of avoided premature deaths concentrated in the densely-populated Los Angeles County area. Morbidity incidence is also reduced as a result of the Plan. It is estimated that reductions in ozone and PM2.5 concentrations will results in about 2,500 fewer asthma-related emergency department visits. In addition, the number of hospital admissions from all endpoints considered (asthma, cardiovascular, respiratory, and ischemic stroke) are estimated to decrease by about 700 per year on average.

[6] The operations of the BenMAP-CE by SCAQMD staff for estimating public health benefits in this report were reviewed by Dr. Jin Huang, a former project manager for the 2014 Abt review and the STMPR expert on BenMAP analysis. The operations were found to be appropriate as described in Appendix 3-C.

TABLE 3-3: HEALTH EFFECT ESTIMATES

	2023	2031	Average Annual
Premature Deaths Avoided, All Cause			
Short-Term Ozone Exposure[1]	45	89	49
Long-Term PM2.5 Exposure	1,394	2,716	1,512
Short-Term PM2.5 Exposure[2]	100	194	108
Reduced Morbidity Incidence			
Short-Term Ozone Exposure[1]			
Emergency Room Visits, Asthma	2,209	4,154	2,350
Hospital Admissions (HA), All Respiratory	68	148	78
Hospital Admissions (HA), Asthma	64	119	68
Minor Restricted Activity Days[4]	327,312	610,075	346,679
School Loss Days, All Cause[4]	100,034	184,781	105,451
Long-Term PM2.5 Exposure			
Acute Bronchitis	1,039	1,890	1,087
Short-Term PM2.5 Exposure			
Acute Myocardial Infarction, Nonfatal	33	71	38
Asthma Exacerbation (Wheeze, Cough, Shortness of Breath)	23,321	42,780	24,495
Asthma, New Onset (Wheeze)	2,956	5,577	3,151
HA, All Cardiovascular (less Myocardial Infarctions)	164	337	183
HA, All Respiratory (less Asthma)[3]	136	290	155
HA, Ischemic Stroke	79	171	91
HA and ED Visits, Asthma	142	260	149
Lower Respiratory Symptoms	12,268	22,387	12,850
Upper Respiratory Symptoms	24,342	44,720	25,587
Minor Restricted Activity Days[4]	528,869	961,248	552,809
Work Loss Days[4]	91,689	166,826	95,892

* Each health effect represents the point estimate of a statistical distribution of potential outcomes. Please see Appendix 3-B where the 95-percent confidence intervals are reported. Health effects for other years during the period 2017 to 2031 were based on interpolated, as opposed to modeled, air quality changes. The study population of each C-R function utilized can be found in Appendix 3-B.

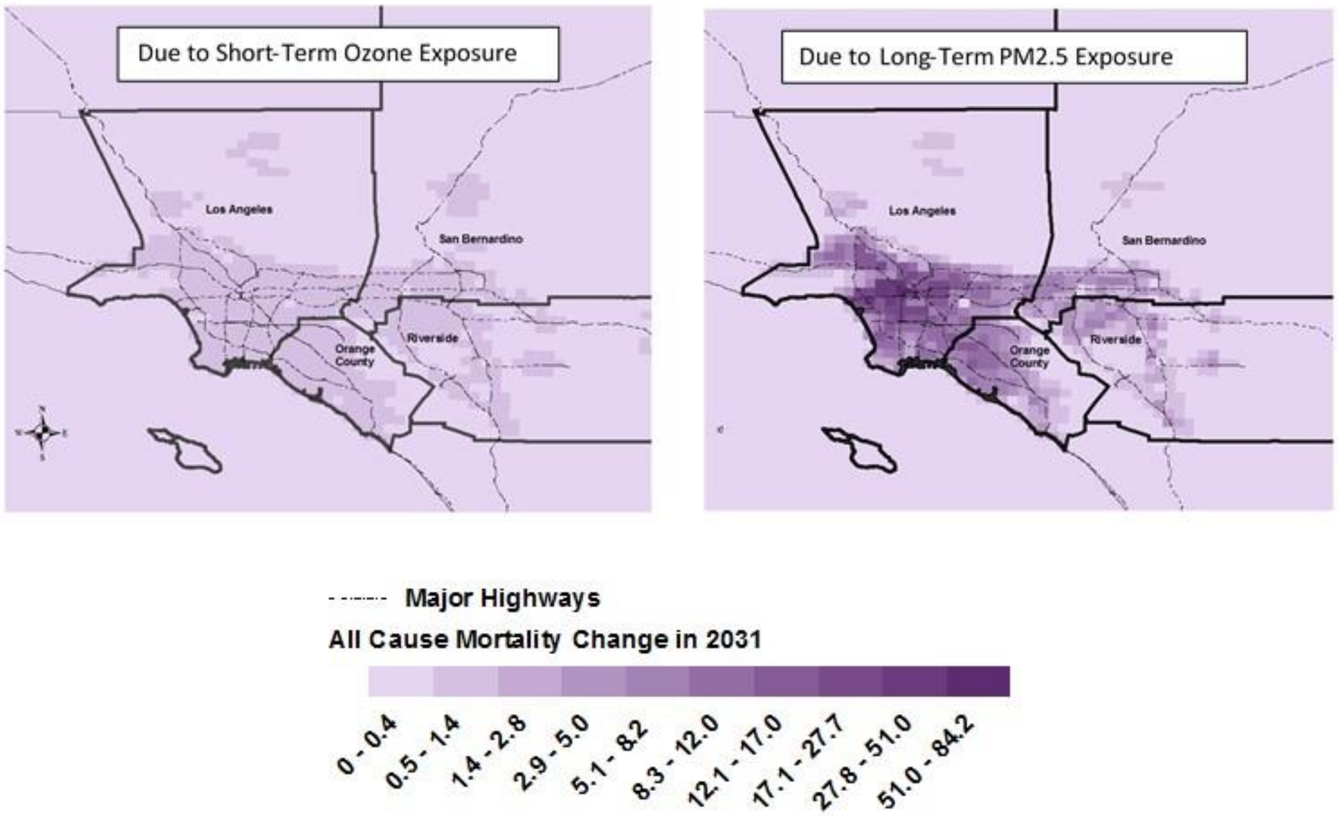
[1] Health effects of ozone exposure are quantified for the summer planning period only (i.e., May 1 to September 30). There are potentially more premature mortalities and morbidity conditions avoided outside the ozone peak season.

[2] Premature deaths avoided due to short-term exposure to PM2.5 are likely to partially overlap with those due to long-term PM2.5 exposure. Therefore, the total premature deaths associated with PM2.5 will be lower than simply summing across mortality effects from both short-term and long-term exposure (Industrial Economics and Thurston 2016a; Kunzli et al. 2001).

[3] This is the pooled estimate of two health endpoints: HA, Chronic Lung Disease (less Asthma) (18-64 years old) and HA, All Respiratory (65 or older).

[4] Expressed in person-days. Minor Restricted Activity Days (MRAD) refer to days when some normal activities are avoided due to illness.

FIGURE 3-3: SPATIAL DISTRIBUTION OF ESTIMATED PREMATURE DEATHS AVOIDED (YEAR 2031)



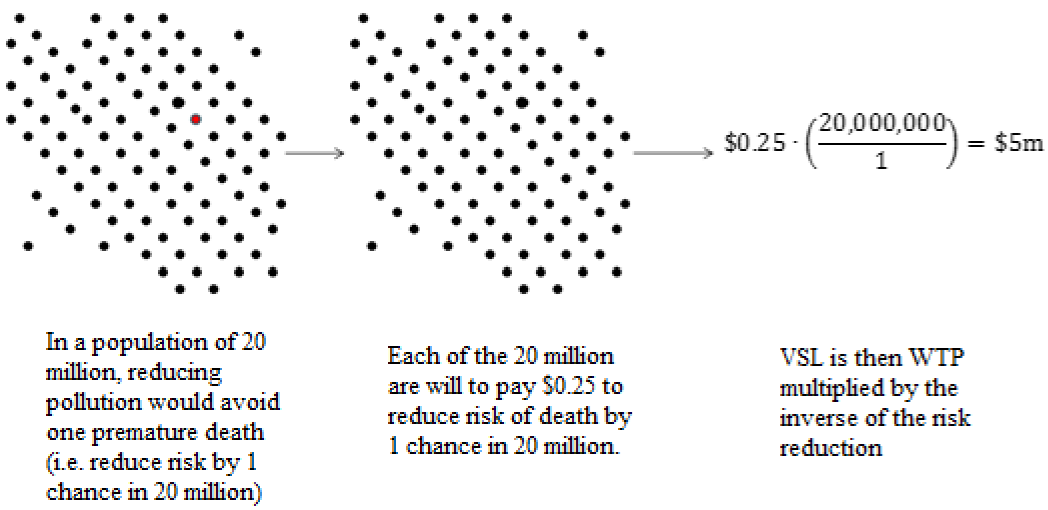
Basin residents are also expected to benefit from the avoidance of large numbers of hospital admissions, emergency room visits, school and work loss days, as well as various respiratory and cardiovascular symptoms. The all-cause mortality effects related to short-term ozone exposure were estimated based on pooling two LA city-specific C-R functions from Bell et al. (2005), and the all-cause mortality effects associated with long-term PM2.5 exposure were estimated based on pooling C-R functions estimated in Jerrett et al. (2005), Jerrett et al. (2013), and the kriging and land use regression results from Krewski et al. (2009). Details of these selected functions and the C-R functions used for morbidity effect estimates can be found in Appendix 3-B.

It should be noted that the health effect estimation does not use a concentration threshold below which the affected population would stop benefiting from further reduced exposure to ambient air pollution. In the analysis, health benefits will continue to accrue due to reduced exposure at all levels of pollutant concentration, even at levels below the current NAAQS.[7] This practice was recommended by Industrial

[7] Note that the control scenario being analyzed here is based on the Final 2016 AQMP control strategies which are designed to bring the Basin into attainment of the federal ozone and PM2.5 standards. Due to the nature of emissions and air quality dynamics, there are spatial variations of pollutant concentrations across the Basin (see Chapter 5 of the Final 2016 AQMP for detailed discussions). In the baseline scenario (without Final 2016 AQMP), there are certain areas in the Basin where the modeled pollutant concentrations are already below the federal standards; however, there are also many other areas with modeled pollutant concentrations still exceeding the standards by attainment deadlines. In the control scenario, pollutant concentrations in all areas are expected to fall below the standards, with some falling slightly below and others significantly below. By not employing a threshold

Economics, Inc. and based on the latest scientific evidence, including those summarized in the ISAs (U.S. EPA 2009; U.S. EPA 2013). It is also consistent with the current analytical approach adopted by the U.S. EPA in its regulatory impact analyses (U.S. EPA 2012; U.S. EPA 2015b).[8] It should also be noted that health effects related to ozone exposure are quantified only for the summer planning period of May 1 to September 30. There are potentially more premature mortalities and morbidity conditions avoided outside the peak ozone season.

FIGURE 3-4: ILLUSTRATIVE EXAMPLE OF VALUE OF STATISTICAL LIFE



Source: U.S. EPA, modified by Industrial Economics, Inc. and SCAQMD staff

After health effects are quantified, they are then translated into dollar values using two types of valuation methodologies.[9] Monetized benefits associated with avoided premature deaths are monetized based on a population's willingness-to-pay (WTP) for a small reduction of mortality risk in a year and generally expressed as the "value of statistical life (VSL)." As illustrated in Figure 3-4, the concept of VSL does not place a monetary value on saving a life with certainty; instead, it is an aggregate WTP of a population so that the associated risk reductions are statistically equivalent to one case of premature death avoided.[10]

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in the analysis, public health benefits are being quantified for all reductions in pollutant concentrations between the baseline and the control scenarios that are attributable to the Final 2016 AQMP.

[8] There was no threshold used in quantifying public health benefits of reduced ozone exposure in the 2015 Regulatory Impact Analysis (RIA) of the Final Revisions to the NAAQS for Ground-Level Ozone. In the same document and in the 2012 RIA for the Final Revisions to the NAAQS for Particulate Matter, the estimated total premature deaths avoided due to long-term exposure to PM2.5 was reported as the sum of two numbers: one represents the number of premature deaths avoided estimated at or above the lowest measured level (LML) of PM2.5 concentration, and the other represents the number of premature deaths avoided estimated below the same LML. This was done as one of the concentration benchmark analyses to address uncertainty. Meanwhile, the mortality-related benefits associated with reduced PM2.5 exposure was monetized for the total premature deaths avoided. More discussion can be found in Appendix 3-B.

[9] Health effects quantification and valuation in this analysis rely on existing high quality studies whose results are applicable and suitable for a benefits analysis of the Final 2016 AQMP. This "benefit transfer" from existing studies to the analysis herein is necessary as it is not feasible for staff to conduct original research for all necessary inputs.

[10] For more details, please see Industrial Economics and Robinson (2016a) and Robinson and Hammitt (2016).

The total monetized benefits of avoided premature deaths were derived by multiplying the number of premature mortalities reduced by the VSL. For morbidity effects, WTP was the preferred valuation method, but in many cases when such estimates are not yet available or reliable, cost of illness (COI) avoided were used to monetize morbidity risk reductions. Avoided COI is conceptually regarded as a conservative estimate of monetized health benefits, as it only accounts for avoided resource costs including direct medical costs and indirect productivity losses, but generally cannot fully account for the benefits of preventing pain and suffering associated with health-related issues.

As shown in Table 3-4, the overall quantifiable and monetized annual public health benefits are estimated to be $14.4 billion in 2023 and $30.9 billion in 2031 with an average annual of $16.5 billion. About 99 percent of these benefits are attributable to mortality-related benefits, among which the avoided premature deaths due to reduced long-term exposure to PM2.5 were estimated to account for over 95 percent of total monetized public health benefits. The estimates were based on the VSL of $9.0 million[11] and the assumption that the WTP for mortality risk reductions will increase as per-capita income grows; specifically, a one percent increase in income was assumed to raise VSL by 1.1 percent (i.e., an income elasticity of 1.1) (Industrial Economics and Robinson 2016a). These values correspond to a present value of quantified benefits of $173.2 billion at a four percent discount rate or $246.1 billion at a one percent discount rate, cumulatively from 2017 to 2031.

TABLE 3-4: MONETIZED PUBLIC HEALTH BENEFITS (BILLIONS OF 2015 DOLLARS)

	Year 2023	Year 2031	Average Annual (2017-2031)	Present Value (2017-2031)
Mortality-related benefits	**$14.2**	**$30.5**	**$16.2**	**$170.8**
Short-Term Ozone Exposure	$0.5	$1.1	$0.6	$6.1
Long-Term PM2.5 Exposure	$13.7	$29.4	$15.7	$164.7
Morbidity-related benefits	$0.2	$0.4	$0.2	$2.4
Grand Total	**$14.4**	**$30.9**	**$16.5**	**$173.2**

Note:
1) Numbers may not sum up due to rounding, and the present value was calculated using a four-percent discount rate.
2) Premature deaths avoided due to short-term exposure to PM2.5 are monetized separately due to potentially double counting concerns with benefits associated with long-term exposure.
3) Health effects of the endpoint “Asthma, New Onset (Wheeze)” are not monetized, due to lack of a valuation method.
4) The monetized public health benefits reported in this table were estimated for the four-county region, which includes areas that are located outside the Basin. However, staff estimated that mortality-related benefits accrued to the areas within the Basin would account for 99 percent of the total. In other words, the difference is minimal between quantifying public health benefits for the Basin and for the four-county region.
5) See Appendix 3-B for a detailed discussion regarding morbidity-related public health benefits.

[11] All VSL values presented here are in 2013 dollars and income levels, health benefits results estimated from them are converted to 2015 dollars using published U.S. GDP deflators for consistency with this report.

As noted for Table 3-3, the effects of reduced short-term PM2.5 exposure on mortality incidence likely overlap to some extent with those from long-term PM2.5 exposure. Thus, for the purposes of this analysis, we exclude the monetized value of these benefits from the total quantified public health benefits to avoid issues of double-counting. Here we provide the monetized value of avoided premature deaths from short-term PM2.5 exposure separately for informational purposes. Based on the estimated avoided premature deaths of 100 and 194 on average in 2023 and 2031, respectively, the corresponding monetized benefits are $1.0 billion and $2.1 billion per year using the mid-point estimate of VSL.[12]

Sensitivity and Uncertainty Analyses

It should be emphasized that, as with all scientific studies and evaluations, there are various sources of uncertainty surrounding the estimated public health benefits, including the uncertainty embedded in data inputs, uncertainty of the C-R functions chosen, and uncertainty of valuation. Given the significant contribution of mortality-related benefits, staff conducted several sensitivity and uncertainty analyses regarding three major sources of uncertainties in public health benefits estimations.

Sensitivity Analysis using Different Sets of VSL and Income Elasticity

The first sensitivity analysis considers alternative VSL and income elasticities. The base VSL of $9.0 million represents the mid-point of the recommended VSL range of $4.2 million to $13.7 million (Industrial Economics and Robinson 2016a). This VSL range is based on a review of recent, peer-reviewed studies on the value of mortality risk reductions and considered as reasonable for regulatory analysis (Robinson and Hammitt 2016). In addition, a lower income elasticity of 0 (i.e., VSL does not change with income level) and a higher income elasticity of 1.4 (i.e., a one percent income growth increases VSL by 1.4 percent) were also recommended to be used in the sensitivity analysis, based on a study by Viscusi (2015). Table 3-5 shows the range of monetized public health benefits, where the lower bound assumes a VSL of $4.2 million and an income elasticity of 0 while the upper bound assumes a VSL of $13.7 million and an income elasticity of 1.4. In 2023, the range of benefits is from $5.6 to $22.7 billion, and for 2031, the range is from $10.9 to $49.9 billion. The lower bound ranges from about 35 to 40 percent of the mid-point benefits for 2023 and 2031, while the upper bound is about 160 percent of the mid-point estimate. Applying the same sensitivity analysis to the present value of quantified public health benefits, the range will be $66 billion to $273 billion, cumulatively from 2017 to 2031, with a mid-point estimate of $173 billion.

[12] Further information on this analysis can be found in Appendix 3-B.

TABLE 3-5: SENSITIVITY ANALYSIS OF MORTALITY EFFECTS VALUATION

Monetized Public Health Benefits (Billions of 2015 dollars)						
	2023			2031		
	Lower Bound	Mid-point	Upper Bound	Lower Bound	Mid-point	Upper Bound
Base VSL*	$4.2	$9	$13.7	$4.2	$9	$13.7
Income Elasticity	0	1.1	1.4	0	1.1	1.4
Mortality-related benefits	**$5.6**	**$14.2**	**$22.7**	**$10.9**	**$30.5**	**$49.9**

* The base VSL is expressed in millions of 2013 dollars and based on 2013 income levels.

Sensitivity Analysis using C-R Functions from Different Study Locations and Endpoints

To test the sensitivity of mortality-related health benefits to the recommended C-R functions for long-term exposure to PM2.5, three alternative sets of C-R functions estimated for different geographies and incidence data were used, as recommended by Industrial Economics (2016a). The sets of pooled C-R functions include those estimated from California data, those estimated from national data, and those estimated based on cardiovascular disease (CVD) related mortality incidence rather than all-cause mortality incidence. The first two sets of C-R functions consider studies conducted at progressively larger geographic scales, usually with larger sample sizes. The third set focuses on the impact of long-term PM2.5 exposure on cardiovascular mortality risk, based on studies of affected populations in Los Angeles and California. In addition to the consistent evidence of a causal relationship, the biological mechanism of how exposure to PM2.5 affects cardiovascular mortality risk was also extensively evaluated.

Table 3-6 shows the results of the sensitivity analysis for both health impacts and monetized benefits in milestone years 2023 and 2031. It can be seen that the quantified public health benefits appear to be lower under all three alternative sets of C-R functions, ranging from about 65 percent for the national estimates to 19 percent for the California estimates. However, it should be noted that only the national estimates are directly comparable to the main estimates because of similar study populations. The key difference between the main estimates and the national estimates stem from the estimated magnitude of how mortality risk responds to a change in PM2.5 concentration, which is lower in the national studies used. The other two sensitivity tests also have different magnitudes of concentration-response relationship, but there are additional differences. The sensitivity test based on California estimates consists of the pooling of two studies which have a large variance in their estimated C-R relationships. The pooling method based on IEc's recommendation weighs the study with the smaller magnitude of mid-point estimate (Thurston et al. 2016) much more than the other study with a larger magnitude mid-point estimate (Jerrett et al. 2013); if an equal weighting pooling method would have been applied to these two studies, it would result in greater health impact estimates which are closer to those found for the CVD studies. The CVD-only mortality impacts did not account for impacts associated with other causes of mortality and are thus likely underestimated the magnitude of total mortality-related benefits due to reduced long-term exposure to PM2.5 (Industrial Economics and Thurston 2016a).

TABLE 3-6: SENSITIVITY ANALYSIS OF PREMATURE DEATHS AVOIDED AND MONETIZED BENEFITS ASSOCIATED WITH REDUCED LONG-TERM EXPOSURE TO PM2.5

Scenarios	Premature Deaths Avoided (Annual Impacts)		Monetized Benefit (Billions of 2015$ per Year)	
	2023	2031	2023	2031
Main Scenario (L.A. Studies)	1,394	2,716	$13.7	$29.4
California Studies	258	509	$2.5	$5.5
National Studies	918	1,790	$9.0	$19.4
CVD (L.A. and CA Studies)	339	663	$3.3	$7.2

Distribution of PM2.5 Mortality-related Health Impacts by Lowest Measured Level

While the U.S. EPA concluded that, for both ozone and PM2.5, the current scientific evidence does not support the existence of a threshold concentration level below which no health impacts occur (U.S. EPA 2009; U.S. EPA 2013), various different health impact analysis have included a threshold, particularly for PM2.5, for the purpose of addressing the issue of statistical uncertainty at very low concentration levels (U.S. EPA 2012; U.S. EPA 2015b; CARB 2010). In these analyses, a threshold was determined by the lowest measured level (LML) of PM2.5 concentration in the study where the selected C-R function was estimated.

To address the uncertainty associated with this topic, a sensitivity analysis was conducted on the public health benefits of the Final 2016 AQMP, using a threshold of 5.8 $\mu g/m^3$ based on the LML for national data and 9.5 $\mu g/m^3$ based on the LML for Los Angeles data, both from Krewski et al. (2009). It was found that 94 percent and 68 percent of the premature deaths avoided reported in Table 3-3 for 2031 are associated with PM2.5 concentrations that were reduced to 5.8 $\mu g/m^3$ and 9.5 $\mu g/m^3$, respectively (see Table 3-7). Therefore, at least 68 percent of the avoided premature deaths associated with reduced long-term exposure to PM2.5 can be regarded with sufficient confidence, as it accounts for concentration levels observed in at least one the studies from which the C-R functions were derived. Conversely, at most 30 percent of the health benefits are accompanied by a greater degree of statistical uncertainty, as they relied on extrapolation of study results.

The results of various sensitivity and uncertainty analyses conducted were consistent with the initial analysis. While it is important to recognize the uncertainties regarding valuation parameters, which specific function is most appropriate to use, and the extrapolation of concentration-response results to very low levels of pollution concentration, the sensitivity analyses continued to demonstrate the significant contribution of cleaner air to public health improvements, specifically from avoided premature deaths due to lower air pollution-related health risk.

TABLE 3-7: DISTRIBUTION OF MORTALITY-RELATED HEALTH IMPACTS BY LML SCENARIO IN 2031

	Avoided Premature Deaths		
LML scenario	**Above LML threshold**	**Below LML threshold**	**Percent above threshold**
5.8 μg/m³	2,552	164	94%
9.5 μg/m³	1,836	880	68%

Moreover, the quantifiable public health benefits associated with improved air quality were assessed relative to reduced morbidity conditions and premature mortalities from exposure to ozone and PM2.5, respectively. To avoid potentially double counting health effects, this analysis uses C-R functions that do not have overlapping health endpoints for the same age group, whether the overlap may be large or small. It also does not add to the overall quantified public health benefits the monetized value of avoided premature deaths due to short-term exposure to PM2.5, due to concerns over potentially double counting benefits with those associated with long-term exposure to PM2.5. Moreover, the present state of knowledge allows a quantitative assessment of the relationship between ozone and PM2.5 and the health effects as noted in Table 3-2. However, not enough information is currently available in scientific literature to allow for all adverse health effects identified to be measured and valued in dollars, mainly because sufficient data are not available to establish a quantitative relationship between these pollutant levels and some of these health effects. Hence, the quantified public health benefits may be underestimated.

It should also be emphasized that improved public health can generate direct economic benefits other than increased productivity and fewer lost work days in the short-term. As an example of other health benefits that can occur, but are not quantified here, a recent study (Isen et al. forthcoming) showed that improvement in early-childhood health has long-term economic benefits as well. Reductions of in-utero and early-infancy exposure to air pollution were found to increase labor participation among the affected individuals 30 years later; that is, working-age adults are more likely to hold a job when they were less exposed to air pollution as an infant.

Public Welfare Benefits

NAAQSs for criteria pollutants, set pursuant to the CAA, include both primary standards designed to protect public health and secondary standards to protect public welfare, including preventing damage to agriculture, ecology, visibility, buildings, and materials. In the previous section, the public health benefits associated with the Final 2016 AQMP, which is designed to attain the federal ozone and PM2.5 standards, were quantified. The Final 2016 AQMP is additionally expected to provide benefits protective of public welfare. Although these additional benefits are not specifically quantified for this AQMP, we provide a qualitative description of these public welfare benefits. We additionally include a discussion of the benefits estimated in these categories from the Socioeconomic Reports of previous AQMPs and the scientific literature that provided the methodological basis for quantification. The 2014 report by Abt Associates recommended that the literature and methodologies be updated to reflect the latest advancement in scientific knowledge and that the sufficiency of data and information should also be evaluated. Implementation of these recommendations will be conducted for future AQMPs.

Agricultural Benefit

Agriculture is an integral part of the economy in the Basin. Riverside and San Bernardino counties are ranked in the top 25 counties in California in value of agricultural commodity production. The total value of agricultural production in the four-county region was $2.3 billion, comprised of $1.36 billion from Riverside, $527 million from San Bernardino, $230 million from Los Angeles, and $132 million from Orange (CDFA 2015). Some of the leading commodities produced in these counties include: milk, nursery, grapes (table), hay (alfalfa), eggs, and cattle (milk cows).

Ozone damages vegetation and many crops more than all other pollutants combined. Since the early 1970s, numerous studies have shown that ozone inhibits crop productivity in California, resulting in reductions in crop yield (Larsen and Heck 1976; Oshima et al. 1976; CARB 1987). Improvements in air quality, in particular reductions in ozone concentrations, can improve the productivity of crops. The benefits to agriculture from improved air quality have been quantified in the Socioeconomic Report of previous AQMPs. Using results from more recent studies on the effects of ozone on crop yield (Olszyk and Thompson 1989; Randall and Soret 1998), combined with land-use and economic data, the cash value of increased crop yields that would result from implementation of the 2007 AQMP was estimated. It was projected that the 2007 AQMP would result in a cash value of $23.2 million (in 2000 dollars) for the year 2023. Since the 2012 AQMP was a PM2.5 plan, ozone concentrations were not modeled to derive agricultural benefits. In addition to the benefits to crops from reducing ozone, air contaminants can also damage livestock as they do humans. This livestock benefit was not quantified in previous AQMPs and is also not quantified here.

Implementation of the Final 2016 AQMP will result in agricultural benefits such as increased productivity of agricultural crops in the four counties. However, updating the economic methods used for quantifying these benefits was suggested by Abt Associates (2014). These updates cannot be implemented at this time but are planned for socioeconomic assessments in future AQMPs.

Material Benefit

Material benefit is the benefit accrued by the reduction of damage to materials from air pollution. Studies have identified the types of damage that can occur from air pollution and estimated their monetary value. For total suspended particulate matter (TSP) in particular, it causes accelerated wear and breakdown of painted wood and stucco surfaces of residential and commercial properties (Murray et al. 1985). In addition, TSP leads to additional household cleaning costs due to soiling damages (Cummings et al. 1985). Using the results from these studies, the benefits of air pollution controls under previous AQMPs were estimated. The monetary benefit, as a result of implementing the 2007 AQMP, from decreases in cost for repainting stucco and wood surfaces, and cleaning and replacing damaged materials was projected to be $308 million (in 2000 dollars) for the year 2023. Material benefits due to the 2012 AQMP was projected to be about $13 million (in 2005 dollars) for the year 2023. The large difference between the benefits estimated from these two previous AQMPs is due to the 2007 AQMP being an ozone attainment plan with more PM2.5 co-benefits, whereas the 2012 AQMP was a PM2.5 attainment plan with fewer PM2.5 reductions.

In addition to the these damages, a link exists between several pollutants (ozone, sulfur dioxide, PM2.5, and nitrogen oxides) and ferrous metal corrosion; erosion of cement, marble, brick, tile, and glass; and the fading of fabric and coated surfaces (Cummings et al. 1985; Murray et al. 1985). The damage and conversely the potential benefits from reducing the exposure to these items currently cannot be quantified and valued in dollars.

There will also be benefits of reduced damage to materials as a result of the Final 2016 AQMP, which will reduce PM2.5 and correspondingly TSP. However, the studies used previously to quantify these benefits are outdated, and the Abt report (2014) recommended not quantifying these benefits until a systematic literature review of current research on this topic could be conducted and the sufficiency of data and information could be reevaluated. This literature review is planned for socioeconomic assessments in future AQMPs.

Visibility Benefit

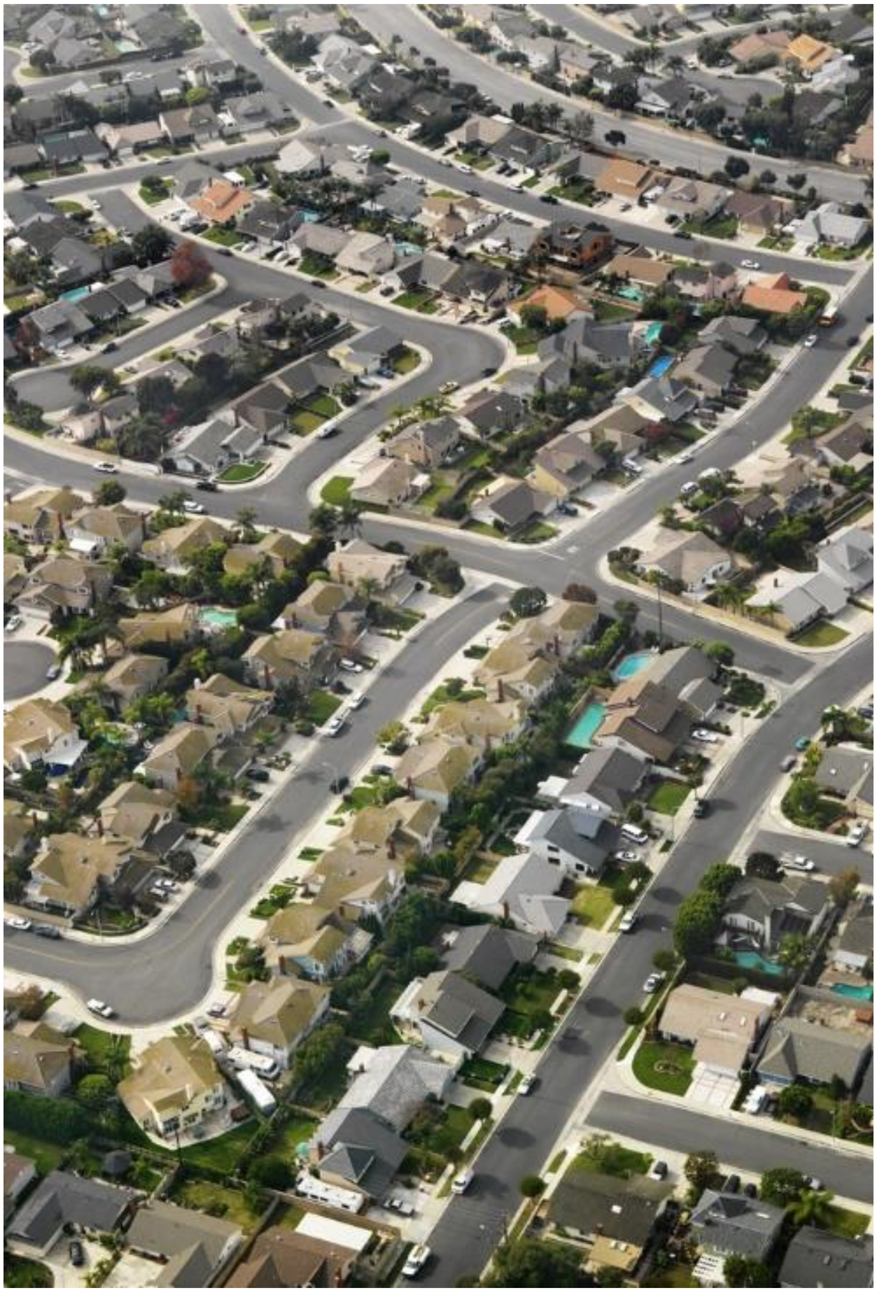
Visibility benefits are the benefits individuals place on the ability to see distant vistas, in places where they live, work, and travel. In qualitative terms, an example of this for the Basin is the value people place on being able to see the San Gabriel Mountains, which were designated a National Monument, from much greater distances, more often. Studies have found that individuals place a monetary value on being able to see distant vistas (Smith and Osborne 1996). A local study by Beron et al. (2001), which estimated parameters that could quantify the value of these visibility benefits,[13] was applied to valuation of the visibility improvements of previous AQMPs. The visibility benefit of the 2007 AQMP was projected to be $5.2 billion (in 2000 dollars) for the year of 2020, and $649 million (in 2005 dollars) as a result of the 2012 AQMP for the year of 2023. The larger benefit from the 2007 AQMP is due to a greater reduction of PM2.5 concentrations than those achieved in the 2012 AQMP.

There will also be benefits to visibility as a result of the air quality improvements achieved from implementing the Final 2016 AQMP. However, quantification of these benefits was not performed in this analysis based on a recommendation from Abt Associates (2014). The Abt report argued that the local study used to monetize the visibility benefits in previous AQMPs had shortcomings and was dated;[14] therefore, an updated methodology is needed to accurately estimate these benefits. This methodology update is planned for socioeconomic assessments in future AQMPs.

[13] This study used a method called hedonic price analysis, which uses property values along with a diverse set of attributes to estimate the implicit prices of attributes that are associated with a good exchanged in the market.

[14] The methodological improvements since Beron et al. (2001) was published would address issues such as endogeneity in spatial sorting of communities, choice of functional form for the econometric model, and the difficulty of measuring amenities from available data that are likely present in that research.

Chapter 4: Macroeconomic Job Impacts



Chapters 2 and 3 of this report estimated the incremental costs and quantified the public health benefits associated with the proposed Final 2016 AQMP control measures, respectively. The control measures are designed to provide a path to clean air targets and address federal CAA requirements for ozone and PM2.5 standards. The costs and benefits of the Final 2016 AQMP are expected to alter, to various degrees, the economic decisions made by households, businesses, and other economic actors. Some businesses would see production costs go up while other businesses would benefit from a greater demand for their services and technologies. For consumers who consider purchasing or replacing vehicles or certain household appliances, the proposed control strategies would also change or widen the range of product choices that differ in fuel types, energy efficiencies, effective unit prices, and thus potential payback periods. In the meantime, improved public health would contribute to higher labor productivity and reduce healthcare-related expenditures. All these direct effects would then cascade through the regional economy and produce indirect and induced macroeconomic impacts. The immediate and subsequent effects may not just occur in the short-term, but some of them may also have lasting impacts that would subside only after a long period of time.

These direct, indirect, and induced macroeconomic impacts were assessed through a multi-year, multi-sector, and multi-region economic model customized by REMI for the SCAQMD.[1] This model contains 21 sub-county regions within the four-county area of Los Angeles, Orange, Riverside, and San Bernardino, and the rest of the world. The production of the model economy is comprised of 70 public and private sectors. The regionalized input-output framework used in the REMI model depicts the inter-industry relationships and interactions between different sectors of the model economy. The structure of each sub-county region's economy is represented through production, sales, and purchases between sectors; demand and supply of products in each sector; expenditures made by consumers, businesses, and governments; and trades of goods and services which occur between one sub-county region, the rest of the sub-county regions, and the rest of the world. REMI is a dynamic model which simulates the difference in jobs and other macroeconomic variables annually. REMI simulates annual job impacts, resulting in a projection of either jobs gained or foregone. Jobs foregone consists two conceptually distinctive components: jobs losses and jobs not created, but they cannot be numerically separated.

The macroeconomic impacts associated with the Final 2016 AQMP were simulated and projected relative to the baseline forecast for the regional economy, which excludes the implementation of the proposed control strategies in the Final 2016 AQMP. Consistent with the baseline air quality modeling and emission inventory analysis in the Final 2016 AQMP, the baseline economic forecast utilizes the 2016 SCAG Growth Forecast (SCAG 2016), specifically its population and job projections.[2] The regional job impacts were simulated for incremental costs only, public health benefits only, and a combined scenario. The REMI model provides policy variables through which the incremental costs and public health benefits can be entered as changes to the economic variables or parameters in the model equations. In addition to job impacts, potential impacts on regional competitiveness are simulated as part of this analysis and included in Appendix 4-C.

It should be emphasized that the REMI model is designed and used mainly to assess the potential macroeconomic impacts on the overall regional economy and the various sectors within the economy. It is not designed to predict potential impacts on an individual business or facility. Moreover, due to both model and data constraints, the analysis does not take into account the air quality management plans being proposed by other air districts, such as the 2016 ozone and PM2.5 plans by the San Joaquin Valley Air Pollution Control

[1] REMI Policy Insight Plus (PI+) South Coast Sub County Model v1.7.3 (Build 3967). For a full description of the REMI methodology, please refer to the REMI documentation available at http://www.remi.com/products/pi.

[2] Appendix 4-A describes the 2016 SCAG projections of population and jobs, as well as the procedures taken by staff to adjust and update the default REMI baseline forecasts based on SCAG projections and the modeling implications of this update.

District. It is possible that the macroeconomic impacts of these other plans can potentially spillover to the South Coast region, therefore attenuating in some cases and reinforcing in other cases the macroeconomic impacts projected in this chapter. Further, the state and federal actions proposed by CARB would concurrently affect the four-county region and other regions in the state or in the nation, and these effects may change relative prices and other relative conditions between the regional economy and the rest of the world. However, these concurrent effects in other regions are not incorporated in the macroeconomic impact analysis because the customized REMI for the SCAQMD's socioeconomic assessment does not explicitly model regions outside the four counties. While these effects may also attenuate or reinforce the projected impacts, the magnitudes are expected to be sufficiently small.

Projected Job Impacts Due to Estimated Incremental Costs

As discussed in Chapter 2, the total present worth value (PWV) of incremental costs associated with the Final 2016 AQMP control strategies was estimated to be $15.7 billion, and the amortized annual average amounted to $850 million per year between 2017 and 2031. Consumers would see net cost savings of $2.3 billion, mainly due to fuel savings from zero and near-zero emissions light-duty vehicles and also from using residential appliances with higher energy efficiency. In the REMI model, these cost savings would then allow consumers to spend more on other goods and services, whether locally supplied or imported from outside the four-county area.[3]

Almost all private industry sectors in the regional economy are expected to incur varying amounts of cost increases as a direct result of implementing the proposed control strategies (see Table 2-2 in Chapter 2). The additional cost is modeled as a higher cost of doing business, along with a projected decrease in industry output which is seen as a direct effect of the increased costs. Even so, it should be noted that there are also cases where the proposed control strategies generate significant fuel or operation and maintenance cost-savings such that the cost of doing business may be partially offset or actually decrease, especially when coupled with incentives. These decreases in costs would enable regional businesses to increase their output.

These direct changes in the cost of doing business are accompanied by an increased demand for air pollution control equipment or zero and near-zero emission technologies (e.g. low-NOx trucks, burners and heaters), as intended by the proposed control strategies in the Final 2016 AQMP. This would result in increased output and sales for the suppliers of this equipment which would additionally benefit the upstream suppliers who provide intermediate inputs to manufacture such equipment. These potential beneficial impacts flowing from the increased demand on suppliers would highly depend on the location(s) of the potential suppliers. Due to lack of such information in many cases, staff largely relied on REMI's embedded assumption regarding the share of increased local demand met by local *versus* outside suppliers.

The government sector is expected to incur the largest share of the total estimated incremental cost: about 93 percent, or $14.6 billion in PWV. The vast majority of this cost would be expended on the proposed incentive programs, which are devised to accelerate the deployment of zero and near-zero emission technologies. In the event where no additional revenues are raised, the estimated government spending to provide clean air incentives would need to be appropriated from unallocated and non-earmarked funds or from funds for discretionary programs that are supported by existing revenue sources. To be conservative about the prospect of securing additional public revenue from new sources and also to be consistent with

[3] See Appendix 4-B for the policy variables used in the REMI analysis associated with incremental costs.

CARB's modeling approach for the state's mobile source strategy (CARB 2016), the primary scenario of the REMI analysis assumed that all incentive programs would be funded by existing revenue sources for the state budget. This scenario would require a state government budget reallocation and affects the provision of public services in the REMI model. Moreover, this scenario conservatively assumes that the modeling approach adopted in this primary scenario considers that the budget reallocation only affects state funding for the four-county region and does not directly affect other regions within the state.

All of these different cost and demand changes are entered into the appropriate REMI policy variables. Overall, the incremental costs from implementation of the Final 2016 AQMP are projected to result in, on average, slightly more than 9,000 jobs foregone per year during the period from 2017 to 2031. The number of jobs foregone includes both potential job losses and forecasted jobs not created, and 9,000 jobs foregone would represent a 0.08 percent decrease from the baseline total of jobs in the four-county region. This represents an annualized job growth rate of 1.01 percent from 2016 to 2031, which implies a less than 0.01 percentage point slowdown from the baseline job growth forecast. Table 4-1 shows the job impacts by industry sector for the initial implementation year of the Final 2016 AQMP (2017), the milestone years for ozone attainment demonstration (2023 and 2031), as well as the annual average between 2017 and 2031.

All sectors, except manufacturing (NAICS 33) and management of companies and enterprises (NAICS 55), are expected to provide fewer jobs relative to the baseline forecast. The jobs forgone projected for each of these sectors represent a decrease of less than one percent from each sector's baseline job counts. The average annual job impacts show that the state and local governments together would account for more than half of overall jobs foregone in the region. Most of this projected decrease from the baseline forecast would occur to state jobs within the four-county region, largely due to the modeling assumptions that the proposed incentive programs would be funded by existing sources of state government revenues and that this would only affect state budget spending within the four-county region.

In the REMI model, the reallocation of public funds to the proposed clean air incentive programs would directly result in funds diverted from local spending and thus jobs foregone in many sectors of the regional economy. For example, the construction sector would see jobs foregone mainly due to reduced government spending on local projects such as infrastructure improvements. Despite these projected decreases in the number of jobs from the baseline forecast, the proposed incentive programs would create indirect benefits for the suppliers of zero and near-zero emission vehicles and equipment. However, the four-county region is not expected to reap much of these benefits since most of the equipment targeted by the proposed incentive programs was assumed to be manufactured outside the region, based on the current industry structure of the regional economy that is summarized in the simplified model economy. Whether this model assumption holds true throughout the analysis horizon will significantly impact both the direction and the magnitude of the REMI analysis results.

TABLE 4-1: ANNUAL REGIONAL JOB IMPACTS OF INCREMENTAL COSTS BY SECTOR

Assuming Incentive Programs Funded by Existing Sources of *State Government Revenues*
(Relative to Baseline)

Sector	NAICS	Jobs			Average Annual (2017-2031)		
		2017	2023	2031	Jobs	Baseline Jobs	% Change
Agriculture, Forestry, Fishing, and Related Activities	11	-9	-7	1	-4	28,747	-0.01%
Mining, Oil and Gas Extraction	21	-59	-157	-233	-141	26,073	-0.54%
Utilities	22	-24	-112	-948	-254	25,739	-0.99%
Construction	23	-2,093	-2,205	-1,272	-1,475	591,549	-0.25%
Manufacturing	33	874	1,431	1,411	1,277	662,486	0.19%
Wholesale Trade	42	-275	-153	494	40	489,248	0.01%
Retail Trade	44-45	-1,132	-856	955	-385	1,038,587	-0.04%
Transportation and Warehousing	48-49	-260	305	739	315	383,908	0.08%
Information	51	-147	-82	13	-38	316,884	-0.01%
Finance and Insurance	52	-475	-259	140	-99	567,305	-0.02%
Real Estate and Rental and Leasing	53	-420	-446	-137	-275	683,422	-0.04%
Professional, Scientific, and Technical Services	54	-791	-771	-384	-493	899,580	-0.05%
Management of Companies and Enterprises	55	8	69	133	82	118,815	0.07%
Administrative and Waste Management Services	56	-959	-424	566	-22	865,447	0.00%
Educational Services	61	-199	-179	4	-95	250,443	-0.04%
Health Care and Social Assistance	62	-1,206	-1,110	-58	-617	1,363,990	-0.05%
Arts, Entertainment, and Recreation	71	-192	-105	52	-44	347,599	-0.01%
Accommodation and Food Services	72	-684	-903	-602	-672	751,627	-0.09%
Other Services, except Public Administration	81	-858	-521	360	-122	726,486	-0.02%
State and Local Government	92	-7,735	-9,259	-3,991	-6,274	1,030,886	-0.61%
Total		**-16,635**	**-15,741**	**-2,760**	**-9,299**	**11,168,820**	**-0.08%**

Another important assumption is the funding source of incentive programs. Table 4-2 presents the results of a sensitivity analysis where the funding for the proposed incentive programs comes from outside the four-county region and is considered as "free" money in the sense that it has minimal impacts on local public spending and the disposable income of the region's residents. This could arguably be the case when the proposed incentive programs are financed by existing federal funds. In this alternative scenario, implementation of the Final 2016 AQMP would result in an addition of average 6,300 jobs per year from 2017 to 2031, or a 0.06 percent increase from the overall baseline number of jobs in the region. This job impact would barely change the forecast 1.02-percent annualized job growth at the baseline.

Table 4-2: Sensitivity Analysis of Annual Regional Job Impacts of Incremental Costs by Sector

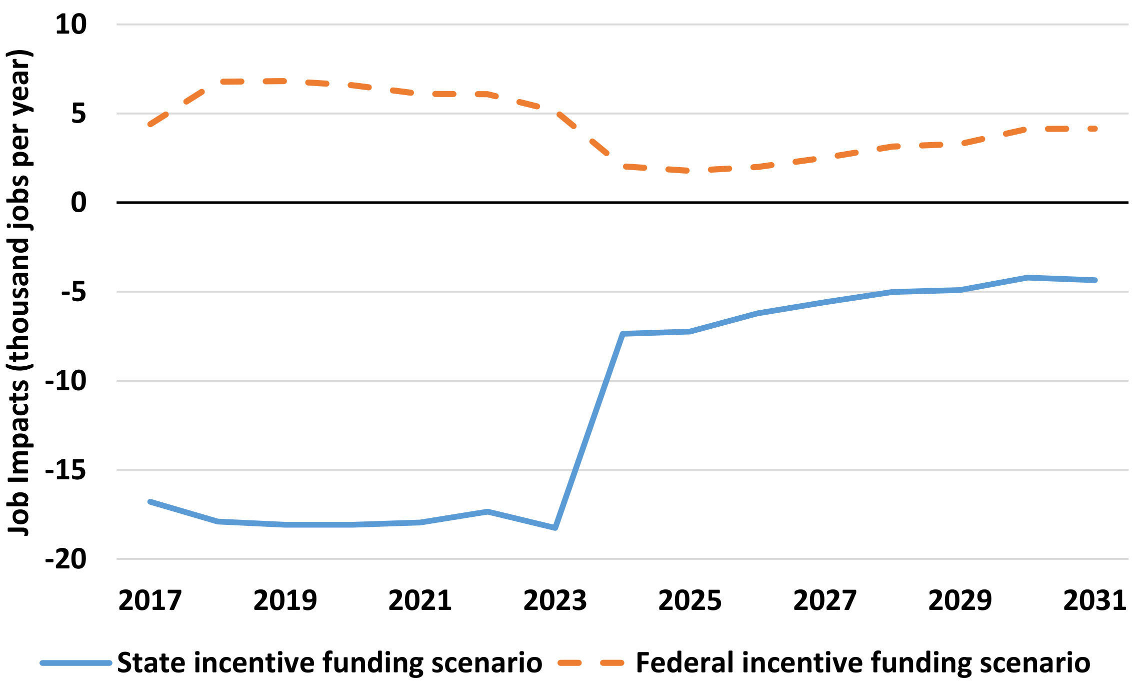
Assuming Incentive Programs Funded by Existing Sources of *Federal Government Revenues*
(Relative to Baseline)

Sector	NAICS	Jobs			Average Annual (2017-2031)		
		2017	2023	2031	Jobs	Baseline Jobs	% Change
Agriculture, Forestry, Fishing, and Related Activities	11	1	2	3	2	28,747	0.01%
Mining, Oil and Gas Extraction	21	-3	-113	-226	-114	26,073	-0.44%
Utilities	22	11	-72	-932	-227	25,739	-0.88%
Construction	23	307	376	-864	130	591,549	0.02%
Manufacturing	33	1,394	1,555	1,360	1,362	662,486	0.21%
Wholesale Trade	42	224	336	660	368	489,248	0.08%
Retail Trade	44-45	329	772	1,617	717	1,038,587	0.07%
Transportation and Warehousing	48-49	156	672	835	550	383,908	0.14%
Information	51	47	79	52	64	316,884	0.02%
Finance and Insurance	52	218	314	302	278	567,305	0.05%
Real Estate and Rental and Leasing	53	119	206	156	170	683,422	0.02%
Professional, Scientific, and Technical Services	54	285	433	29	304	899,580	0.03%
Management of Companies and Enterprises	55	99	127	138	117	118,815	0.10%
Administrative and Waste Management Services	56	327	1,010	1,076	922	865,447	0.11%
Educational Services	61	55	91	105	84	250,443	0.03%
Health Care and Social Assistance	62	316	563	679	524	1,363,990	0.04%
Arts, Entertainment, and Recreation	71	65	95	114	87	347,599	0.03%
Accommodation and Food Services	72	181	200	-97	86	751,627	0.01%
Other Services, except Public Administration	81	291	530	735	586	726,486	0.08%
State and Local Government	92	141	497	2	311	1,030,886	0.03%
Total		**4,559**	**7,673**	**5,745**	**6,321**	**11,168,820**	**0.06%**

These two scenarios analyze the job impacts from full funding from state only and federal only. In reality, the incentives will likely be funded from a combination of state and federal sources and hence the projected job impacts would likely fall in between these two scenarios (see Figure 4-1).

FIGURE 4-1: REGIONAL JOB IMPACTS OF INCREMENTAL COSTS, 2017-2031

(SCAQMD Four-County Region, 1990-2016)



Projected Job Impacts of Quantified Public Health Benefits

Similar to the job impacts of incremental costs, the job impacts due to public health improvements were also simulated annually for the period of 2017 to 2031. Public health improvements consist of two components: avoided premature deaths and reduced morbidity incidence. These improvements were quantified and monetized as described in Chapter 3.[4] The largest amount of public health benefits comes from the aggregated

[4] In the Draft Socioeconomic Report released on November 19, 2016, only the portion of mortality-related public health benefits that would accrue to the working age population (age 25-65) were inputted into the REMI model to simulate job impacts. This portion represented 17 percent of the previous estimate of total mortality-related benefits. REMI staff commented at the November 3rd, 2016 STMPR meeting that they would recommend inputting 100 percent of the estimated total public health benefits and considered staff's approach to be very conservative. In the Final Socioeconomic Report, the estimated total of mortality-related public health benefits was revised downward using the updated air quality modeling results. However, staff did not revise the amount of mortality-related public health benefits when evaluating job impacts. The amount of public health benefits inputted into the REMI model now accounts for 25 percent of the revised total morality-related benefits, and therefore, still represents a conservative estimate of positive job

willingness-to-pay for a lower risk of premature deaths as a result of decreased exposure to PM2.5 and ozone, based on Value of Statistical Life (VSL). These monetized benefits, while not occurring in the market economy through direct transactions of goods and services, were considered to enhance the quality of life or amenity in the region. In the modeled economy, an increase in a region's amenity, which includes but is not limited to better environmental quality such as cleaner air, acts to attract more economic migrants into the region. Therefore, it directly increases local labor supply as well as local demand for housing, which in turn produces ripple effects throughout the regional economy.

The other component of the public health benefits is derived from reduced morbidity incidence, such as fewer hospital admissions and visits to emergency departments, fewer absences from work and school, and fewer episodes of experiencing cardiovascular and respiratory symptoms. The monetized morbidity-related benefits are estimated based on the willingness-to-pay for a lower morbidity risk, and where those estimates are not available, the avoided cost of illness was used.[5] The portion of morbidity-related benefits associated with avoided work loss days and school loss days was valued based on the market price of a worker's productivity (i.e., hourly earnings) that results from less work absences due to fewer illnesses for adult workers and their children. These benefits were modeled in REMI as an increase in labor productivity for all industries in the region. Other morbidity-related benefits were considered to result in less spending on healthcare and related services, thus allowing households to reallocate their budget and increase spending on other goods and services. The change in healthcare-related expenditures was modeled as a decrease in consumer spending for six categories in the REMI model, including spending on hospitals, health insurance, nursing homes, paramedical services, pharmaceutical and other medical products, and physician services.

Table 4-3 shows the annual regional job impacts of quantified public health benefits for the initial implementation year of the Final 2016 AQMP (2017), the milestone years for ozone attainment demonstration (2023 and 2031), as well as the annual average between 2017 and 2031. Under the primary scenario, the public health benefits are projected to increase the number of jobs in the region by about 21,000 in 2023 and 43,500 in 2031 relative to the baseline. The annual job impacts for the analysis horizon of 2017-2031 correspond with an average annual increase of 23,000 jobs, which is about 0.2 percent above the baseline regional total jobs. The mortality-related benefits contribute the largest share to the number of jobs gained, at about 22,900 on average per year, while morbidity-related benefits (increased labor productivity and reduced healthcare costs) contribute fewer than 200 jobs per year on average.

impacts according to REMI staff. Additionally, as shown below, staff also conducted a sensitivity analysis to demonstrate the relationship between the amount of mortality-related public health benefits inputted into REMI and the corresponding job impacts generated by REMI. See Appendix 4-B for more discussion and also for the policy variables used in the REMI analysis associated with public health benefits.

[5] This specific methodology was recommended by IEc (Industrial Economics and Robinson 2016).

TABLE 4-3: ANNUAL REGIONAL JOB IMPACTS OF QUANTIFIED PUBLIC HEALTH BENEFITS

(Relative to Baseline)

	Jobs			Average Annual (2017-2031)	
Primary Scenario	**2017**	**2023**	**2031**	**Jobs**	**% Change**
Quantified Public Health Benefits	1,294	21,017	43,481	23,036	0.20%
Mortality-Related Benefits	1,284	20,851	43,282	22,894	0.20%
Morbidity-Related Benefits	10	166	192	144	0.00%
Sensitivity Analysis					
Quantified Public Health Benefits (with Discounted Mortality-Related Benefits)	652	10,591	21,792	11,576	0.10%
Mortality-Related Benefits Discounted by 50%	642	10,425	21,582	11,431	0.10%

Note: REMI model results are not additive, so the total job impact can not necessarily be found from adding the individual components.

The mortality-related public health benefits were derived from the willingness-to-pay to lower mortality risk with certainty, which is a non-market good. Due to remaining uncertainties surrounding the macroeconomic modeling of non-market benefits and whether the amount of the benefits should be adjusted before being entered into REMI to enact regional amenity improvements (Abt Associates 2014; Lahr 2016), a sensitivity analysis was performed where the monetized benefits associated with avoided premature deaths were discounted by half as REMI amenity inputs. The sensitivity test was performed based on recommendations in the 2014 Abt Report and a separate third-party evaluation (Lahr, 2016).[6] The purpose was to examine how sensitive job impacts are to the inputs of REMI policy variable "Non-pecuniary (Amenity) Aspects."

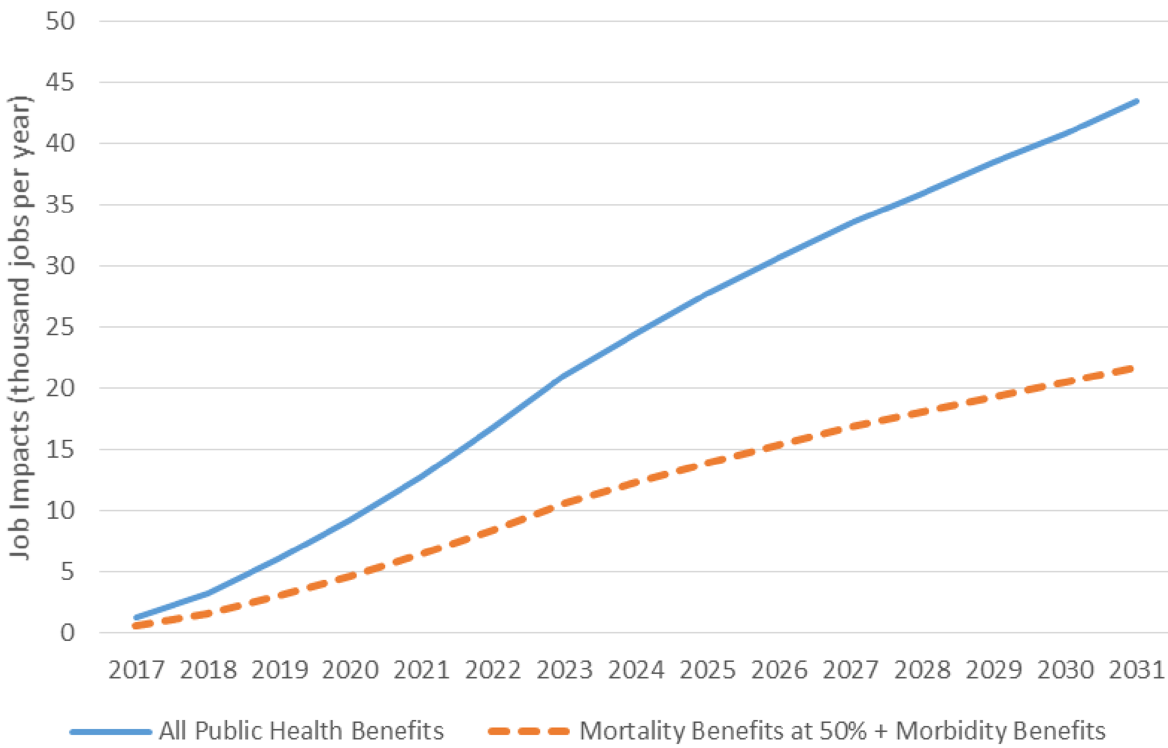
In order to have comparable results, the sensitivity analysis scenario was conducted for both components of public health benefits combined and for the mortality-related portion separately. The results of the sensitivity analysis reported in Table 4-3, show that the job impacts of the total quantified public health benefits are reduced by half when the value of amenity inputs is reduced by the same magnitude. This approximately one-to-one correlation (correspondence of reduction in job impacts) is due to the fact that mortality benefits account for over 99 percent of total quantified public health benefits. Overall, the sensitivity test results suggest that, if any scaling or weighting is necessary for the non-market clean air benefits to enter into REMI as regional amenity improvement, the job impacts as projected by REMI would be reduced by approximately the same factor.

Figure 4-2 shows how the job impacts change over the course of the analysis horizon. Under both the primary scenario and sensitivity test, the job impacts grow at a relatively faster rate between 2017 and 2023 and

[6] The 2014 Abt report recommended that the SCAQMD "initiate a research task to consider the weighting of estimates of air quality benefits to reflect the relative importance of air quality changes compared to other area specific amenities" and "keep abreast of the USEPA's development of methods for applying benefits in economy-wide models." The sensitivity test is staff's initial effort to implement the former recommendation, and the latter recommendation was also being implemented concurrently. The Abt report further recommended an evaluation of REMI's logic for incorporating amenities in its model; however, REMI contested the reasoning behind this recommendation.

relatively slower rate from 2024 to 2031, mirroring the year-to-year change of quantified public health benefits.

FIGURE 4-2: REGIONAL JOB IMPACTS OF QUANTIFIED PUBLIC HEALTH BENEFITS, 2017-2031



As discussed above, the regional job impacts of quantified public health benefits are driven by three forces at work. First, increased economic migration into the region, due to improved regional amenities (or "quality of life"), would result in a larger labor supply and also higher demand for goods and services, thus creating ripple effects throughout the regional economy. Second, the benefits related to avoided morbidity incidence would decrease healthcare-related consumer spending, thus directly resulting in reduced jobs and output in healthcare industries; these healthcare savings can then be spent on other goods and services, which would result in positive job impacts when these goods and services are supplied by local businesses and industries. Third, increased labor productivity due to fewer absences from work would make the region more competitive, thus driving up output and jobs in all sectors.

Table 4-4 shows the distribution of job impacts across all major sectors under the primary scenario. All sectors are projected to experience job gains relative to the baseline. The largest job gain, in both absolute and percentage terms, is expected in the state and local government sector. This is mainly due to increases in public services and infrastructure investments in the region to accommodate a larger population because of increased migration into the area. For the same reason, the construction sector and the accommodation and food services sector are also projected to see large gains in jobs. Some of the least impacted sectors are the agriculture, forestry, fishing, and related activities sector; the mining sector; and the information sector.

TABLE 4-4: ANNUAL REGIONAL JOB IMPACTS OF QUANTIFIED PUBLIC HEALTH BENEFITS BY SECTOR

(Relative to Baseline)

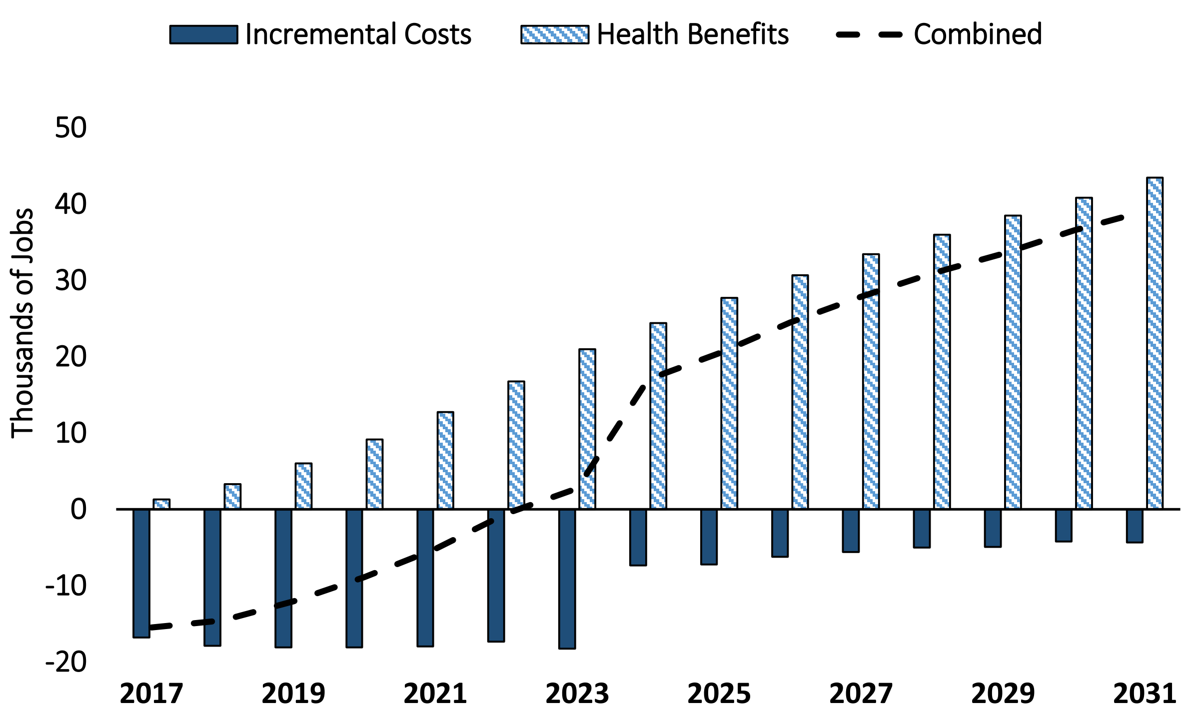
Sector	NAICS	Jobs			Average Annual (2017-2031)		
		2017	2023	2031	Jobs	Baseline Jobs	% Change
Agriculture, Forestry, Fishing, and Related Activities	11	0	6	13	7	28,747	0.02%
Mining, Oil and Gas Extraction	21	3	19	20	15	26,073	0.06%
Utilities	22	4	66	138	73	25,739	0.28%
Construction	23	152	2,188	3,179	2,049	591,549	0.35%
Manufacturing	33	46	679	1,375	740	662,486	0.11%
Wholesale Trade	42	37	572	1,274	652	489,248	0.13%
Retail Trade	44-45	139	2,136	4,570	2,384	1,038,587	0.23%
Transportation and Warehousing	48-49	23	318	756	371	383,908	0.10%
Information	51	12	160	405	192	316,884	0.06%
Finance and Insurance	52	33	320	887	401	567,305	0.07%
Real Estate and Rental and Leasing	53	85	1,436	3,268	1,655	683,422	0.24%
Professional, Scientific, and Technical Services	54	63	1,033	2,075	1,117	899,580	0.12%
Management of Companies and Enterprises	55	8	120	262	135	118,815	0.11%
Administrative and Waste Management Services	56	72	1,202	2,561	1,335	865,447	0.15%
Educational Services	61	33	538	1,098	583	250,443	0.23%
Health Care and Social Assistance	62	127	2,444	6,129	2,941	1,363,990	0.22%
Arts, Entertainment, and Recreation	71	14	155	500	210	347,599	0.06%
Accommodation and Food Services	72	143	2,627	5,396	2,888	751,627	0.38%
Other Services, except Public Administration	81	63	660	1,740	805	726,486	0.11%
State and Local Government	92	238	4,337	7,833	4,486	1,030,886	0.44%
Total		**1,294**	**21,017**	**43,481**	**23,036**	**11,168,820**	**0.21%**

Projected Job Impacts of the Final 2016 AQMP

The simulation of the regional economy with all of the incremental cost and benefit-related policy variables combined together represents the regional economic impact of the Final 2016 AQMP. Figure 4-3 illustrates how the net job impacts of the Final 2016 AQMP change over time, along with the job impacts attributable separately to incremental costs and public health benefits under their respective primary scenarios as described in the previous sections (i.e., incentives funded by existing state revenue sources and full air-related public health benefits for regional amenity adjustments). Overall, the regional economy is projected to experience jobs forgone in the first years because the negative effects, mainly associated with the incremental costs of proposed control measures, would dominate the positive effect that largely stems from public health benefits. Over time, however, as public health benefits continue to increase, net job gains are projected for most of the industries.

On an annual average, the combined effects of public health benefits and incremental costs associated with the Final 2016 AQMP are expected to result in a gain of 14,000 jobs per year from 2017 to 2031, relative to the baseline job forecast. This represents an annualized job growth rate of 1.04 percent, or a 0.02 percentage point acceleration from the baseline job growth during the same period. Table 4-5 reports the average annual net job impacts by sector. It is projected that the initial negative job impacts would spread among most of the public and private sectors. However, almost half of the 15,300 jobs foregone projected for year 2017 are concentrated in the state and local government sector. Construction, and healthcare and social assistance sectors would also have more than 1,000 jobs foregone in that year. However, by 2023, most sectors would see job increases from their baseline forecast. In 2031, only mining and utilities sectors would still experience jobs foregone; however, on an annual average, the net negative job impact for these two sectors are expected to be less than one percent lower than their baseline number of jobs. All of these changes are relatively small when compared with the overall size of the four-county economy.

FIGURE 4-3: REGIONAL JOB IMPACTS OF THE FINAL 2016 AQMP, 2017-2031



Under the alternative scenario where incentives are financed by existing federal funds, the projected combined job impact becomes an average gain of 29,000 jobs per year, relative to the baseline job forecast. The corresponding annualized job growth rate will increase very slightly and remain at around 1.04 percent from 2017 to 2031.

TABLE 4-5: ANNUAL NET JOB IMPACTS BY SECTOR

(Relative to Baseline)

Sector	NAICS	Jobs				Average Annual (2017-2031)	
		2017	2023	2031	Jobs	Baseline Jobs	% Change
Agriculture, Forestry, Fishing, and Related Activities	11	-8	-1	13	2	28,747	0.01%
Mining, Oil and Gas Extraction	21	-56	-137	-213	-126	26,073	-0.48%
Utilities	22	-20	-47	-810	-182	25,739	-0.71%
Construction	23	-1,940	-16	1,907	573	591,549	0.10%
Manufacturing	33	920	2,110	2,785	2,017	662,486	0.30%
Wholesale Trade	42	-238	420	1,767	691	489,248	0.14%
Retail Trade	44-45	-993	1,281	5,521	1,995	1,038,587	0.19%
Transportation and Warehousing	48-49	-237	624	1,496	685	383,908	0.18%
Information	51	-135	78	418	154	316,884	0.05%
Finance and Insurance	52	-442	62	1,026	301	567,305	0.05%
Real Estate and Rental and Leasing	53	-335	989	3,127	1,378	683,422	0.20%
Professional, Scientific, and Technical Services	54	-728	262	1,690	623	899,580	0.07%
Management of Companies and Enterprises	55	16	189	395	216	118,815	0.18%
Administrative and Waste Management Services	56	-888	779	3,125	1,312	865,447	0.15%
Educational Services	61	-167	359	1,101	487	250,443	0.19%
Health Care and Social Assistance	62	-1,079	1,334	6,065	2,323	1,363,990	0.17%
Arts, Entertainment, and Recreation	71	-178	51	551	166	347,599	0.05%
Accommodation and Food Services	72	-541	1,723	4,786	2,212	751,627	0.29%
Other Services, except Public Administration	81	-794	141	2,098	683	726,486	0.09%
State and Local Government	92	-7,497	-4,925	3,836	-1,791	1,030,886	-0.17%
Total		**-15,340**	**5,274**	**40,681**	**13,720**	**11,168,820**	**0.12%**

Table 4-6 shows the distribution of net job impacts in 2017, 2023, and 2031 among five groups categorized by occupational earnings. In general, the job impacts are distributed rather evenly across all five groups, with no positive or negative job impacts overwhelmingly borne by any particular group. All groups are projected to see small numbers of jobs foregone in 2017 which mirrors the initial negative job impacts among various sectors. In 2031, all groups are projected to experience small job gains of 0.3 to 0.5 percent, relative to the baseline forecast.

TABLE 4-6: NET JOB IMPACTS BY OCCUPATIONAL EARNINGS GROUP

Group	2015 Median Weekly Earnings*	% Impact from Baseline			No. of Occupations
		2017	2023	2031	
1	$236 - $480	-0.13%	0.11%	0.46%	19
2	$481 - $619	-0.11%	0.08%	0.36%	19
3	$620 - $767	-0.12%	0.08%	0.40%	19
4	$768 - $980	-0.27%	-0.10%	0.26%	19
5	$990 - $1738	-0.12%	0.03%	0.26%	19

*Source: REMI. For the list of occupations by earning group, see Appendix 4-B

Preliminary Discussion of Health Effects of Unemployment

The results of the impact analysis reported above show that implementation of the Final 2016 AQMP would lead to very small job impacts (positive or negative) relative to the baseline and would have minimal effects on the region's long-term job growth. Of the four different scenarios analyzed, the annualized long-term job growth rate between 2016 and 2031 in the region would remain similar to the baseline rate, at slightly above one percent. Although this is the case, SCAQMD staff has explored the possibility of incorporating possible health effects that may occur from unemployment into this quantitative macroeconomic job impact analysis. The following section describes the current state of knowledge on this topic.

Recent economics literature has shown that job displacement, particularly due to plant closings and layoffs, could lead to adverse health effects on the individuals who experience job losses (see Tekin (2015) for a thorough review). In a groundbreaking study by Sullivan and von Wachter (2009), displaced workers were found to experience increased mortality risk immediately following their job loss. The heightened risk, although subsiding over time, was still present to some extent 20 years after the initial episode of job displacement. On these grounds, some of the SCAQMD's stakeholders have requested further investigation and analysis on whether air regulations and programs, while aimed to protect public health, may have actually resulted in job losses and thus produced undesirable health outcomes. These concerns were expressed during the stakeholder interviews conducted by Abt Associates as part of their review of SCAQMD socioeconomic assessment, and Abt recommended that staff keep abreast of the findings from U.S. EPA's ongoing efforts to review methodology for employment effects of regulation (Abt Associates 2014).

There are two major analytical difficulties in conducting a formal analysis on this topic. First, a macroeconomic impact assessment—including the policy simulations conducted using the Regional Economic Models, Inc. (REMI)'s Policy Insight Plus model—generates job impacts in terms of the projected number of jobs foregone. This number consists of two conceptually distinctive components: job losses and forecasted jobs not created, but they cannot be numerically separated. At the same time, while job losses are associated with higher health risks, the linkage between a job that never existed and public health is not well understood, let alone quantified. Furthermore, while a number of empirical studies, based on observed or surveyed data, have identified negative job impacts of past environmental regulations in the heavy polluting industries (e.g., Greenstone (2002)), the overall impact on economy-wide employment has been found to be largely muted, due to various factors including employment shifts from heavy polluting to less polluting industries (see Morgenstern (2002)for a literature review). There is also empirical evidence suggesting that the negative job impact observed among the more polluting industries was, in large part, a result of slower or decreased hiring and had minimal impacts on the incumbent workers (Curtis 2014).[7]

Another major analytical difficulty is how to account for public health effects of unemployment, regardless of whether they are related to environmental regulations. Rhum (2000) and a series of follow-up studies have reported the counterintuitive finding that, as headline unemployment rates went up, public health metrics improved (usually measured by reduced mortality rate). Interestingly, it was also found that the improvement was most pronounced among the elderly, who were unlikely to be directly impacted by labor market fluctuations.[8] The SCAQMD commissioned Dr. Erdal Tekin to conduct a literature review and examine the health effects of unemployment in the four-county region. His final report provided similar results; that is, adverse health effects were generally observed among individuals who recently became unemployed, but the overall mortality risk as a public health indicator decreased when unemployment rose (Tekin 2015).[9]

To be integrated into the quantitative analysis of public health benefits discussed in the earlier section, health effects of unemployment on both displaced workers and on other segments of the population will need to be taken into account. Furthermore, a methodology needs to be developed to project job losses, which are usually an unknown fraction of projected jobs foregone. In the October 2015 meeting of the U.S. EPA's Science Advisory Board – Economy-Wide Modeling Panel, several economists on the panel did not support the inclusion of health effects of unemployment and other second-order effects when conducting macroeconomic impact modeling or cost-benefit analysis of environmental policies and regulations. The reasons cited included the current lack of sufficient empirical evidence, the difficulty to establish causality, and the anticipated small magnitude of such effects (U.S. EPA 2015a).

Although it is not currently possible to systematically quantify the health effects of potential unemployment related to air regulations and programs, it does not mean that the consequences of facilities closing and job losses are not considered when developing the Final 2016 AQMP or during rulemaking process. The SCAQMD is committed to protecting the health of residents, while remaining sensitive to businesses. These commitments are manifested through the SCAQMD's efforts at many fronts, including public processes to

[7] It is worth emphasizing, however, that these empirical studies were usually based on large samples of firm-level data and the findings were derived for the general pattern of firm behavior observed in the data. These findings cannot be taken to rule out outlying behavior of an individual firm, and they also cannot be relied upon to predict the outcome of an environmental regulation that is of a very different scale or targets very different industry sectors.

[8] Stevens et al. (2015) posited that one of the many plausible mechanisms could be the effect of labor market competition on the quality of senior healthcare. During periods of low unemployment, shortage of skilled healthcare workers could adversely impact nursing home operations and raise mortality risks for their elderly residents.

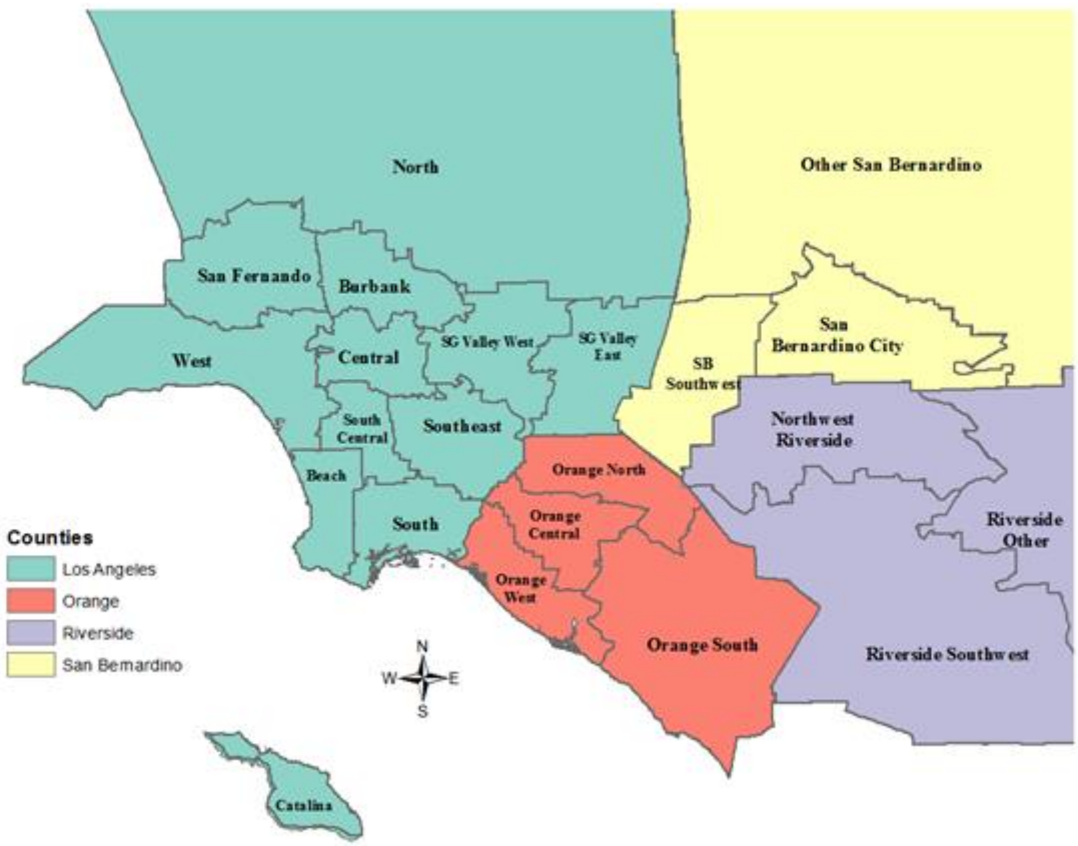
[9] Full report available here: http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/unemploymentandhealth_dec2015_012616.pdf

solicit input and comments from all interested parties and continuous outreach to the general public and affected businesses, as well as performing a socioeconomic assessment which the Governing Board must consider for rules or rule amendments significantly affecting air quality or emission limitations.

Chapter 5: Sub-Regional Distribution of Impacts

This chapter assesses the sub-regional distribution of incremental costs, public health benefits, and job impacts to provide information on how the Final 2016 AQMP may affect different communities within the four-county region of Los Angeles, Orange County, Riverside and San Bernardino. As Figure 5-1 shows, there are 11 sub-county regions within Los Angeles County, four within Orange County, and three each within Riverside and San Bernardino counties. The four counties are divided into these sub-county regions based on socioeconomic characteristics found in the U.S. Census Bureau's American Community Survey (Lieu, Dabirian, and Hunter 2012). The REMI model used to simulate regional macroeconomic impacts based on the incremental costs and public health benefits of the Final 2016 AQMP was customized according to these same sub-county definitions.

FIGURE 5-1: 21 SUB-COUNTY REGIONS



Description of the 21 Sub-County Regions

With six commercial airports, the nation's two largest marine ports, and over 8 million workers[1] generating more than a trillion dollars in GDP[2], the regional economy of Los Angeles, Orange, Riverside, and San Bernardino counties is one of the largest and most productive in the United States. This section provides a snapshot of how different communities within the four-county region vary according to key demographic and economic indicators. All indicators discussed below are based on the REMI baseline projections that have been adjusted according to the 2016 SCAG Growth Forecast (see Appendix 4-A).

The four-county region is home to nearly 18 million people. By 2031, the region is expected to gain an additional two million people (SCAG 2016). About 75 percent of the region's population, or about 14 million people, reside in the coastal counties of Los Angeles and Orange, while the remaining 25 percent, or about 4 million people, live further inland in Riverside and San Bernardino counties. Figure 5-2 (a) demonstrates the population distribution among 21 sub-county regions in 2016, while Figure 5-2 (b) shows widely varying population density in each of the sub-regions.

The densest populated areas in the region are the South Central and Central sub-regions in Los Angeles County. South Central is home to a little over a million people, or roughly 15,000 people per square mile. The Central sub-region in Los Angeles also has a population over a million and a density of 13,000 people per square mile. The densest populated areas in Orange County are the Central and Western sub-regions, which have a population density of 10,000 and 6,000 people per square mile respectively. In comparison, the sub-regions further inland are much less densely populated. San Bernardino City, San Bernardino Southwest, and Northwest Riverside, for example, have population densities of 3,000 people per square mile, about one fifth of the population density in South Central Los Angeles.

[1] EDD estimates as of July 2016.

[2] U.S. Bureau of Economic Analysis, 2015 GDP estimates for Los Angeles-Long Beach-Anaheim and Riverside-San Bernardino-Ontario metros.

FIGURE 5-2 (A): POPULATION BY SUB-COUNTY REGION, 2016

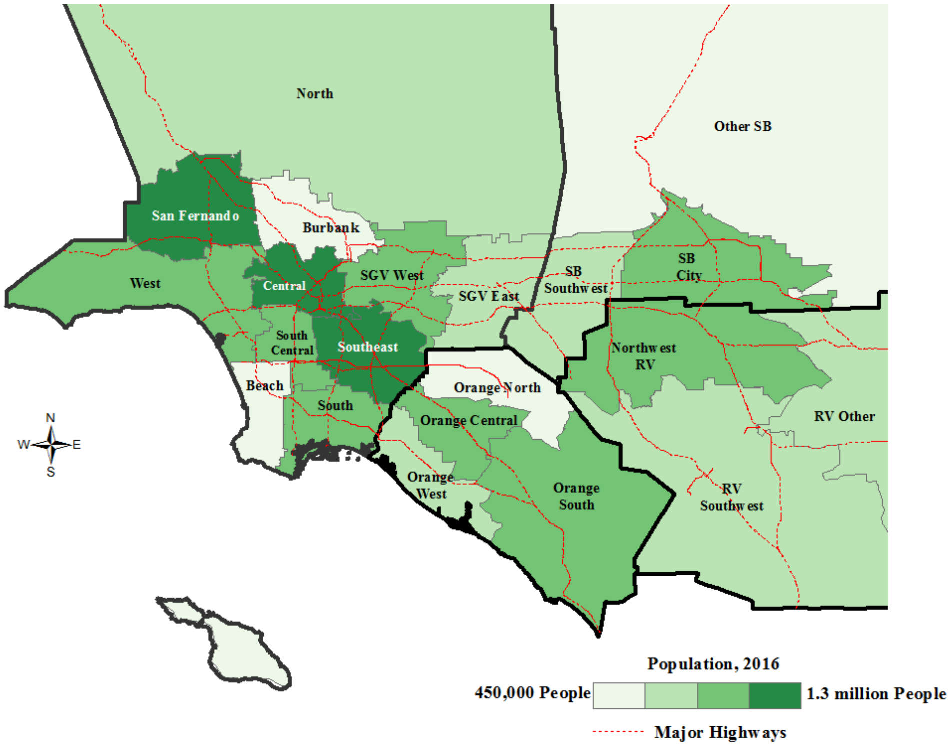
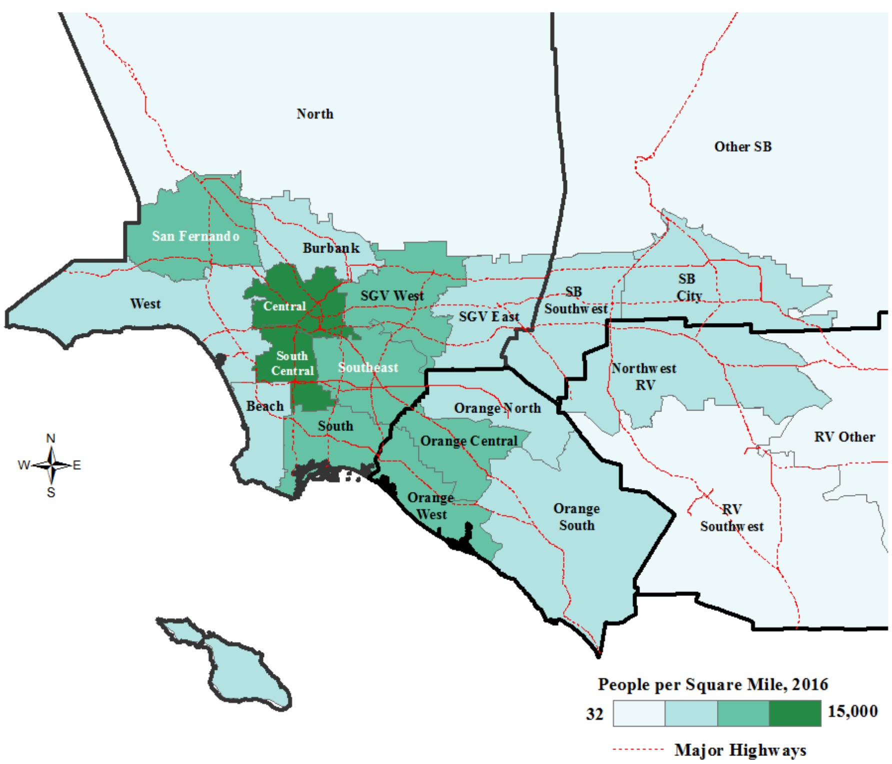


FIGURE 5-2 (B): POPULATION DENSITY BY SUB-COUNTY REGION, 2016



As seen in Figure 5-3, jobs are largely concentrated in the Central and Western sub-regions of Los Angeles, which collectively provide nearly one out of every five jobs in the region. In the Inland area, the largest concentration of jobs is found along the San Bernardino and Riverside border, yet this cluster of San Bernardino Southwest, San Bernardino City, and Northwest Riverside only supplies about one out of every ten jobs in the region.

FIGURE 5-3: JOB COUNTS BY SUB-COUNTY REGION, 2016

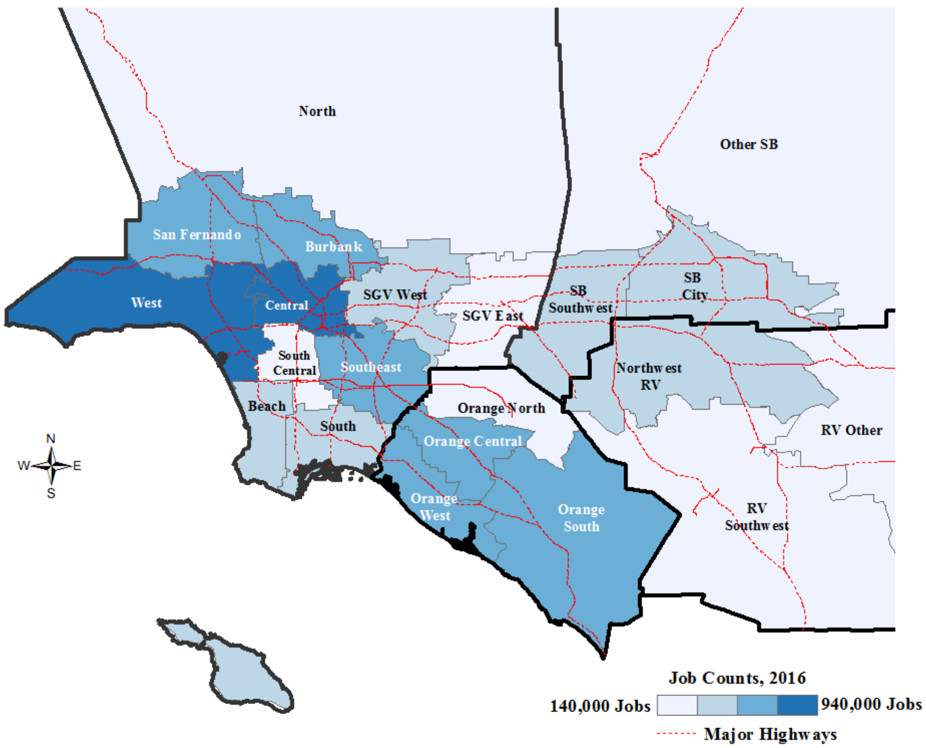


Figure 5-4 (a) shows the number of jobs per working age adult (25 to 64 years old). Most sub-county regions have about one job per working-age adult, with a few exceptions. The South Central and Other San Bernardino regions have relatively scarce employment opportunities, with less than one job per working-age adult. In comparison, residents in Burbank and the West region of Los Angeles have better employment prospects, with approximately two jobs per working-age adult. Figure 5-4 (b) illustrates the age-dependency ratio, defined as the number of those too young or elderly to work per working-age adult. The western region of Los Angeles has the lowest age-dependency ratio of 43 dependents per 100 workers; whereas, eastern Riverside has the largest at 58 dependents per 100 workers. Higher age-dependency ratios in the inland area than in Los Angeles or Orange counties is largely a result of proportionally more families with young children and more affordable family housing, but it also indicates more pressure on workers in these areas, as well as in certain areas in Los Angeles and Orange counties, to provide for those not in the workforce. Such pressure is especially high in regions such as South Central Los Angeles, where jobs are harder to come by, as indicated in Figure 5-4 (a).

FIGURE 5-4 (A): JOBS PER WORKING-AGE ADULT BY SUB-COUNTY REGION, 2016

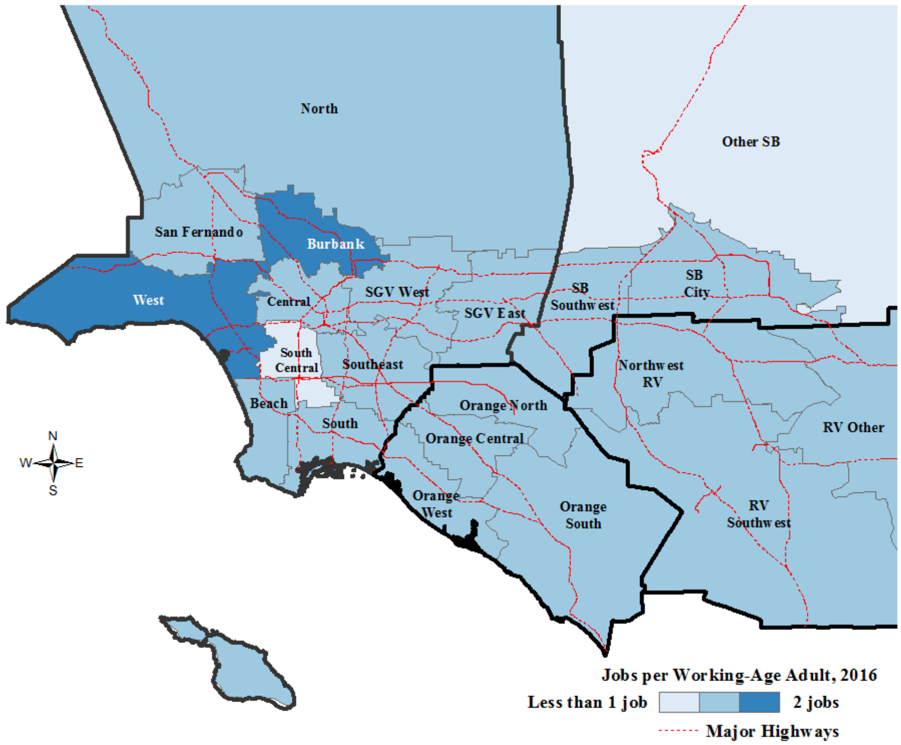
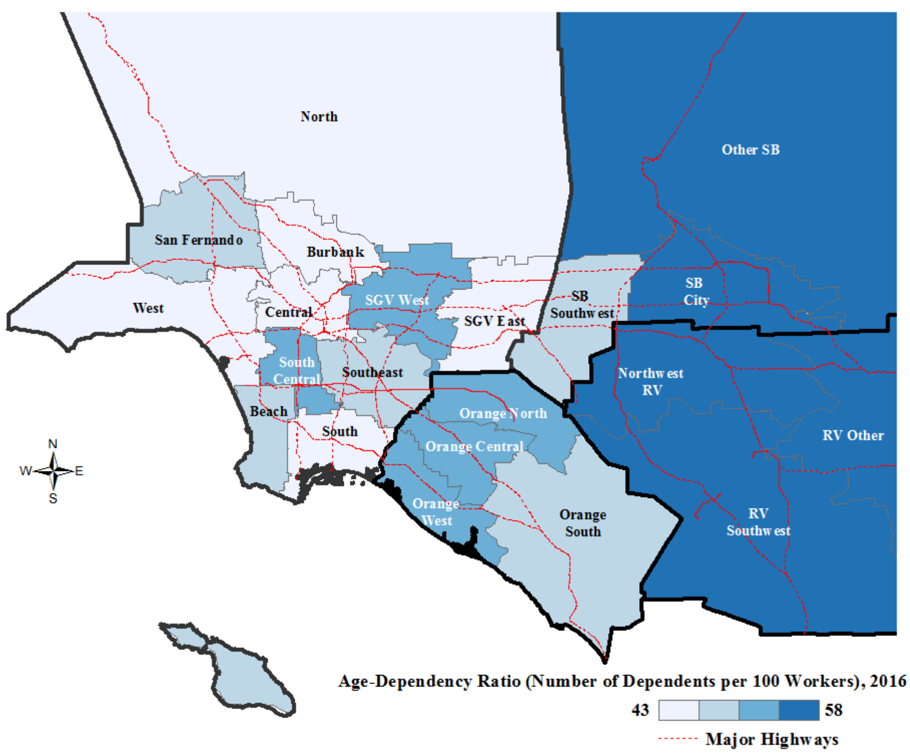


FIGURE 5-4 (B): AGE-DEPENDENCY RATIOS BY SUB-COUNTY REGION, 2016



In terms of economic output, Figure 5-5 (a) shows the distribution of industry output by sub-county region, with all dollar amounts being expressed in 2015 dollars. More than a quarter of the region's output, or about $420 billion, is generated in Central and West Los Angeles and Orange South; whereas, all sub-regions in Riverside and San Bernardino combined produced about $240 billion, or approximately 15 percent of the regional economic output. Figure 5-5 (b) illustrates different labor productivity across sub-county regions. Output per worker is highest in the beach and southern area of Los Angeles, with about $230,000 and $208,000 being generated per worker in 2016, respectively. The lowest levels of output per worker are in inland, with a range of about $130,000 being generated per worker in Other San Bernardino to about $150,000 in San Bernardino Southwest. The differences largely reflect the very different industry structures across the four-county region, with more capital-intensive industries tending to locate in the coastal counties and more labor-intensive industries in the inland area.

FIGURE 5-5 (A): ECONOMIC OUTPUT BY SUB-COUNTY REGION, 2016

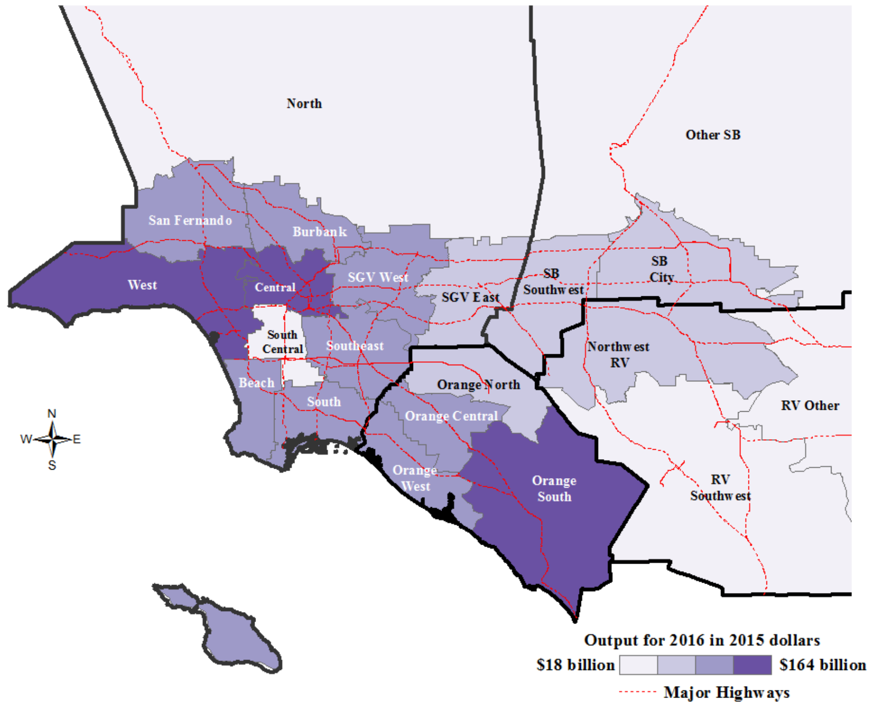
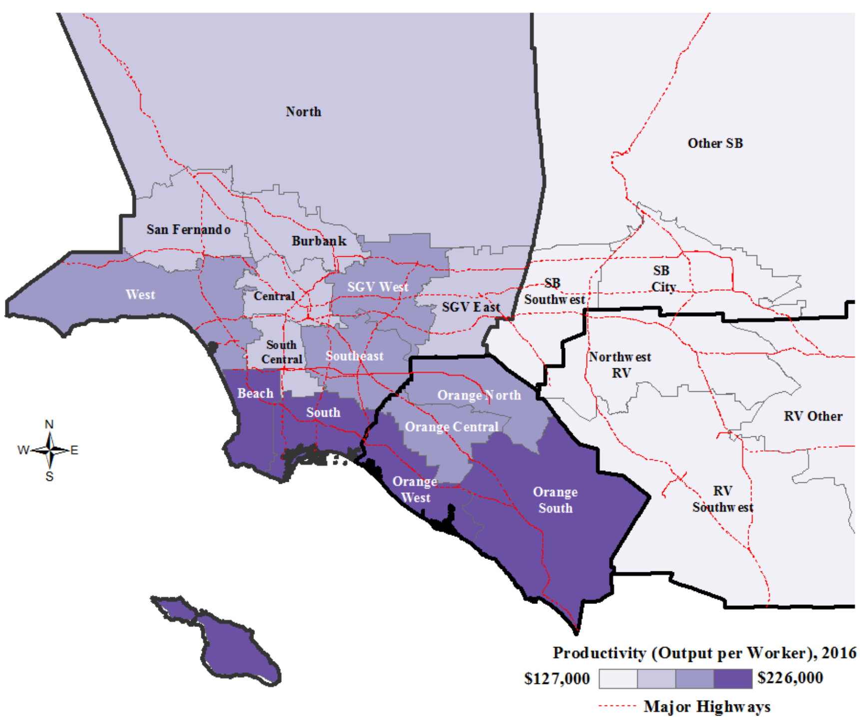


FIGURE 5-5 (B): WORKER PRODUCTIVITY BY SUB-COUNTY REGION, 2016



Sub-County Distribution of Estimated Incremental Costs

As reported in Chapter 2, the present worth value of the total incremental cost associated with the Final 2016 AQMP is $15.7 billion. From 2017 to 2031, private industries, consumers, and the public sector will collectively spend an average of $848 million each year. Table 5-1 reports the average annual total incremental costs by sub-county region, which range from a high of $61 million in San Fernando Los Angeles to a low of $21 million in Orange North (also illustrated in Figure 5-6). On a per capita basis, the range of average annual incremental costs narrows to a high of $54 per person in the Beach & Catalina sub-region of Los Angeles County to a low of $43 per person in the majority of areas. This range of incremental cost is relatively small when considering the four-county region's per capita personal income of about $49,700.[3]

TABLE 5-1: TOTAL AND PER CAPITA INCREMENTAL COST BY SUB-COUNTY REGION[4] (AVERAGE ANNUAL, 2017-2031)

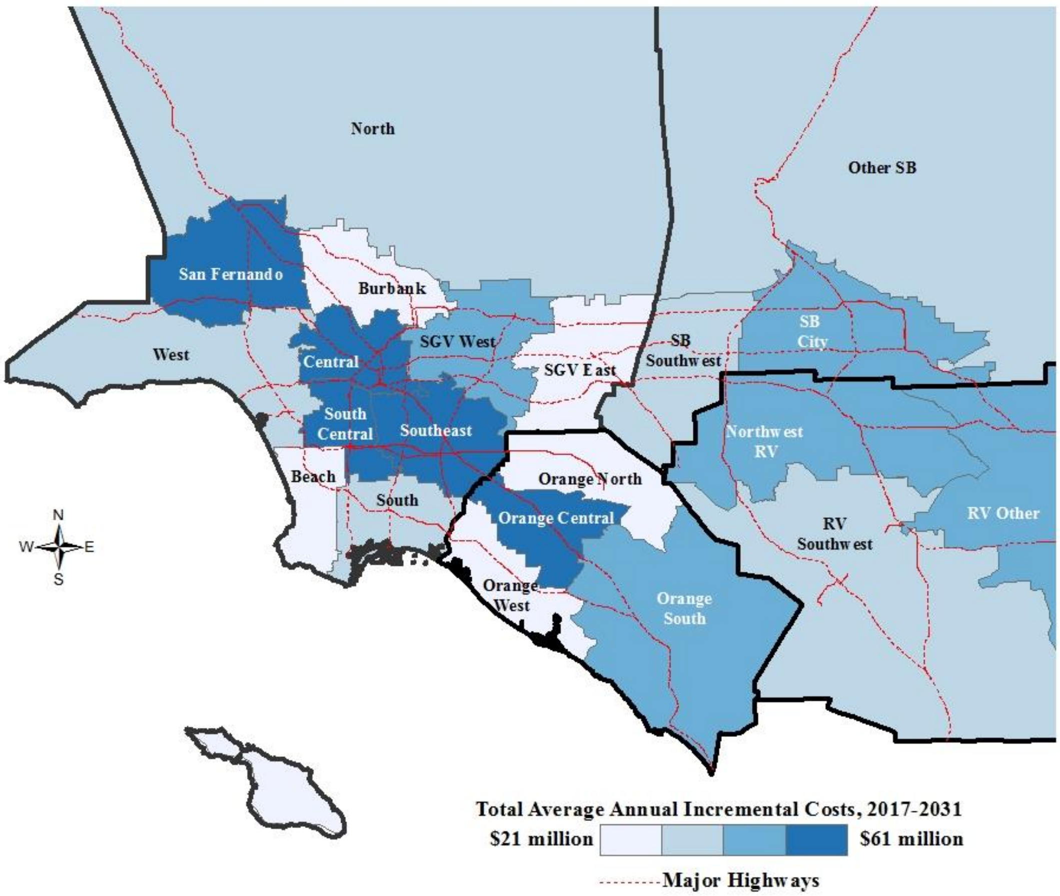
County	Sub-county Region	Average Annual Incremental Cost ($Millions)	Per Capita Average Annual Incremental Cost ($)
Los Angeles	Beach & Catalina	32	54
Los Angeles	Burbank	26	43
Los Angeles	Central	59	43
Los Angeles	North	38	47
Los Angeles	San Fernando	61	43
Los Angeles	San Gabriel Valley East	30	44
Los Angeles	San Gabriel Valley West	43	43
Los Angeles	South	45	50
Los Angeles	South Central	48	43
Los Angeles	Southeast	57	46
Los Angeles	West	41	43
Orange	Orange Central	47	43
Orange	Orange North	21	44
Orange	Orange South	47	43
Orange	Orange West	31	44
Riverside	Northwest Riverside	43	44
Riverside	Riverside Other	41	43
Riverside	Riverside Southwest	36	47
San Bernardino	San Bernardino City	41	44
San Bernardino	Other San Bernardino	31	43
San Bernardino	San Bernardino Southwest	31	43
All Sub-County Regions		**848**	**45**

Note: Total average annual incremental cost may not sum up to the total in Table 2-1 due to rounding.

[3] SCAQMD staff calculation based on U.S. BEA's personal income data for 2015 (in current dollars) and U.S. Census Bureau's 2015 population estimates for each of the four counties.

[4] It should be noted that the cost distribution presented here is for informational purposes only, and mostly reflects sub-county per capita population distribution of the incremental costs. It may not reflect the actual cost distribution under all plausible cost scenarios. Staff expects to be able to gather more detailed information during the program implementation and rulemaking process.

FIGURE 5-6: TOTAL INCREMENTAL COSTS BY SUB-COUNTY REGION (AVERAGE ANNUAL, 2017-2031)



Sub-County Distribution of Monetized Public Health Benefits

As discussed in Appendix I of the Final 2016 AQMP, air pollution continues to be linked to increases in death rates (mortality) and increases in illness and other health effects (morbidity). Based on the quantification of health benefits in Chapter 3, it has been estimated that the four-county region will gain a total public health benefit of $173 billion in present worth value, which represents an average annualized benefit of $16.5 billion from 2017 to 2031 for the avoided incidence of mortality and morbidity.

Tables 5-2 and 5-3 report the total and per capita annual average public health benefits for each of the 21 sub-county regions, respectively. The per capita public health benefits will be further analyzed between EJ and non-EJ communities in Chapter 6. Mortality-related benefits associated with reduced long-term exposure to PM2.5 make up the vast majority, or over 99 percent, of total public health benefits quantified, and they range from an annual average of $2 billion in Central Los Angeles to $93 million in Other San Bernardino. As public health benefits were calculated based on reduced health risk per person, the $2 billion of public health benefits projected for Central Los Angeles does not only reflect the larger reductions in PM2.5 concentrations estimated in and around that area, but also its population size which is among the largest in the four-county region (see Chapter 3 and Figure 5-2(a)). That is why, in per capita terms, the range narrows to $1,600 per person in Central Los Angeles and $130 per person in Other San Bernardino.[5]

Mortality-related benefits associated with reduced short-term exposure to ozone range from an annual average of $49 million in Northwest Riverside to $9 million in South Central Los Angeles, reflecting the larger reductions of ozone concentration in and around Northwest Riverside. In per capita terms, this becomes $50 dollars per person in Northwest Riverside and $9 per person in South Central Los Angeles.

[5] Per capita calculation uses SCAG-adjusted REMI population projection data for 2016. Therefore, differing population growth in each sub-county region may also contribute to the differences of annual average per capita public health benefits observed across the sub-county regions.

TABLE 5-2: TOTAL PUBLIC HEALTH BENEFITS BY 21 SUB-COUNTY REGION (AVERAGE ANNUAL, 2017-2031)

County	Sub-county Region	Average Annual PM2.5 Benefits ($Millions)		Average Annual Ozone Benefits ($Millions)		Total Annual Average Benefits ($Millions)
		Mortality	Morbidity	Mortality	Morbidity	
Los Angeles	Beach & Catalina	578	5	17	2	602
Los Angeles	Burbank	477	4	16	2	499
Los Angeles	Central	2,135	20	21	3	2,179
Los Angeles	North	149	2	27	5	182
Los Angeles	San Fernando	1,031	9	48	7	1,096
Los Angeles	San Gabriel Valley East	643	6	25	4	678
Los Angeles	San Gabriel Valley West	1,323	11	21	3	1,358
Los Angeles	South	775	8	19	3	805
Los Angeles	South Central	1,138	13	9	2	1,162
Los Angeles	Southeast	1,411	15	20	3	1,450
Los Angeles	West	1,378	11	29	3	1,421
Orange	Orange Central	762	9	25	5	801
Orange	Orange North	404	4	16	2	426
Orange	Orange South	526	5	44	6	581
Orange	Orange West	708	5	27	3	743
Riverside	Northwest Riverside	635	6	49	8	698
Riverside	Riverside Other	141	1	33	4	178
Riverside	Riverside Southwest	289	2	35	5	332
San Bernardino	Other San Bernardino	93	1	25	4	122
San Bernardino	San Bernardino City	505	5	43	7	559
San Bernardino	San Bernardino Southwest	566	6	30	5	606
All Sub-County Regions		**15,668**	**146**	**580**	**84**	**16,478**

TABLE 5-3: PER CAPITA PUBLIC HEALTH BENEFITS BY 21 SUB-COUNTY REGION (AVERAGE ANNUAL, 2017-2031)

County	Sub-county Region	Per Capita Average Annual PM2.5 Benefits ($)		Per Capita Average Annual Ozone Benefits ($)		Total Annual Average Benefits Per Capita ($)
		Mortality	Morbidity	Mortality	Morbidity	
Los Angeles	Beach & Catalina	969	9	29	4	1,010
Los Angeles	Burbank	787	6	26	3	822
Los Angeles	Central	1,592	14	16	2	1,624
Los Angeles	North	190	2	34	6	232
Los Angeles	San Fernando	740	7	35	5	786
Los Angeles	San Gabriel Valley East	938	8	37	5	989
Los Angeles	San Gabriel Valley West	1,331	11	21	3	1,365
Los Angeles	South	861	9	21	3	894
Los Angeles	South Central	1,039	12	9	2	1,061
Los Angeles	Southeast	1,158	12	17	3	1,190
Los Angeles	West	1,483	11	31	3	1,528
Orange	Orange Central	702	8	23	4	737
Orange	Orange North	855	8	33	5	901
Orange	Orange South	493	4	41	6	544
Orange	Orange West	1,016	7	38	4	1,066
Riverside	Northwest Riverside	656	6	50	8	721
Riverside	Riverside Other	154	1	36	4	195
Riverside	Riverside Southwest	385	3	47	7	442
San Bernardino	Other San Bernardino	134	1	36	5	177
San Bernardino	San Bernardino City	545	5	46	7	603
San Bernardino	San Bernardino Southwest	809	8	43	7	866
All Sub-County Regions		**832**	**8**	**31**	**4**	**876**

Figures 5-7 (a) and (b) provide a visualization of how mortality-related benefits are distributed in the region. Figure 5-7 (a) shows that the largest average annual mortality-related benefits associated with decreased PM2.5 exposure are concentrated around Central Los Angeles; whereas, Figure 5-7 (b) shows that the largest average annual mortality-related benefits associated with decreased ozone exposure spread towards San Fernando Los Angeles, Orange South, and inland towards Northwest Riverside and San Bernardino City.

FIGURE 5-7 (A): DISTRIBUTION OF MORTALITY-RELATED BENEFITS FOR PM2.5 BY SUB-COUNTY REGION (AVERAGE ANNUAL, 2017-2031)

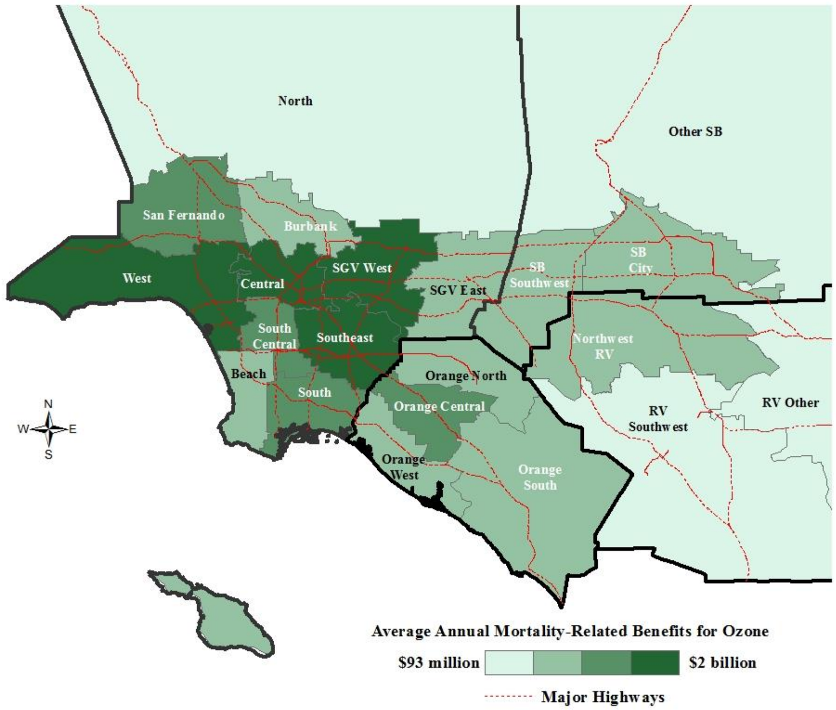
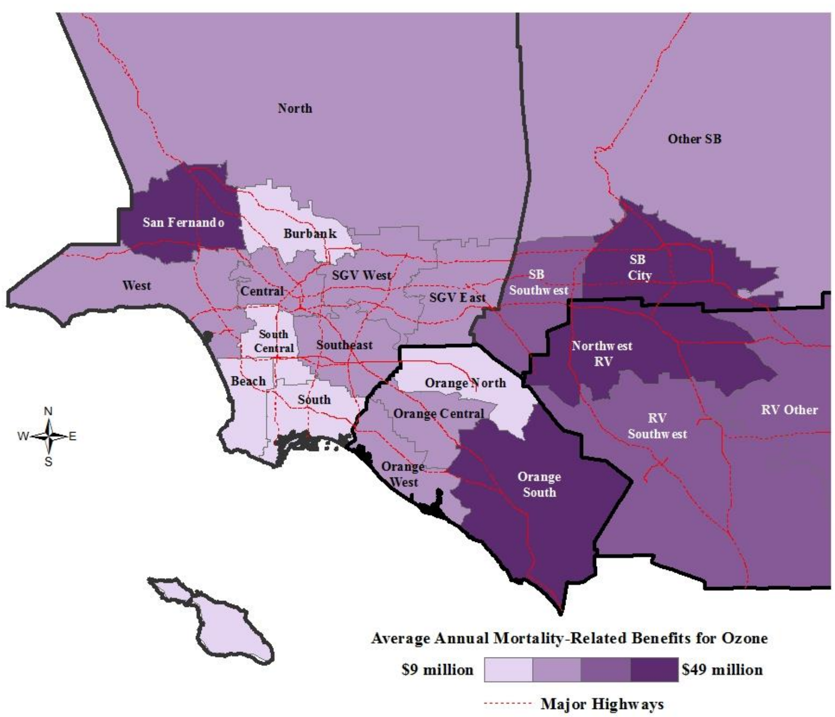


FIGURE 5-7 (B): DISTRIBUTION OF MORTALITY-RELATED BENEFITS FOR OZONE BY SUB-COUNTY REGION (AVERAGE ANNUAL, 2017-2031)



Morbidity-related benefits related to decreased PM2.5 and ozone exposure are much lower than mortality-related benefits and are similar to the spatial distributions shown in Figures 5-7(a) and (b), respectively. Together, the highest morbidity-related benefits are in Central Los Angeles, with an annual average of $23 million, and lowest in Riverside Other and Other San Bernardino with an annual average of $5 million. This translates into a $16 benefit per person and $5 to $6 benefit per person, respectively.

Sub-County Distribution of Projected Job Impacts

As discussed in Chapter 4, the costs and benefits of the 2016 AQMP are expected to alter, to various degrees, the economic decisions made by households, businesses, and other economic actors. Some businesses would see production costs go up while other businesses would benefit from a greater demand for their services and technologies. For consumers who consider purchasing or replacing vehicles or certain household appliances, the proposed control strategies would also change or widen the range of product choices that differ in fuel types, energy efficiencies, effective unit prices, and thus potential payback periods. In the meantime, improved public health would contribute to higher labor productivity and reduce healthcare-related expenditures. All these direct effects would then cascade through the regional economy and produce indirect and induced macroeconomic impacts. Given this, the region is expected to gain, on average, about 14,000 jobs per year as a result of implementing the Final 2016 AQMP.

Figure 5-8 (a) shows the distribution of the annual average net job impacts by sub-county region. Central Los Angeles is expected to gain the largest number of jobs at 2,100 on average per year. Northwest Riverside is also expected to gain a relatively large amount of jobs per year at about 1,800. The largest number of jobs foregone are expected in Riverside Other at about 40 jobs foregone on average per year. Figure 5-8 (b) shows the average annual percent change in jobs compared to the baseline, which represents job impacts that would occur regardless of whether the 2016 AQMP is implemented. The largest percent increases are concentrated in the Inland Empire and South Central Los Angeles and range from a 0.02percent job increase in Burbank Los Angeles to 0.34 percent job increase in South Central Los Angeles relative to the baseline. Job decreases relative to the respective baseline forecasts is observed among several sub-county regions, with a -0.01 percent decline in jobs relative to the baseline in Riverside Other and slightly lesser declines in Orange South and Los Angeles North.

FIGURE 5-8 (A): DISTRIBUTION OF NET JOB IMPACTS BY SUB-COUNTY REGION (ANNUAL AVERAGE, 2017-2031)

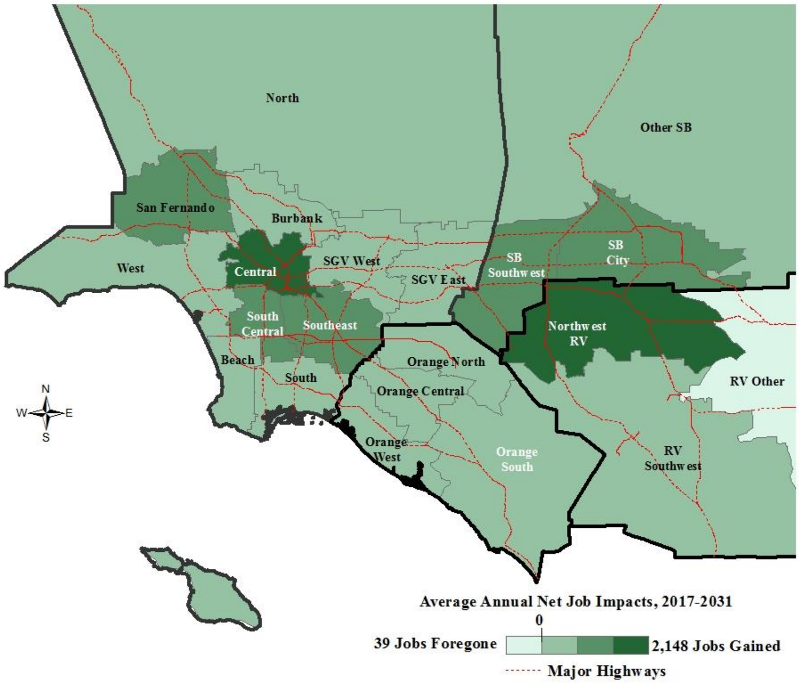
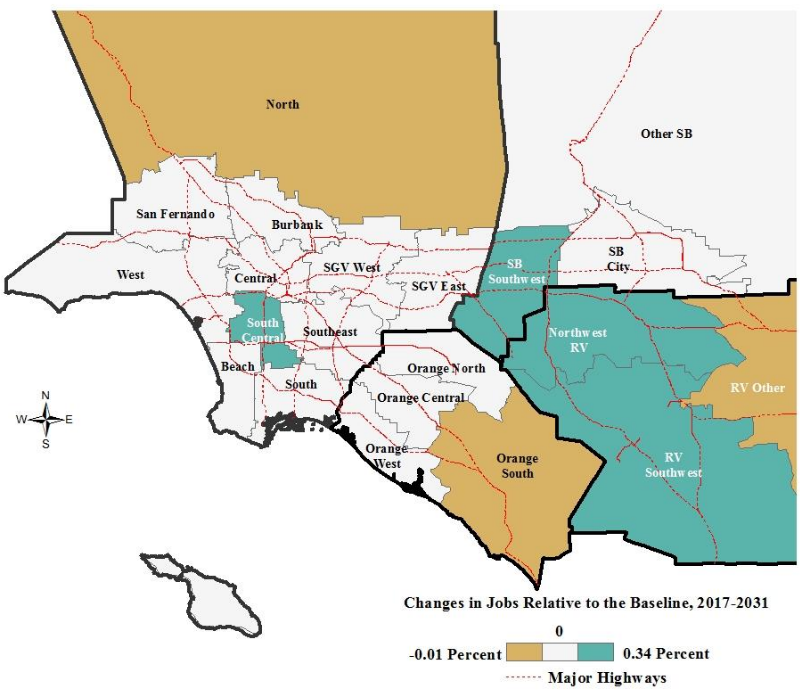


FIGURE 5-8 (B): PERCENT CHANGE RELATIVE TO THE BASELINE BY SUB-COUNTY REGION (ANNUAL AVERAGE, 2017-2031)



Chapter 6: Environmental Justice

The SCAQMD defines EJ as "equitable environmental policymaking and enforcement to protect the health of all residents, regardless of age, culture, ethnicity, gender, race, socioeconomic status, or geographic location, from the health effects of air pollution." It is akin to the U.S. EPA's definition: "Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."[1] California state law similarly defines EJ as "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies."[2]

For grant allocation purposes, the SCAQMD developed guidelines for EJ area designation. Currently, a community (geographically defined as a two-kilometer-by-two-kilometer grid cell) is designated as an EJ area if at least ten percent of the area's population falls below the federal poverty line, and if the area's PM2.5 concentration or toxic cancer risk is within the top 15^{th} percentile among all areas within the Basin.[3] Additionally, for the allocation of the Greenhouse Gas Reduction Fund (GGRF), a local administering agency such as the SCAQMD relies upon a list of disadvantaged communities being created by the California Environmental Protection Agency (CalEPA). CalEPA created and updates the list using the California Communities Environmental Health Screening Tool (CalEnviroScreen) to "assess all census tracts in California to identify the areas disproportionately burdened by and vulnerable to multiple sources of pollution," whether air related or not.[4] Currently, the top 25 percent of most impacted census tracts are eligible for receiving grants funded by the GGRF.

The 2014 Abt report recommended that the SCAQMD expand the EJ analysis in its socioeconomic assessments with respect to its existing regulatory and policy impact analyses (Abt Associates 2014). It recommended that staff consider alternative designations of EJ areas by utilizing screening tools to identify vulnerable and susceptible populations. The report stated that a screening analysis could be used to identify geographic locations where the populations are potentially subject to disproportionate risk or exposure, based on an existing (baseline) profile of pollution emissions or releases, as well as the affected population's health conditions and socioeconomic status. The report noted that these factors have been shown to be important determinants of the degree of vulnerability and susceptibility to pollution exposure. Furthermore, the report recommended that a distributional analysis of policy impacts be included for purposes of assessing and comparing the distribution of health risk with and without the proposed policy, and evaluating whether any changes in health risk distribution represent an increase or a decrease in health risk inequality between the most vulnerable and susceptible populations and all other residents in the Basin.

SCAQMD staff has worked closely with IEc and its scientific advisors to implement Abt's recommendations as described above. Based on a thorough review and update of EJ literature, alternative screening and designation methods were identified and tailored for the purpose of preparing the socioeconomic impact analysis for the Final 2016 AQMP. Moreover, two inequality indices were proposed for evaluating the

[1] See http://www3.epa.gov/environmentaljustice/.

[2] California Senate Bill 115, Solis, 1999; California Government Code § 65040.12(c).

[3] For funding allocation purposes, the SCAQMD also designates EJ areas in Coachella Valley, which is not located within the Basin. An EJ area there has at least ten percent of the area's population falling below the federal poverty line and its PM10 concentration within the top 15^{th} percentile among all areas in Coachella Valley.

[4] California Senate Bill 535 (De León) designated CalEPA as the agency in charge of identifying disadvantaged communities for GGRF allocation. The Bill directed that a quarter of the proceeds from the GGRF must go to projects that provide a benefit to disadvantaged communities; moreover, at least ten percent of the funds must be for projects located within those communities (see http://www.calepa.ca.gov/EnvJustice/GHGInvest/).

distribution of health risk and for comparing differential policy impacts, if any, between EJ and non-EJ communities. The interim drafts of IEc's report were reviewed by the 2016 AQMP Socioeconomic Assessment EJ Working Group (Group).[5] The Group's comments and suggestions were reported back to the STMPR Advisory Group and incorporated into IEc's final report (2016).[6]

Alternative EJ Screening and Designation Methods

For purposes of the socioeconomic impact analysis, IEc recommended the use of quantitative indicators based on state-of-the-science literature guidance in designating EJ communities. Following its review of the existing EJ screening tools and methodologies, IEc recommended a list of alternative definitions in designating EJ communities based on a screening method derived from CalEnviroScreen 2.0.[7] IEc recommended multiple alternative definitions based on two considerations: first, these alternative definitions can be used as a sensitivity analysis for the current grant distribution definition of EJ; second, these alternative definitions, all with a similar structure, can also serve as sensitivity analyses for one another.

Alternative Definition 1 consists of poverty status and air quality related environmental indicators, which are most akin to those used by the SCAQMD in the current EJ designation for grant allocation purposes. Definition 2 expands the indicators by also including other demographic indicators available in CalEnviroScreen 2.0, including age, asthma, education, linguistic isolation, low birth weight, and unemployment. Definition 3 further expands the indicators by adding other non-air related environmental indicators available in CalEnviroScreen 2.0, including drinking water, pesticides, toxic releases, and traffic that are directly related to pollution exposure, as well as environmental effects such as cleanup sites, groundwater threats, hazardous waste, impaired water bodies, and solid waste that are considered to contribute less to possible pollution burden than the environmental indicators that are directly associated with pollutant exposure (CalEPA and OEHHA 2014). Definitions 2a and 3a include an additional indicator of race/ethnicity to Definitions 2 and 3, respectively. These alternative definitions are listed in Table 6-1 below.

As in CalEnviroScreen 2.0, each indicator is calculated at the level of census tract. All the individual indicators, except for toxic cancer risk and race/ethnicity, are derived from the same raw data provided on the CalEnviroScreen 2.0 website. The diesel PM concentration indicator in CalEnviroScreen 2.0 is replaced by toxic cancer risk, which is based on estimates in the SCAQMD's Multiple Air Toxics Exposure Study IV (MATES IV). While diesel PM accounted for 76.2 percent of the overall toxic cancer risk (SCAQMD 2015), the MATES IV estimates additionally account for other important contributors to toxic cancer risk. These toxic cancer risk estimates are used for the SCAQMD's current EJ area designation for grant allocation purposes.

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[5] The Socioeconomic Assessment EJ Working Group met for a total of three times in April, May, and September 2016 to discuss respectively the proposed alternative EJ screening and designation methods, distributional analysis, and finally, IEc's Final report and staff's preliminary analysis results.

[6] The final report is available on the SCAQMD website at http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/scaqmdfinalejreport_113016.pdf?sfvrsn=6.

[7] IEc reviewed the current version of CalEnviroScreen (version 2.0), EJScreen and Community-Focused Exposure and Risk Screening Tool (C-FERST) both developed by the U.S. EPA, Environmental Justice Screening Method (EJSM) developed by researchers at the University of Southern California, UC Berkeley, and Occidental College, Cumulative Environmental Vulnerabilities Assessment (CEVA) developed by UC Davis, the Social Vulnerability Index (SoVI) 2006-10 developed by University of South Carolina, the 2010 Social Vulnerability Index (SVI) developed by the Agency for Toxic Substances & Disease Registry.

TABLE 6-1: ALTERNATIVE DEFINITIONS FOR EJ COMMUNITY DESIGNATION

Alternative Definition	Demographic Indicators		Environmental Indicators	
	Income	Other Demographic	Air Quality	Other Environmental
1	Poverty status[1]		PM2.5, toxic cancer risk,[2] ozone	
2	Poverty status[1]	Age, asthma, education, linguistic isolation, low birth weight, unemployment	PM2.5, toxic cancer risk,[2] ozone	
2a	Poverty status[1]	Age, asthma, education, linguistic isolation, low birth weight, unemployment, race/ethnicity[3]	PM2.5, toxic cancer risk,[2] ozone	
3	Poverty status[1]	Age, asthma, education, linguistic isolation, low birth weight, unemployment	PM2.5, toxic cancer risk,[2] ozone	Drinking water, pesticides, toxic releases, traffic, *cleanup sites, groundwater threats, hazardous waste, impaired water bodies, solid waste*[4]
3a	Poverty status[1]	Age, asthma, education, linguistic isolation, low birth weight, unemployment, race/ethnicity[3]	PM2.5, toxic cancer risk,[2] ozone	Drinking water, pesticides, toxic releases, traffic, *cleanup sites, groundwater threats, hazardous waste, impaired water bodies, solid waste*[4]

Notes:

1 Unlike the SCAQMD's current EJ definition where poverty status is considered as at least ten percent of population below federal poverty line, the poverty status here is the share of population below twice the federal poverty line to account for the higher than average cost of living in the Basin and the conservative federal poverty level value.

2 Toxic cancer risk is based on estimates from the SCAQMD's Multiple Air Toxics Exposure Study IV (MATES IV).

3 Race/ethnicity is not included as an indicator in CalEnviroScreen 2.0. It is expressed as the percent of population within a census tract with minority status using the U.S. Census Bureau's American Community Survey five-year estimates for 2010-2014. Based on the federal National Environmental Policy Act (NEPA) Guideline, "minority" is defined as "[i]ndividual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic."

4 Consistent with CalEnviroScreen 2.0, the "other environmental" indicators that are shown in *italics* are given half the weight when calculating the overall score for all environmental indicators whereas all other indicators were given the weight of one.

Source: Industrial Economics, Levy, and Harper 2016.

Race/ethnicity is not included as an indicator in CalEnviroScreen 2.0.[8] However, it is included in this analysis based on state-of-the-science literature guidance and input from the EJ Working Group. In order to facilitate potential use of an alternative EJ definition in circumstances where race and ethnicity are legally prohibited

[8] However, a post-screening analysis conducted by OEHHA showed that the more impacted communities identified by CalEnviroScreen 2.0 also have higher shares of minority population (OEHHA 2014).

from being used, race/ethnicity is included in this analysis as a sensitivity test to Alternative Definitions 2 and 3.

Similar to CalEnviroScreen 2.0, each census tract within the Basin was ranked from the most to the least impacted areas, based on a tract's overall screening score.[9] IEc recommended two potential thresholds to designate EJ communities. The first threshold option would define an EJ community as the worst impacted census tracts until the total population residing in these tracts reaches approximately 50 percent of the Basin's population. This threshold roughly reflects the same number of residents as the SCAQMD's current EJ designation, which covers about 47 percent of the Basin's population. In comparison, the second and more stringent threshold option includes the worst impacted census tracts as EJ communities until approximately 25 percent of the Basin's population are identified to live in these communities. This 25-percent population threshold reflects the current practice of setting statewide CalEnviroScreen threshold to allocate the GGRF.[10]

Table 6-2 shows the EJ population distribution across the four counties within the Basin for each EJ definition and based on the two population thresholds. Compared to the SCAQMD's current EJ definition for grant allocation purposes, the EJ population identified by Alternative Definitions 1-3 all consist of a larger share of residents in the Inland region and a smaller share of residents in the coastal counties. While this difference ranges from 4 to 12 percent, depending on the alternative definition and population threshold used, the largest differences appear when the designation threshold is set at the more restrictive population cut-off of top 25 percent and when other non-air related environmental indicators are not included.

TABLE 6-2: EJ POPULATION DISTRIBUTION BY DEFINITION AND DESIGNATION THRESHOLD

County	SCAQMD Definition (~ 50%)	Alternative Definition 1		Alternative Definition 2		Alternative Definition 3	
		Top 50%	Top 25%	Top 50%	Top 25%	Top 50%	Top 25%
Los Angeles	74.4	70.6	72.1	72.5	72.0	68.1	75.2
Orange	10.0	5.7	1.0	3.9	0.1	11.2	4.8
Riverside	5.9	10.0	7.2	9.5	7.1	8.1	6.6
San Bernardino	9.8	13.7	19.7	14.1	20.8	12.5	13.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: County-specific values may not sum up to 100 percent due to rounding error.
Source: Industrial Economics, Levy, and Harper (2016).

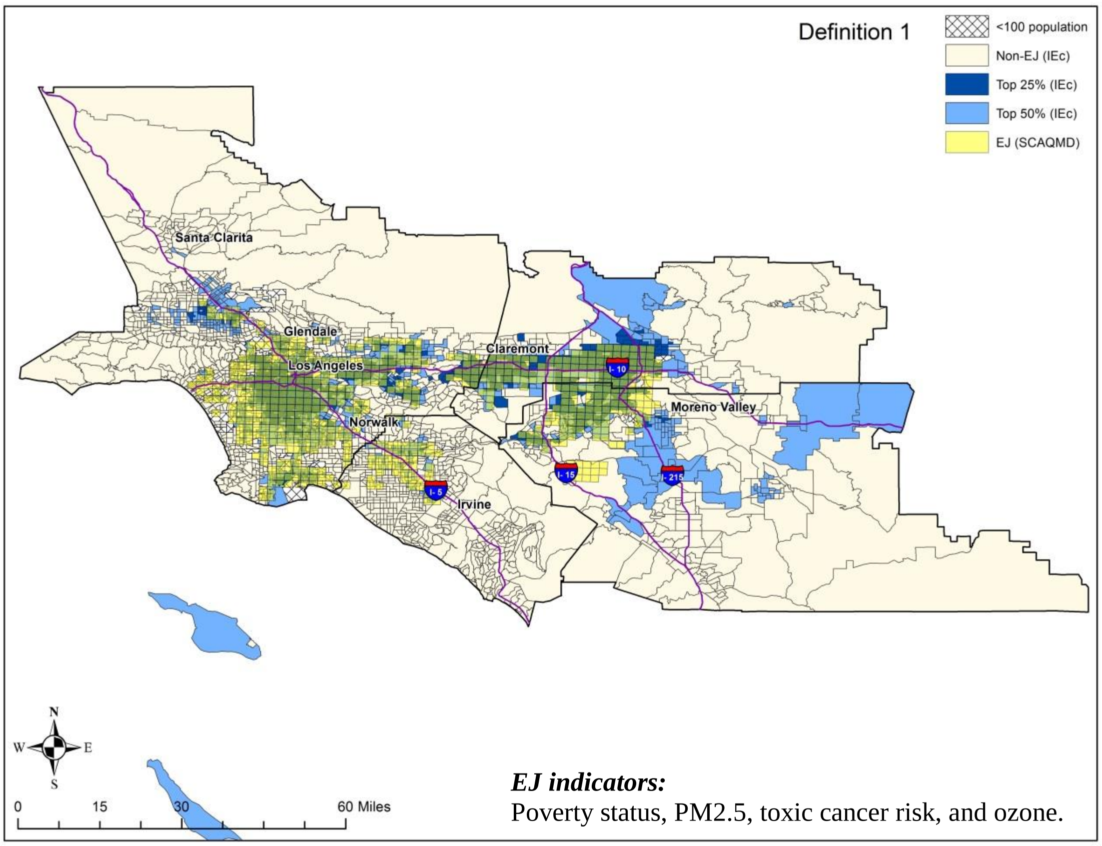
Figures 6-1, 6-2, and 6-3 present the maps of EJ designation results based on Alternative Definitions 1, 2, and 3 respectively. In general, communities that have been designated as EJ communities by the SCAQMD largely overlap with those designated as EJ communities by the alternative definitions recommended by IEc. Particularly, the current SCAQMD EJ designation covers the majority of the worst impacted EJ areas, as identified by the 25-percent population threshold under any of the three alternative definitions. Consistent

[9] The calculation of screening score is identical to the CalEnviroScreen 2.0 method. See Appendix 6-A for an example.

[10] Notice, however, that the Basin has a higher concentration of EJ communities as identified for GGRF allocation purposes based on the statewide ranking using CalEnviroScreen 2.0. Therefore, the number of residents living in the Basin's EJ communities according to the GGRF designation effectively accounts for about 39 percent of the Basin's total population.

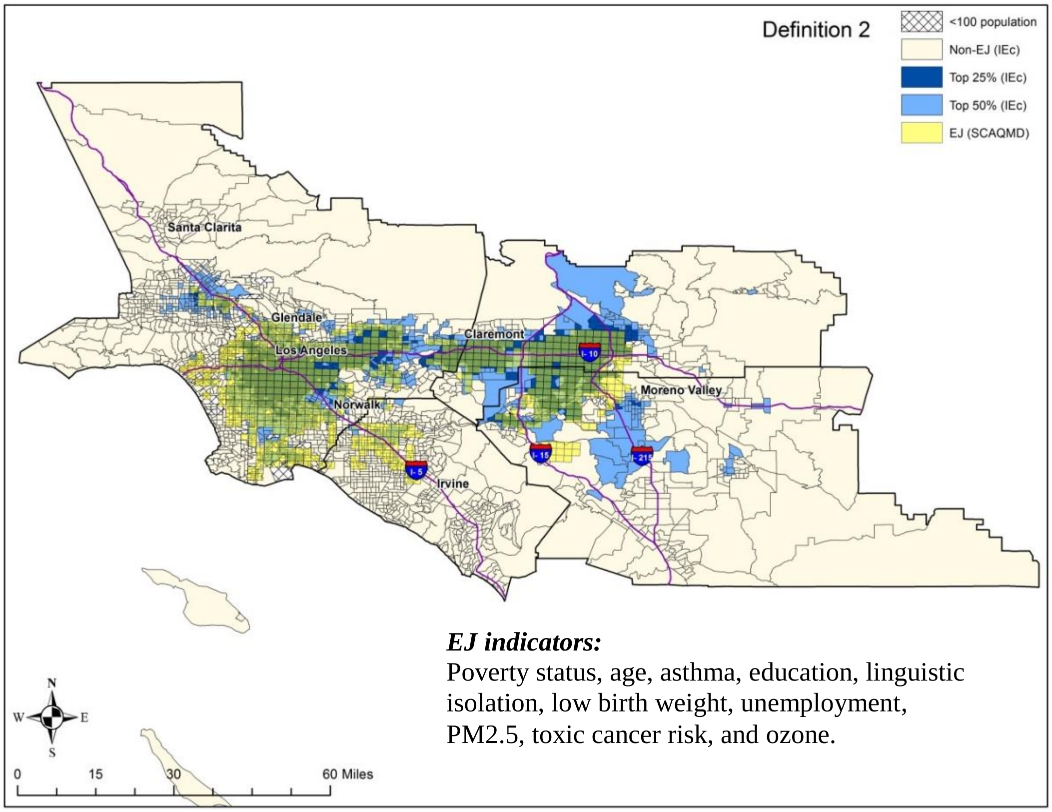
with the EJ population distribution shown in Table 6-2, however, all three maps demonstrate a slight eastward shift away from the coast and toward the inland area when the recommended alternative definitions are used instead of the current SCAQMD EJ designation. Moreover, the eastward shift is somewhat more pronounced under Alternative Definitions 1 and 2, and under these two definitions, there are also visibly fewer EJ communities located in Orange County. The map for Alternative Definition 3 shows the largest difference from the current SCAQMD EJ designation. It includes a number of large, rural, and sparsely populated census tracts at the southeastern most corner of the Basin, as well as a number of census tracts in Orange County between Interstate 405 and the Santa Ana Freeway portion of Interstate 5. Residents in these census tracts are relatively more impacted by other water- and hazardous waste-related environmental burdens, more so than air pollution-related burdens.

FIGURE 6-1: EJ COMMUNITIES DESIGNATED UNDER ALTERNATIVE DEFINITION 1 VERSUS SCAQMD'S CURRENT EJ DESIGNATION



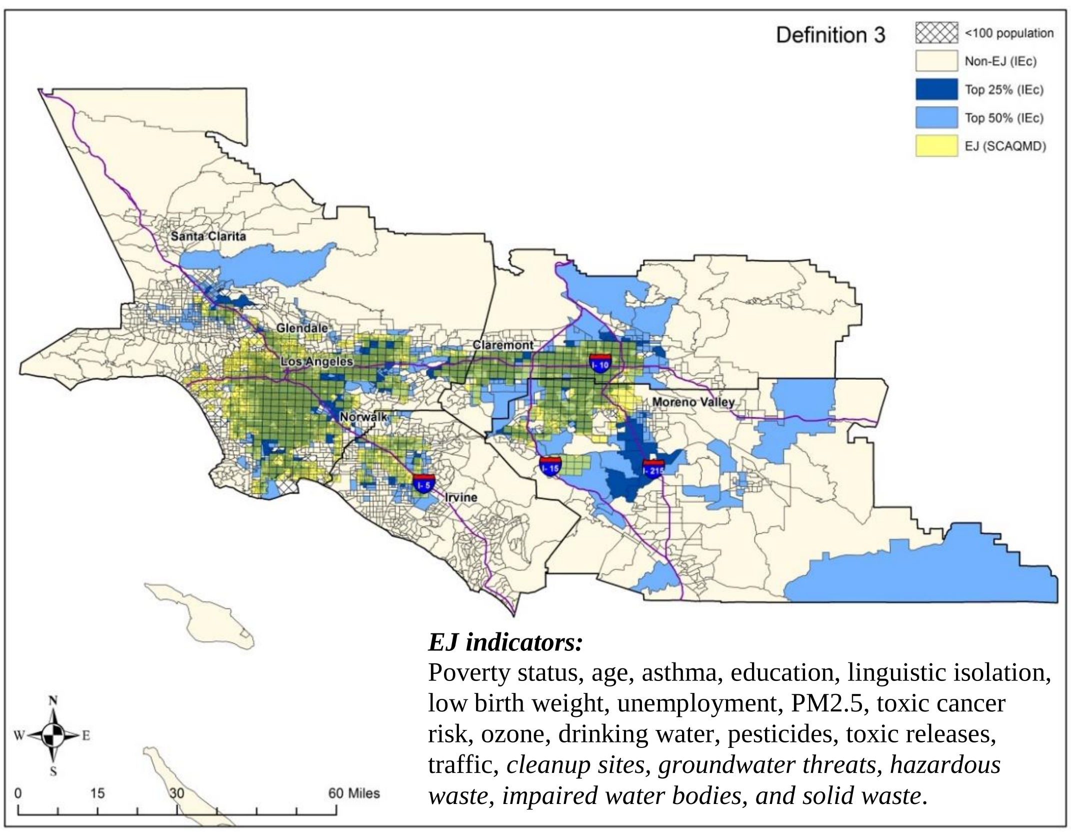
Source: Industrial Economics, Levy, and Harper 2016.

FIGURE 6-2: EJ COMMUNITIES DESIGNATED UNDER ALTERNATIVE DEFINITION 2 VERSUS SCAQMD'S CURRENT EJ DESIGNATION



Source: Industrial Economics, Levy, and Harper 2016.

FIGURE 6-3: EJ COMMUNITIES DESIGNATED UNDER ALTERNATIVE DEFINITION 3 VERSUS SCAQMD'S CURRENT EJ DESIGNATION



Source: Industrial Economics, Levy, and Harper 2016.

According to the literature survey conducted by IEc and its scientific advisors (Industrial Economics et al. 2016), race/ethnicity has been shown to be an important indicator of vulnerability to pollution exposure. Table 6-3 illustrates the impact of adding race/ethnicity to Alternative Definitions 2 and 3 on the EJ population distribution across the four counties. This additional EJ indicator is based on the percent minority population within a census tract, with the definition of minority being "[i]ndividual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic." (Council on Environmental Quality 1997) Table 6-3 allows the comparison of population distributions between EJ definitions without and with race/ethnicity (i.e., between Alternative Definitions 2 and 2a and between Alternative Definitions 3 and 3a). It can be seen that the inclusion of race/ethnicity results in very minor changes to how the EJ population is distributed.

TABLE 6-3: IMPACT OF RACE/ETHNICITY INCLUSION ON EJ POPULATION DISTRIBUTION

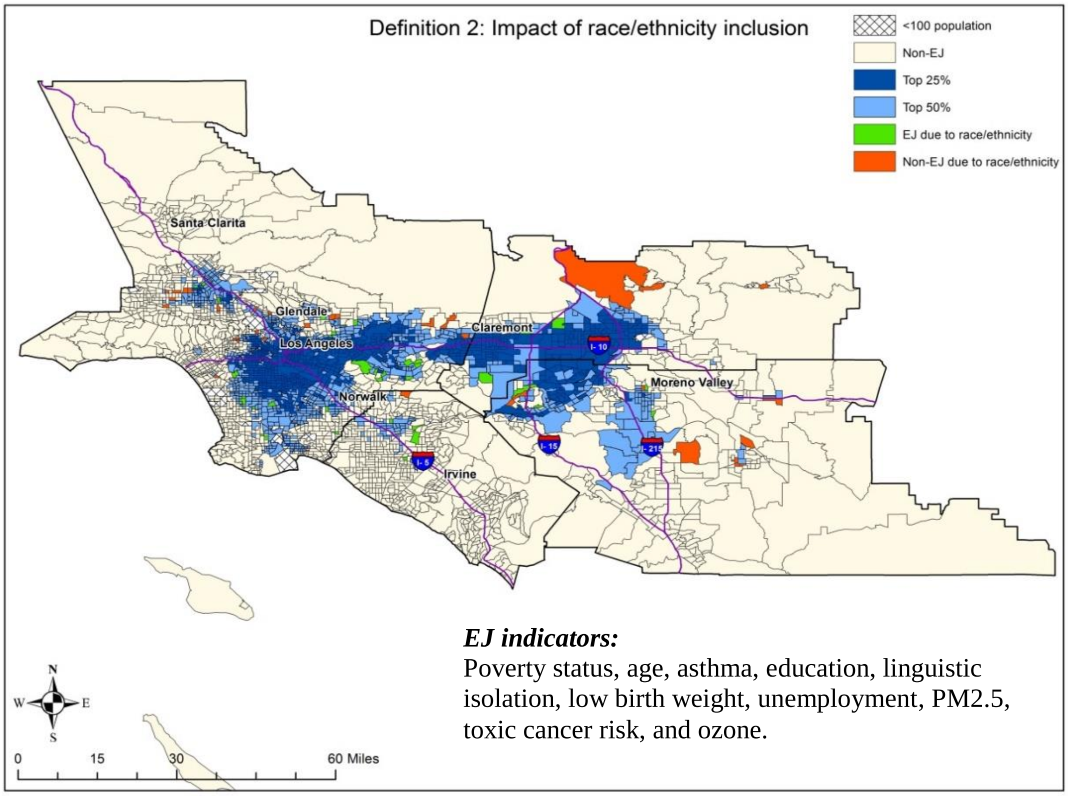
County	Top 50%		Top 25%		Top 50%		Top 25%	
	Def. 2	Def. 2a	Def. 2	Def. 2a	Def. 3	Def. 3a	Def. 3	Def. 3a
Los Angeles	72.5	72.2%	72.0	72.8%	68.1	68.6%	75.2	76.4%
Orange	3.9	4.2%	0.1	0.0%	11.2	11.1%	4.8	4.6%
Riverside	9.5	9.2%	7.1	6.4%	8.1	7.9%	6.6	6.3%
San Bernardino	14.1	14.3%	20.8	20.8%	12.5	12.4%	13.5	12.7%
Total	100.0	100%	100.0	100%	100.0	100%	100.0	100%

Note: County-specific values may not sum up to 100 percent due to rounding error.
Source: Industrial Economics, Levy, and Harper (2016).

Similarly, marginal changes in EJ designations are observed in Figures 6-4 and 6-5, where race/ethnicity was added to the existing list of demographic indicators under Alternative Definitions 2 and 3, respectively. Generally speaking, some census tracts outside of the main contiguous EJ area are now non-EJ communities, and at the same time, some census tracts within the contiguous area from central Los Angeles east along the Interstate 10 corridor are now EJ communities. For either designation threshold, these changes affect only about two percent of the Basin's population.

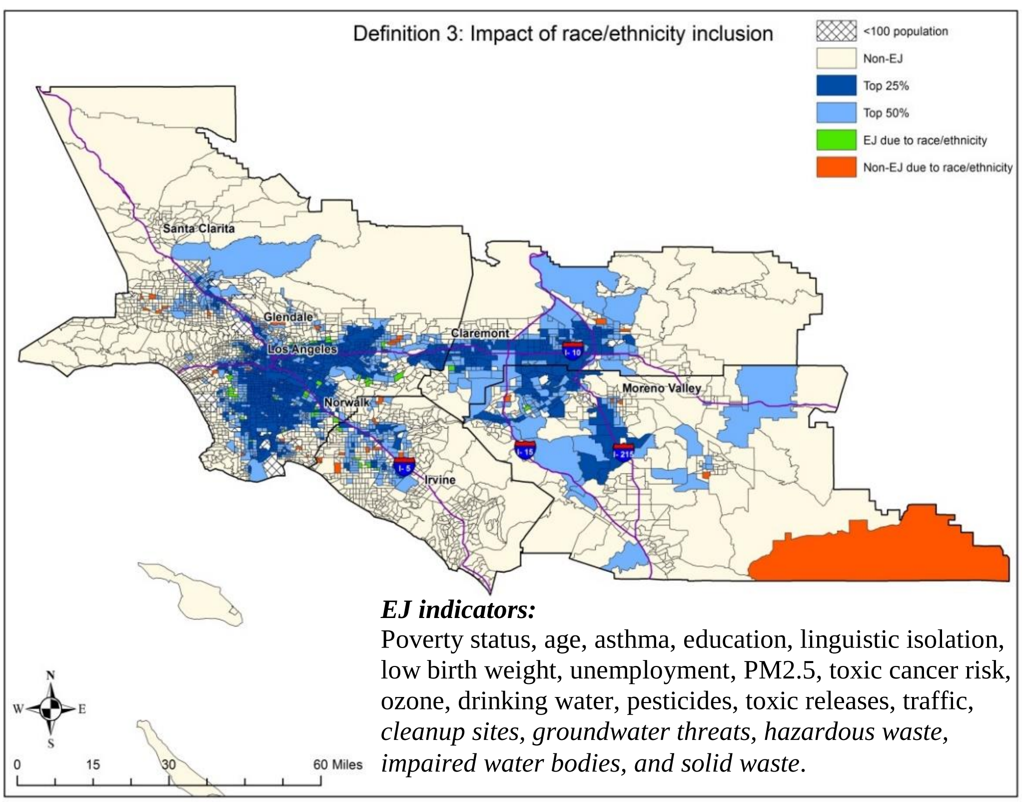
Nonetheless, it should be emphasized that the minimal changes as a result of adding race/ethnicity do not imply a lack of significance of race/ethnicity as an EJ indicator. Rather, these minimal changes suggest a likely high correlation between race/ethnicity and many, if not all, of the indicators that are already included under Alternative Definitions 2 or 3.

FIGURE 6-4: IMPACT OF RACE/ETHNICITY INCLUSION ON EJ COMMUNITY DESIGNATION UNDER ALTERNATIVE DEFINITION 2



Source: Industrial Economics, Levy, and Harper 2016.

FIGURE 6-5: IMPACT OF RACE/ETHNICITY INCLUSION ON EJ COMMUNITY DESIGNATION UNDER ALTERNATIVE DEFINITION 3



Source: Industrial Economics, Levy, and Harper 2016.

Quantified Public Health Effects and Monetized Benefits in EJ and non-EJ communities

For the purpose of analyzing the distributional impacts of the Final 2016 AQMP, it was recommended by IEc that the analysis be conducted for PM2.5- and ozone-related mortality risk in adults, as well as for morbidity risk of asthma-related emergency department (ED) visits in children, as different age groups could experience varying impacts for a particular health endpoint. This section summarizes the health effects for these recommended health endpoints and the monetized overall public health benefits, as a result of implementing the Final 2016 AQMP, based on the annual estimates for year 2031 within the Basin.[11] Based on the finding that the projected air quality (measured by ozone and PM2.5 concentrations at the grid-cell level) in 2023 and in 2031 are almost perfectly correlated,[12] the distribution of public health benefits for year 2023 is expected to be very similar to the results for year 2031, except that the 2023 benefits would be of a smaller magnitude due to the projected smaller changes in pollutant concentrations for the earlier milestone year.

Table 6-4 compares the projected decreases in the number of premature deaths per million residents in 2031 in EJ and non-EJ communities due to implementation of the Final 2016 AQMP. Similarly, Table 6-5 compares the projected decreases in the number of asthma-related ED visits per million residents in 2031 in EJ and non-EJ communities. Table 6-4 shows that, on average, EJ communities are projected to experience greater public health benefits of avoided premature deaths among adults, as a result of implementing the Final 2016 AQMP. Table 6-5 shows that, while all communities would see reductions in the risk of asthma-related ED visits in children, non-EJ communities are expected to see a greater decrease in that risk than EJ communities.

TABLE 6-4: ANNUAL AVOIDED PREMATURE DEATHS AMONG ADULTS (25 YEARS OR OLDER)* ANTICIPATED THROUGH IMPLEMENTING THE FINAL 2016 AQMP

By EJ Designation and for Year 2031

		Decrease in Number of Premature Deaths per Million Residents 25 Years or Older		Difference
EJ Designation		**EJ Communities**	**Non-EJ Communities**	**(EJ) – (Non-EJ)**
Definition 1	Top 50%	169	140	29
	Top 25%	180	145	35
Definition 2	Top 50%	173	136	37
	Top 25%	175	144	31
Definition 3	Top 50%	167	140	27
	Top 25%	155	146	10

*Due to both long-term exposure to PM2.5 and short-term exposure to ozone
Note: Numbers may not sum up due to rounding.

[11] The health effects and monetized public health benefits are slightly less than those reported in Chapter 3. The difference of about one percent is due to the effects and benefits estimated within the four-county region but outside the Basin.
[12] The correlation coefficient of pollutant concentrations for year 2023 and for year 2031 is greater than 0.99 for both baseline and control scenarios.

TABLE 6-5: ANNUAL AVOIDED ASTHMA RELATED ED VISITS AMONG CHILDREN (YOUNGER THAN 18)* ANTICIPATED THROUGH IMPLEMENTING THE FINAL 2016 AQMP

By EJ Designation and for Year 2031

		Decrease in Number of Asthma-Related ED Visits per Million Residents Younger than 18		Difference
EJ Designation		EJ Communities	Non-EJ Communities	(EJ) – (Non-EJ)
Definition 1	Top 50%	698	700	-2
	Top 25%	685	703	-18
Definition 2	Top 50%	701	697	3
	Top 25%	691	702	-11
Definition 3	Top 50%	683	717	-35
	Top 25%	645	720	-75

*Due to short-term exposure to ozone only
Note: Numbers may not add up due to rounding.

Finally, Table 6-6 shows the per capita monetized public health benefits in EJ and non-EJ communities, respectively. As previously discussed in Chapter 3, these monetized benefits are largely driven by projected avoided premature deaths; therefore, consistent with the comparison results shown in Table 6-4, EJ communities are projected to experience a larger per capita health benefits. In other words, proportionally more of the quantified public health improvement due to implementing the Final 2016 AQMP are projected to accrue to EJ communities than non-EJ communities, regardless of the alternative definition or designation threshold chosen.

TABLE 6-6: MONETIZED ANNUAL PUBLIC HEALTH BENEFITS

By EJ Designation and for Year 2031

		Per Capita Monetized Benefits (in 2015 Dollars)		Difference in Per Capita Benefits
EJ Designation		EJ Communities	Non-EJ Communities	EJ - Non-EJ
Definition 1	Top 50%	$1,865	$1,554	$311
	Top 25%	$2,011	$1,610	$402
Definition 2	Top 50%	$1,906	$1,510	$395
	Top 25%	$2,029	$1,597	$432
Definition 3	Top 50%	$1,843	$1,546	$297
	Top 25%	$1,928	$1,615	$313

Notably, the difference in per capita health benefits is consistently larger when the designation threshold is set at the top 25-percent of population. This indicates that the most vulnerable and susceptible communities will experience proportionally more of the projected health benefits of cleaner air. It is also observed that, regardless of the threshold used, the difference in per capita health benefits is the smallest under Alternative Definition 3, where other non-air related environmental indicators are included for EJ screening. This implies that, as clean air policy is not designed to alleviate other types of environmental risks or degradation, Alternative Definition 3 may not be the best way to designate EJ communities for the purpose of evaluating the effectiveness of air regulations and programs in reducing health risk disparity, which is used in the recent EJ literature as the barometer for environmental justice.

Evaluating Distributional Impact of the Final 2016 AQMP via Health Risk Inequality Index

According to the U.S. EPA's latest *Guidelines for Preparing Economics Analyses* (2016), examining the distribution of changes in health benefits alone may not completely reflect the distributional impact since "an unequal distribution of environmental improvements may actually help alleviate existing disparities (Maguire and Sheriff 2011)" (p. 10-7). The *Guidelines* recommend the consideration of changes in distributions of health and environmental outcomes, such as health risk, between baseline and policy scenarios.

Consistent with the *Guidelines*, IEc recommended that the distributional impact of the Final 2016 AQMP be analyzed by comparing the distributions of exposure-related mortality and morbidity risk between baseline and policy scenarios (Industrial Economics et al. 2016). The purpose of analyzing more than one health endpoint is two-fold: first, health risk for different health endpoints cannot easily be combined into one meaningful risk metric; second, different health endpoints may have varying impacts on different population groups, such as age cohorts. Therefore, the distribution of PM2.5 and ozone exposure related mortality risk is analyzed, as premature death is the most severe effect of air pollution among all health endpoints. However, it is more likely that a larger effect of mortality risk changes will be experienced by the older age cohort. To complement the distributional analysis of mortality risk, the exposure related morbidity risk distribution is also analyzed for asthma-related ED visits among children, whose lungs are not yet fully developed and are therefore more susceptible than adults to respiratory health impacts.

The distributional analysis consists of three main steps as described below:[13]

1. Health risk related to the exposure of a pollutant was estimated separately for the baseline and the policy (control) scenario using BenMAP-CE and accounting for exposure to all emission sources of the pollutant, whether anthropogenic or biogenic.[14]
2. Inequality index values, which summarize the distribution of exposure related health risk among all census tracts within the Basin, were calculated for the baseline and the policy scenario separately.[15]
3. The inequality index values calculated in Step 2 were decomposed into the inequality *between* the EJ and the non-EJ group of communities and the inequality *within* either group of communities.

Based on IEc recommendations, the analysis uses both Atkinson and Kolm-Pollak Inequality Indices to show

[13] A similar methodology was used in Fann et al. (2011). See Appendix 6-B for further discussion.

[14] BenMAP-CE was also used to quantify health benefits in Chapter 3. See Appendix 3-B for a discussion of BenMAP-CE operational steps.

[15] Some studies have shown that using inequality index to summarize the distribution of a "bad" (e.g., health risk), as opposed to a "good" (e.g., income) can lead to violations of some axioms that an inequality index must satisfy. For this reason, SCAQMD staff analyzed the distributions of the complement of health risk (one minus the health risk), which is directly interpretable as a "good," i.e., the percent of population not expected to experience premature deaths or asthma-related ED visits (see Appendix 6-B for further discussion).

the potential changes in health risk inequality. Generally speaking, a higher inequality index value indicates greater inequality. However, it should be noted that an inequality index value is, in essence, a single number that indicates the statistical dispersion of a distribution,[16] and the directional change is much more meaningful than the precise value of an inequality index. Moreover, the index value and changes in index value cannot be compared across different indices.[17] An analogous example is stock market indices: the *directional changes* of Dow Jones Industrial Average and S&P 500 are both important financial market indicators, but the value of the indices do not carry much meaning and the values and their absolute changes also should not be compared against each other.

Additionally, it should also be noted that the Atkinson Inequality Index is based on *relative* inequality whereas the Kolm-Pollak Inequality Index is based on *absolute* inequality. As an illustrative example of the difference, let us assume that there is no within-group inequality (i.e., identical health risk at each census tract within either the EJ or non-EJ group of communities), and therefore, the overall inequality can be entirely attributed to inequality between the EJ and the non-EJ group of communities. In this example, if the ratio of health risk between EJ and non-EJ groups stays constant across the baseline and the policy scenario (e.g., health risk ratio for baseline: 0.0004/0.0002 = health risk ratio for policy: 0.0002/0.0001), then the Atkinson Index will also stay constant and show no change in inequality. In contrast, the Kolm-Pollak Index will show a decrease in inequality in this example as the absolute difference in health risk shrinks (i.e., [0.0004-0.0002 = 0.0002] > [0.0002-0.0001 = 0.0001]).[18]

Table 6-7 reports the impact of the Final 2016 AQMP on the overall distribution of health risk within the Basin in 2031. The inequality in PM2.5 and ozone exposure related mortality risk among adults is projected to decrease with either inequality index. The inequality in ozone exposure related asthma ED visits among children is also projected to decrease according to either inequality index.

[16] Not all measures of statistical dispersion can qualify as an inequality index. Only those that satisfy a list of required axioms can be used as inequality indices. See Industrial Economics et al. (2016) for a discussion of the axioms.

[17] The inequality index values also cannot be compared across different inequality aversion parameters even with the same inequality index. See Industrial Economics et al. (2016) for more discussion of inequality aversion.

[18] In this analysis, the absolute and relative changes in inequality are very similar in value because the distributions of the complement of health risks average around 0.99, from which point small changes in absolute or percentage terms are similar.

TABLE 6-7: OVERALL DISTRIBUTIONAL IMPACT OF THE FINAL 2016 AQMP IN 2031

	PM2.5 and Ozone Exposure Related Mortality Risk (Among Residents 25 Years or Older)		**Ozone Exposure Related Asthma ED Visits for Asthma (Among Residents Younger than 18)**	
	Atkinson Index [Relative Inequality] Inequality Aversion = 0.5	**Kolm-Pollak Index [Absolute Inequality]** Inequality Aversion = 0.5	**Atkinson Index [Relative Inequality]** Inequality Aversion = 0.5	**Kolm-Pollak Index [Absolute Inequality]** Inequality Aversion = 0.5
	(Values in 10^{-8})	(Values in 10^{-8})	(Values in 10^{-8})	(Values in 10^{-8})
Baseline	6.3	6.3	15.7	15.5
Policy	4.4	4.4	13.9	13.8
Change	↓	↓	↓	↓

Note: Inequality aversion parameters take on non-negative values only, and a higher value indicates that a society is more "inequality averse". However, the same parameter value does not imply the same degree of inequality aversion between Atkinson and Kolm-Pollak Indices.

Tables 6-8 and 6-9 decompose the overall inequality of health risk, for Atkinson and Kolm-Pollak Indices respectively, into two components: inequality *between* EJ and non-EJ groups of communities and a weighted average inequality *within* each group; moreover, the decomposition was conducted for all three alternative EJ definitions and the two population thresholds for EJ designation. In terms of *relative* inequality as measured by the Atkinson Index (see Table 6-8), it is observed that there is consistently greater within- than between-group dispersion for both mortality and morbidity risk analyzed here. Nonetheless, both between- and within-group inequalities are reduced for PM2.5 and ozone exposure related mortality risk among adults. In the meantime, the inequality between EJ and non-EJ communities is shown to increase for the health risk of ozone exposure related asthma ED visits among children, although the corresponding within-group inequality decreases. This implies that the decrease in overall inequality, as measured by the Atkinson Index for the risk of asthma-related ED visits among children as shown in Table 6-7, is due to a larger reduction in the relative within-group inequality, which dominates any increase in the relative between-group inequality.

In terms of *absolute* inequality as measured by the Kolm-Pollak Index (see Table 6-9), it also shows greater within- than between-group dispersion. Furthermore, the changes of absolute inequality corroborate the results shown for relative inequality.

The result of increased inequality of ozone-exposure related risk of asthma ED visits among children between EJ and non-EJ communities is primarily due to the chemical mechanism of ozone formation in the Basin. This mechanism and the atmospheric dispersion of precursor pollutants from the emission sources lead to greater reductions in ozone concentrations in the downwind inland areas of the Basin, and smaller reductions in the central Los Angeles areas of the Basin. In the meantime, the central Los Angeles areas have a greater proportion of census tracts designated as EJ communities than the less populous inland areas. (See Table 6-2 and note that census tracts are designed to have similar population sizes across all tracts.). As a result, while the ozone-exposure related health risk is projected to decline everywhere in the Basin, it would decline less in many of the EJ communities located around central Los Angeles.

TABLE 6-8: DECOMPOSED DISTRIBUTIONAL IMPACT OF THE FINAL 2016 AQMP IN 2031 USING RELATIVE INEQUALITY-BASED ATKINSON INDEX *(Inequality Aversion = 0.5)*

	PM2.5 and Ozone Exposure Related Mortality Risk (Among Residents 25 Years or Older)				Ozone Exposure Related Asthma ED Visits for Asthma (Among Residents Younger than 18)			
	Top 50%		*Top 25%*		*Top 50%*		*Top 25%*	
	Between	Within	Between	Within	Between	Within	Between	Within
	(All values are in 10^{-8})							
Def. 1								
Baseline	0.3	6.0	0.3	6.0	1.7	14.0	1.3	14.5
Policy	0.2	4.2	0.2	4.2	2.0	12.0	1.5	12.5
Change	↓	↓	↓	↓	↑	↓	↑	↓
Def. 2								
Baseline	0.4	5.9	4.5	6.5	2.5	13.2	1.5	14.2
Policy	0.3	4.1	2.9	4.6	2.7	11.2	1.7	12.3
Change	↓	↓	↓	↓	↑	↓	↑	↓
Def. 3								
Baseline	0.4	5.9	4.0	6.7	0.9	14.8	0.6	15.1
Policy	0.3	4.1	2.8	4.6	1.1	12.8	0.8	13.1
Change	↓	↓	↓	↓	↑	↓	↑	↓

TABLE 6-9: DECOMPOSED DISTRIBUTIONAL IMPACT OF THE FINAL 2016 AQMP IN 2031 USING ABSOLUTE INEQUALITY-BASED KOLM-POLLAK INDEX *(Inequality Aversion = 0.5)*

	PM2.5 and Ozone Exposure Related Mortality Risk (Among Residents 25 Years or Older)				Ozone Exposure Related Asthma ED Visits for Asthma (Among Residents Younger than 18)			
	Top 50%		*Top 25%*		*Top 50%*		*Top 25%*	
	Between	Within	Between	Within	Between	Within	Between	Within
	(All values are in 10^{-8})							
Def. 1								
Baseline	0.3	6.0	0.3	6.0	1.7	13.8	1.2	14.3
Policy	0.2	4.2	0.2	4.2	2.0	11.9	1.4	12.4
Change	↓	↓	↓	↓	↑	↓	↑	↓
Def. 2								
Baseline	0.4	5.9	0.3	6.0	2.4	13.1	1.4	14.1
Policy	0.3	4.1	0.2	4.1	2.7	11.1	1.7	12.1
Change	↓	↓	↓	↓	↑	↓	↑	↓
Def. 3								
Baseline	0.4	5.9	0.3	6.0	0.9	14.6	0.6	14.9
Policy	0.3	4.1	0.2	4.2	1.1	12.7	0.8	13.0
Change	↓	↓	↓	↓	↑	↓	↑	↓

Chapter 7: CEQA Alternatives

The California Environmental Quality Act (CEQA) requires that SCAQMD propose alternatives to the 2016 AQMP. These alternatives should include realistic measures to attain the basic objectives of the project (i.e., the obligation to adopt attainment plans to meet the PM2.5 and ozone NAAQS) and provide the means for evaluating the comparative merits of each alternative. The range of alternatives must be sufficient to permit a reasoned choice but need not include every conceivable project alternative. The key issue is whether the selection and discussion of alternatives fosters informed decision making and public participation.

The Program Environmental Impact Report (PEIR) considers four CEQA Alternatives to the proposed 2016 AQMP.[1] For purposes of socioeconomic impact assessment, except for Alternative 1—No Project, it is assumed that the remaining three alternatives would lead to attainment of NAAQS. Each of the four alternatives and how their socioeconomic impacts were modeled are described below.

Description of CEQA Alternatives

Alternative 1—No Project

CEQA requires the evaluation of the No Project Alternative, which consists of what would occur if the proposed project was not approved; in this case, not adopting the 2016 AQMP. The net effect of not adopting the 2016 AQMP would be a continuation of the 2012 AQMP and the 2007 AQMP. This approach is consistent with CEQA Guidelines §15126.6 (e)(3)(A), which states: "When the project is the revision of an existing land use or regulatory plan, policy or ongoing operation, the 'no project' alternative will be the continuation of the existing plan, policy, or operation into the future. Typically this is a situation where other projects initiated under the existing plan will continue while the new plan is developed. Thus, the projected impacts of the proposed plan or alternative plans would be compared to the impacts that would occur under the existing plan".

The No Project Alternative would implement any remaining control measures in the 2012 AQMP and fulfill the "black box" measure commitment in the future pursuant to the 2007 AQMP to achieve the 1997 8-hour ozone standard (80 ppb) by 2023 but would not propose enough reductions to achieve the 2008 8-hour ozone standard (75 ppb) by 2031 or the 2012 annual PM2.5 standard (12.0 $\mu g/m^3$) by 2025 as projected to be accomplished by the proposed 2016 AQMP control measures. Since no emission reductions are expected from the projected baseline inventory, there will be no emission reduction related costs or public health benefits, therefore also no resultant macroeconomic impacts under Alternative 1. However, the No Project Alternative would not be sufficient to satisfy the SCAQMD's SIP obligations. As discussed in Chapter 1, the receipt of federal highway funding for transportation investment in the region hinges on adopting an appropriate plan to attain the NAAQS; therefore, failure to do so could have undesirable economic consequences for the region. The potential macroeconomic impacts resulting from such a scenario are not quantified in this report due to a wide range of uncertainties regarding sanction implementation and impacts. For instance, the baseline economic projections used in the analysis relies on the 2016 SCAG Growth Forecast, which assumes that the region would continue receiving federal highway funding. Thus, analyzing the economic impacts of this potential funding shortfall would require new transportation and air quality model forecasts, which is beyond the scope of this analysis.

[1] Environmental Audit Inc. and Inabinet 2016; available at: http://www.aqmd.gov/docs/default-source/ceqa/documents/aqmd-projects/2016/2016aqmpfpeir.pdf?sfvrsn=4

Alternative 2—Mobile Source Emission Reductions Only

Alternative 2 retains all mobile source control strategies proposed by SCAQMD and CARB, along with CARB's consumer product control measure; however, the stationary source control measures as proposed by SCAQMD would not be implemented under this alternative. For the purpose of conducting a comparable socioeconomic analysis between the Final 2016 AQMP and the CEQA alternatives, the amount of NOx and VOC emission reductions attributable to stationary source control measures under the proposed Final 2016 AQMP — annual average of 8 tpd in 2023 and 20 tpd in 2031 for NOx; and annual average of 8 tpd in 2023 and 12 tpd in 2031 for VOC, would then be classified as achievable under CAA §182(e)(5) measures under Alternative 2, in order to still meet the ozone NAAQS.

It was further assumed that: first, most of the mobile source CAA §182(e)(5) measures would generate NOx and VOC emission reductions as a co-benefit and their associated costs would be an average of $50,000 per ton of NOx reduced;[2] and second, only limited, strategic VOC reductions of 3 tpd in 2023 and 4 tpd in 2031 will be needed from the remaining mobile source CAA §182(e)(5) measures and they would incur an additional cost per ton similar to the proposed VOC-only control measures.

Table 7-1 presents the list of ozone control measures considered for Alternative 2, for which emission reductions were quantified. Similar to the conclusion made in the Final 2016 AQMP, it is assumed that the implementation of all ozone control strategies would result in attainment of the 2012 annual PM2.5 standard.[3]

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[2] As calculated by the discounted cash flow method. $50,000 per ton of NOx emission reduction was considered in the 2014 NOx RECLAIM amendments as the cost-effectiveness threshold. This threshold was assumed to reflect the expectation that the not-yet-identified technologies under the CAA §182(e)(5) measures could be significantly more expensive than the average of $29,000 per ton estimated for the further deployment measures proposed by CARB.

[3] The Final 2016 AQMP contains two *contingency* PM2.5 control measures with quantified emission reductions; therefore, their incremental costs have been estimated. They are BCM-01: Further Emission Reductions from Commercial Cooking and BCM-04: Emission Reductions from Manure Management Strategies. The costs associated with these two measures are retained for socioeconomic assessment for CEQA Alternatives 2-4.

TABLE 7-1: OZONE MEASURES CONSIDERED FOR SOCIOECONOMIC ASSESSMENT UNDER ALTERNATIVE 2

Measure	Title	Implementation Agency
MOB-10	Extension of the SOON Provision for Construction/Industrial Equipment [NOx]	SCAQMD
MOB-11	Extended Exchange Program [VOC, NOx, CO]	SCAQMD
MOB-14	Emission Reductions from Incentive Programs [NOx, PM]	SCAQMD
ORLD-01	Advanced Clean Cars 2	CARB
ORLD-03	Further Deployment of Cleaner Technologies: On-Road Light Duty Vehicles*	CARB
ORHD-02	Low-NOx Engine Standard – California and Federal Action	CARB
ORHD-04	Advanced Clean Transit	CARB
ORHD-05	Last Mile Delivery	CARB
ORHD-09	Further Deployment of Cleaner Technologies: On-Road Heavy Duty Vehicles	CARB
ORFIS-01	More Stringent National Locomotive Emission Standards	U.S. EPA
ORFIS-02	Tier 4 Vessel Standards	U.S. EPA
ORFIS-04	At-Berth Regulation Amendments	CARB
ORFIS-05	Further Deployment of Cleaner Technology: Off-Road Federal and International Sources	CARB
OFFS-01	Zero Emission Off-Road Forklift Regulation Phase 1	CARB
OFFS-04	Zero Emission Airport Ground Support Equipment	CARB
OFFS-05	Small Off-Road Engines	CARB
OFFS-07	Low-Emission Diesel Requirement	CARB
OFFS-08	Further Deployment of Cleaner Technologies: Off-Road Equipment	CARB
CPP-01	Consumer Products Program	CARB
CAA §182(e)(5) Measures (to Replace Stationary Source Control Measures)		

*NOx and VOC emission reductions estimated for this measure are considered as co-benefits.

Alternative 3—CARB and SCAQMD Regulations Only

Alternative 3 is designed to implement those control strategies that are regulatory in nature only. These strategies are proposed by both SCAQMD and CARB for stationary, area, and mobile sources, and include some measures regulating federal sources. Consequently, the emission reductions projected to be generated by incentive-based control strategies would be classified as achievable under CAA §182(e)(5) measures to meet the NAAQS. For socioeconomic analysis purposes, it was assumed that the CAA §182(e)(5) measures under Alternative 3 would be similar in nature to the incentive-based control strategies proposed in the Final 2016 AQMP, except that no incentives would be provided. In other words, Alternative 3 would retain all proposed control strategies under the Final 2016 AQMP. However, all emission reductions quantified for each control measure would be achieved via rule-making only.

Table 7-2 presents the list of ozone control measures considered for Alternative 3, for which emission reductions were quantified.[4]

[4] See Footnote 3 for the treatment of contingency PM2.5 control measures.

TABLE 7-2: OZONE MEASURES CONSIDERED FOR SOCIOECONOMIC ASSESSMENT UNDER ALTERNATIVE 3

Measure	Title	Implementation Agency
BCM-10	Emission Reductions from Greenwaste Composting [VOC, NH3]	SCAQMD
CMB-03	Emission Reductions from Non-Refinery Flares [NOx,VOC]	SCAQMD
CMB-02	Emission Reductions from Replacement with Zero or Near-Zero NOx Appliances in Commercial and Residential Applications	SCAQMD
CMB-04	Emission Reductions from Restaurant Burners and Residential Cooking [NOx]	SCAQMD
CTS-01	Further Emission Reductions from Coatings, Solvents, Adhesives, and Sealants [VOC]	SCAQMD
ECC-02	Co-Benefits from Existing Residential and Commercial Building Energy Efficiency Measures [NOx,VOC]*	SCAQMD
ECC-03	Additional Enhancements in Reducing Existing Residential Building Energy Efficiency [NOx,VOC]	SCAQMD
CMB-01	Transition to Zero & Near-Zero Emission Technologies for Stationary Sources [All Pollutants]	SCAQMD
CMB-05	Further NOx Reductions from RECLAIM Assessment [NOx]	SCAQMD
FUG-01	Improved Leak Detection and Repair [VOC]	SCAQMD
MOB-10	Extension of the SOON Provision for Construction/Industrial Equipment [NOx]	SCAQMD
MOB-11	Extended Exchange Program [VOC, NOx, CO]	SCAQMD
MOB-14	Emission Reductions from Incentive Programs [NOx, PM]	SCAQMD
ORLD-01	Advanced Clean Cars 2	CARB
ORHD-02	Low-NOx Engine Standard – California and Federal Action	CARB
ORLD-03	Further Deployment of Cleaner Technologies: On-Road Light Duty Vehicles*	CARB
ORHD-04	Advanced Clean Transit	CARB
ORHD-05	Last Mile Delivery	CARB
ORHD-09	Further Deployment of Cleaner Technology: On-Road Heavy Duty Vehicles	CARB
ORFIS-01	More Stringent National Locomotive Emission Standards	U.S. EPA
ORFIS-02	Tier 4 Vessel Standards	U.S. EPA
ORFIS-04	At-Berth Regulation Amendments	CARB
ORFIS-05	Further Deployment of Cleaner Technology: Off-Road Federal and International Sources	CARB
OFFS-01	Zero Emission Off-Road Forklift Regulation Phase 1	CARB
OFFS-04	Zero Emission Airport Ground Support Equipment	CARB
OFFS-05	Small Off-Road Engines	CARB
OFFS-07	Low-Emission Diesel Requirement	CARB
OFFS-08	Further Deployment of Cleaner Technologies: Off-Road Equipment	CARB
CPP-01	Consumer Products Program	CARB

* NOx and/or VOC emission reductions estimated for these measures are considered as co-benefits.

Alternative 4—Expanded Incentive Funding

Alternative 4 would expand the incentive funding programs to accelerate the deployment of cleaner vehicles and technologies, potentially allowing for more emission reductions and possibly earlier attainment of NAAQS. Under this alternative, it was assumed that additional incentive funding sources would be found. For socioeconomic analysis purposes, it was further assumed that additional incentive funds would be available to achieve more NOx emission reductions under ECC-03 "Additional Enhancements in Reducing Existing Residential Building Energy Use" and OFFS-08 "Further Deployment of Cleaner Technologies: Off-road Equipment," and to further accelerate the deployment of facility-based clean technologies under CMB-01 "Transition to Zero and Near-Zero Emission Technologies for Stationary Sources."

The list of Alternative 4 control measures, for which emission reductions were quantified, are the same as those listed in Table 7-2. Additional emission reductions from ECC-03 were obtained by incentivizing more units of electric water heat pumps, electric dryers, and electric pool heat pumps to be purchased and installed. Additional emission reductions from OFFS-08 were obtained by incentivizing a greater volume of turnover for off-road diesel construction equipment and large spark ignition industrial, commercial, and lawn and garden equipment than those included in the Final 2016 AQMP. Accelerated emission reductions from CMB-01 were obtained by incentivizing more low-NOx Internal Combustion Engines to come online by 2023 instead of later years.

Incremental Cost and Related Job Impacts of CEQA Alternatives

Table 7-3 compares the incremental costs and job impacts between the Final 2016 AQMP and the four CEQA alternatives. The annualized total incremental cost of the Final 2016 AQMP was estimated to be $850 million per year between 2017 and 2031, which would result in an average of about 9,000 jobs foregone per year. As all CEQA alternatives, except the No Project Alternative, are required to be realistic and provide a viable path to attainment of NAAQS, thus achieving similar or greater public health benefits.

As discussed above, while under the No Project Alternative there will be no emission reduction-related incremental cost and job impacts, it should be recognized that there could be potential federal sanctions under CAA, which would prohibit the region from receiving federal highway funding for regional transportation investment, and inhibit new business growth through more stringent emission offset requirements. Depending on the region's ability to make up for this lack of funding from other sources, federal sanctions could produce varying impacts on the regional economy, which are not quantified in this analysis as explained above.

TABLE 7-3: AVERAGE ANNUAL INCREMENTAL COSTS AND THE ASSOCIATED JOB IMPACTS OF AQMP AND CEQA ALTERNATIVES, 2017-2031

Scenario	**Average Annual Incremental Costs** (Millions of 2015 Dollars)	**Average Annual Job Impacts Associated with Incremental Costs**	**Percent Change from the Baseline Job Forecast**
Final 2016 AQMP	$848	-9,299	-0.08%
Alt 1—No Project	Not Quantified	Not Quantified	Not Quantified
Alt 2—Mobile Source Emission Reduction Only	$983	-8,616	-0.08%
Alt 3—CARB and SCAQMD Regulation Only	$848	-8,282	-0.07%
Alt 4—Expanded Incentive Funding	$1,017	-14,071	-0.13%

Under Alternative 2—Mobile Source Emission Reduction Only, it was assumed that the stationary source control strategies would be replaced by the CAA §182(e)(5) measures. Under the aforementioned cost assumptions made for the CAA §182(e)(5) measures, Alternative 2 was estimated to be costlier than the Final 2016 AQMP, with an annualized total incremental cost of nearly $1.0 billion per year between 2017 and 2031. However, it should be noted that this result depends on the cost assumptions made for the mobile source CAA §182(e)(5) measure under this alternative. Relative to the baseline job forecast, this alternative would result in an average of about 8,600 jobs foregone per year over the same period, which is, despite the higher costs, a slightly lower number than the jobs foregone associated with the incremental costs of Final 2016 AQMP. This marginally lower job impact is mainly due to the distribution of costs among a different set of industry sectors in the regional economy.

Under Alternative 3—CARB and SCAQMD Regulation Only, it was assumed that all control strategies would remain the same as proposed in the Final 2016 AQMP, except that all emission reductions would be achieved by rule-making and no incentives would be provided. Therefore, all incremental costs were now assumed to be incurred directly by the affected industries and consumers. As a result of this assumption, Alternative 3 was estimated to have the same total incremental cost as the Final 2016 AQMP, annualized at $0.8 billion per year between 2017 and 2031. However, it would result in an average of about 1,000 fewer jobs foregone. This is mainly due to the shifting of incremental costs from the state government, who was assumed to provide all incentive funding under this scenario, to the affected industry sectors and consumers. As discussed earlier in Chapter 4, in the REMI model, the reallocation of public funds to the proposed clean air incentive programs would directly result in funds diverted from local spending and thus jobs foregone in many sectors of the regional economy. In comparison, when private industries and consumers incur the costs, they may reduce spending on other goods and services, some of which may be imported; consequently, the overall adverse effect of increased costs on the regional economy would be slightly dampened.

Under Alternative 4—Expanded Incentive Funding, it was assumed that all control strategies would remain the same as proposed in the Final 2016 AQMP, except that additional or accelerated emission reductions from control measures ECC-03, OFFS-08, and CMB-01 would be achieved with expanded incentive funding. As a result of this assumption, Alternative 4 was estimated to incur an average annual cost of slightly over $1 billion between 2017 and 2031, which is higher than the cost of Final 2016 AQMP. Under the assumption that all incentives would be funded by existing state revenue sources, the higher incentive amount assumed under this alternative would result in a greater negative job impact, or an average of about 14,000 jobs foregone annually relative to the baseline job forecast for the period 2017 to 2031. As discussed earlier, in the REMI model, the reallocation of public funds to the proposed clean air incentive programs would directly result in funds diverted from local spending and thus jobs foregone in many sectors of the regional economy. However, it should be noted that this alternative would also result in greater emission reductions which would likely increase the public health benefits compared to the Final 2016 AQMP.

Finally, it is worth emphasizing that the varying numbers of jobs foregone under Alternatives 2-4 would have minimal impacts on the long-term job growth. The annualized job growth rate between 2017 and 2031 (estimated to be 1.02 percent without the Final 2016 AQMP) would remain between 1.01 and 1.02 percent under all alternatives examined.

Chapter 8: Summary

Summary of Socioeconomic Analyses of the Final 2016 AQMP

The Final 2016 AQMP control strategy will seek emission reductions from stationary and mobile sources through command-and-control regulations and incentives to help accelerate the deployment of cleaner equipment for the purpose of achieving federal and state air quality standards. The total incremental cost of the Final 2016 AQMP was estimated to be $15.7 billion in present worth value (expressed in 2015 dollars) over the life of all equipment and fleets that are expected to be put into operation. Between 2017 and 2031, the amortized annual average incremental cost would be $848 million, which is less than one tenth of a percent (0.07 percent) of the $1.3 trillion worth of annual gross domestic output in the region.

About 60 percent or $9.3 billion of the total incremental cost is related to CARB mobile source control strategies affecting the Basin. About 36 percent or $5.7 billion is associated with SCAQMD control measures for stationary sources, and the remaining 4 percent or $0.6 billion represents SCAQMD's local mobile source measures. The proposed incentives, in the amount of $14.6 billion, would be distributed to eligible industries and consumers and offset more than 90 percent of the total incremental cost estimated for the Final 2016 AQMP.

Importantly, the region will also experience benefits from the implementation of the Final 2016 AQMP. Air pollution continues to be linked to increases in death rates (mortality) and increases in illness and other health effects (morbidity). It was estimated that, as a result of implementing the Final 2016 AQMP, an average of 1,600 premature deaths would be avoided per year. Numerous other non-fatal health conditions were also estimated to be avoided annually, including about 2,500 asthma-related emergency department visits, about 700 hospital admissions related to asthma, cardiovascular, or respiratory conditions, and more than 200,000 person-days of work and school absences. Due to these lowered mortality and morbidity risks, an estimated $173 billion worth of public health benefits are expected to accrue in the four-county region, cumulatively from 2017 to 2031. This represents an average of $16.5 billion in public health benefits per year. Over 95 percent of the estimated public health benefits are associated with avoided premature deaths from reduced long-term exposure to PM2.5. Although not quantified in this report, there exist additional public welfare benefits related to clean air from preventing damage to agriculture, ecology, visibility, buildings, and materials.

The incremental costs and public health benefits of the Final 2016 AQMP are expected to alter, to various degrees, the economic decisions made by households, businesses, and other economic actors. Some businesses would see production costs go up while other businesses would benefit from a greater demand for their services and technologies. For consumers who consider purchasing or replacing vehicles or certain household appliances, the proposed control strategies would also change or widen the range of product choices that differ in fuel types, energy efficiencies, effective unit prices, and thus potential payback periods. Improved public health would contribute to higher labor productivity and reduce healthcare-related expenditures, while also increasing the region's attractiveness to economic migrants. All these direct effects would then cascade through the regional economy and would produce indirect and induced macroeconomic impacts.

As a result of incremental costs and health benefits associated with the Final 2016 AQMP, the overall job impact on the four-county region of Los Angeles, Orange, Riverside, and San Bernardino is projected to range from 9,000 jobs foregone to 29,000 jobs gained per year from 2017 to 2031, relative to the baseline job forecast where the Final 2016 AQMP control strategies are not implemented. In an economy with nearly 18 million people and more than 10 million jobs, the projected changes in the total number of regional jobs are expected to have a minimal impact on the region's long-term job growth. The region's projected annualized job growth rate between 2016 and 2031 will remain at slightly above one percent (1.01 to 1.04 percent) under all Final 2016 AQMP scenarios examined with macroeconomic impact modeling.

Under the primary scenario (i.e., incentives funded by existing state revenue sources and full air-related public health benefits for regional amenity adjustments), the region is expected to gain an average of about 14,000 jobs per year from 2017 to 2031. The annualized job growth rate would increase slightly to 1.04 percent from the baseline rate of 1.02 percent between 2016 and 2031. In the beginning years, however, large amounts of incentives would directly result in funds diverted from local spending and thus jobs foregone in many sectors of the regional economy, among which state and local governments would be most adversely impacted, followed by construction, retail trade, and healthcare and social assistance sectors. Over time, as the proposed control strategies are implemented and public health benefits are realized, increased regional amenity is expected to attract more economic migrants and enlarge the pie of the regional economy, thereby creating more job opportunities in the four-county region.

It should be noted, however, there remains methodological uncertainties regarding macroeconomic modeling of non-market benefits and how clean air related amenities should be weighted relative to other regional amenities (Abt Associates 2014; Lahr 2016); therefore, the results should be regarded with caution. Nonetheless, it should also be noted that, even with the most conservative approach where public health benefits are considered as having no impacts on the regional economy, the projected 2017-2031 annual average job impacts associated with incremental cost only would represent one-tenth of a percent decrease from the forecasted baseline number of total jobs. The annualized job growth rate between 2016 and 2031 would slow down by less than 0.01 percentage point to 1.01 percent. Moreover, as shown in Chapter 4, this slightly negative impact could be potentially mitigated if incentive funding can be obtained from outside the region or state.

To provide stakeholders with more information about how the Final 2016 AQMP would potentially impact different sub-county communities within the region, sub-regional distributions for incremental costs, public health benefits, and net job impacts were also provided. The average annualized incremental costs between 2017 and 2031, if spread among the region's population, would range from approximately $21 million in Orange North, a sub-region of Orange County to $61 million in the San Fernando sub-region of Los Angeles County. The average annual public health benefits range from $122 million in Other San Bernardino, the northern sub-region of San Bernardino County, to $2.1 billion in the Central sub-region of Los Angeles County. Of the 14,000 jobs expected to be gained on average each year during the period of 2017-2031, The Central Los Angeles sub-region of Los Angeles County is expected to see the largest gain of jobs, with nearly 2,000 jobs being added on average each year to the baseline forecast levels, while the Riverside sub-region of Riverside Other will see about 40 jobs foregone on average each year during the same period.

In addition, the EJ analysis was significantly enhanced and expanded compared to previous AQMPs by investigating the distributional impact of the Final 2016 AQMP based on multiple alternative definitions of EJ communities. Specifically, staff examined whether estimated reductions in health risks associated with air pollution would reduce or exacerbate baseline inequality in the Basin. Inequality between EJ and non-EJ communities was also analyzed to identify any potential differences. First, as a result of implementing the Final 2016 AQMP, greater per-capita monetized public health benefits are anticipated to accrue in EJ communities than non-EJ communities. Next, in terms of the distribution of health risk related to air pollution exposure, inequality in mortality-related risk more likely to affect the elderly population was found to decrease overall, which is also true between the EJ and non-EJ communities. This finding is consistent for both mortality-related risk associated with long-term exposure to PM2.5 and short-term exposure to ozone. However, the inequality of morbidity risk for asthma-related ED visits among children that is associated with short-term exposure to ozone are expected to increase slightly between EJ and non-EJ communities, despite a decrease in overall inequality. These general results do not change based on the different EJ definitions analyzed.

Lastly, this report also examines the potential socioeconomic impacts of CEQA alternatives to the proposed 2016 AQMP. The Program Environmental Impact Report includes four alternatives: Alternative 1—No Project; Alternative 2—Mobile Source Emission Reductions Only; Alternative 3—CARB and SCAQMD Regulations Only; and Alternative 4—Expanded Incentive Funding. All the alternatives above, except the No Project Alternative, are required to be realistic and provide a viable path to attainment of NAAQS, thus achieving similar or greater public health benefits. Therefore, for Alternatives 2, 3, and 4, only incremental costs and the associated job impacts were analyzed and compared to the corresponding impacts of the proposed 2016 AQMP. For purposes of the socioeconomic assessment, Alternatives 2 and 3 were analyzed based on the assumption that they would lead to NAAQS attainment with CAA §182(e)(5) measures (i.e., "black box" measures). Alternative 4 assumes additional or accelerated emission reductions achievable by expanded incentive funding. Incremental costs of both Alternatives 2 and 3 are projected to result in fewer jobs foregone than the proposed 2016 AQMP; whereas, incremental costs for Alternative 4 are projected to result in more jobs foregone, mainly due to higher incentive amounts assumed to be provided by existing sources of state funds for local spending. Alternative 4 would result in more emission reductions, however, which would also likely increase public health benefits above the 2016 AQMP. Caution should be exercised, however, as the projected cost estimates and job impacts are highly dependent on the assumptions made for each alternative.

Enhancements Made to the 2016 AQMP Socioeconomic Assessment

As mentioned in Chapter 1, Abt Associates conducted a review in 2014 of the SCAQMD's practices for conducting socioeconomic assessments for previous AQMPs during rulemaking. The key purpose was to evaluate whether these practices represented state-of-the-art methods for these assessments, whether the scope of the analysis undertaken was adequate, and whether the documentation assured a transparent and balanced presentation to reflect interests from different parties. As a result of the 2014 review, a concerted effort among staff, sister agencies, and the public has been made to enhance the development and documentation of the 2016 AQMP Socioeconomic Report.

First and foremost, this report is designed to be accessible and transparent to the general public. The main document presents the general picture of socioeconomic impacts while clearly defining methodologies employed and data sources utilized. Careful consideration has been given to report not only overall impacts, but to also discuss uncertainty and provide a range of estimates through sensitivity analyses.[1]

[1] This includes sensitivity analyses for health benefits in Chapter 3, macroeconomic modeling of non-market benefits in Chapter 4, macroeconomic modeling of different incentive funding scenarios in Chapter 4, and EJ community definitions and distributional analysis in Chapter 6.

When quantification of uncertainty is not feasible, a qualitative discussion about uncertainty sources, the expected magnitude, and impact of uncertainty (i.e. negative or positive effect on results) has been added. In addition, the appendices provide technical readers with more detail about the analyses, while an executive summary geared towards a more general audience condenses the analyses and results. As each component of the 2016 Socioeconomic Report has been developed, it has been presented at various meetings to the STMPR Advisory Group, the AQMP Advisory Group, and the interested parties from the public to enhance transparency and solicit feedback. Staff also presented the preliminary outline of this report and described analysis methodologies at six AQMP scoping meetings in July 2016.

To implement Abt's recommendation to clearly define the baseline for socioeconomic analysis and clarify whether the baseline should include SCAG's TCMs, staff worked closely with SCAG staff and consultants from REMI and the Center for Continuing Study of the California Economy. Following many rounds of communication and discussions, consensus was reached that TCMs, along with other components of the 2016 RTP/SCS, should be considered as baseline for the AQMP socioeconomic assessment, and that, for informational purposes, the benefits and costs associated with TCMs would be provided separately in the 2016 AQMP Appendix IV-C: Regional Transportation Plan/ Sustainable Communities Strategy and Transportation Control Measures. This baseline definition is also consistent with the AQMP baseline inventory of air pollutant emissions, which considers any emission reductions associated with SCAG's 2016 RTP/SCS and all its sub-components (TCMs included) as accounted for in the baseline. Additionally, as in the past, the default baseline forecasts of population and jobs in the REMI model were adjusted in accordance with the population and job projections from SCAG's 2016 Growth Forecast, which was also largely used to project future baseline emissions of air pollutants.[2]

In order to improve the public health benefits analysis conducted in the socioeconomic assessment, SCAQMD commissioned IEc to conduct an updated literature review of epidemiological studies to quantify concentration-response functions, which quantitatively describe the relationship between exposure to air pollution and various health endpoints, and economic valuation functions, which are used to monetize quantified public health benefits. Based on the review of literature, IEc provided staff with recommendations on which health endpoints to include in the public health benefits analysis of the Final 2016 AQMP and which mathematical functions should be used to evaluate and quantify benefits. IEc also provided recommendations on the use of the U.S. EPA's BenMAP tool, including choices of data input, assumptions and procedures that were appropriate for the functions used in the analysis. IEc recommendations and the analysis results were presented during each step of the process to the STMPR Advisory Group for review and guidance. In addition to IEc recommendations, the BenMAP operations were further reviewed and confirmed as appropriate by Dr. Jin Huang, a former project manager for the 2014 Abt review and the STMPR expert on BenMAP analysis.

IEc also reviewed the most updated literature of environmental justice studies and analytical tools. Based on the review, IEc recommended alternative EJ screening definitions and the most appropriate screening tools that have been developed to help identify EJ communities for socioeconomic assessment purposes. Additionally, IEc also recommended the state-of-science methodology to analyze the impacts of the proposed 2016 AQMP on health risk distributions between and within EJ and non-EJ communities. To engage the community and develop the most applicable approach in the region, the 2016 AQMP Socioeconomic Assessment Environmental Justice Working Group.

[2] See Appendix 4-A for more discussion.

was formed to review and provide comments and suggestions on IEc's recommendations and staff's analysis results. The Working Group's feedback helped inform and enhance the EJ analyses in this report.

Finally, SCAQMD commissioned a third-party evaluation by Dr. Michael Lahr on REMI's modeling of non-market benefits and Abt's further recommendation to evaluate how to improve the input of these benefits into REMI. REMI models non-market benefits as an improvement to regional amenities, or quality of life; however, the 2014 Abt Report indicated that there remained methodological uncertainties as to how these benefits could be best incorporated into macroeconomic modeling and asked staff to keep abreast of developments at the U.S. EPA's Science Advisory Board Panel on Economy-Wide Modeling. While it is generally recognized that location-specific amenities such as climate, clean air, public safety, and other public service provisions, make a region more attractive to economic migrants, the 2014 Abt report also indicated that prospective economic migrants may consider air quality differently than other types of amenities when making their location choices; however, such differences, if any, were not taken into account under the prior modeling approach. As such, Abt recommended identifying methods to properly normalize the magnitude of adjustments made to the sub-region specific amenity coefficients in REMI's migration equation, which links air quality change with the relative attractiveness of one area compared to another. Based on the qualitative conclusion made in the third-party evaluation, SCAQMD staff conducted a sensitivity analysis of job impacts where the REMI input related to the non-market portion of public health benefits was discounted by half, therefore significantly lessening the magnitude of adjustments to the amenity coefficients in REMI. Staff preliminarily concluded that this adjustment is a major determinant to the non-market benefits related job impact; however, further research is needed to determine the proper scaling of the related REMI input.

Future Enhancements for Future AQMPs

SCAQMD staff will continue working to update the technical aspects of its analyses which includes updating methodologies to quantify visibility, material, and agricultural benefits, developing methods to properly normalize the magnitude of adjustment to the amenity coefficient in REMI, evaluating the use of other modeling tools such as partial equilibrium modeling to supplement REMI for small scale impacts, updating best practices for estimating small business impacts, and closely monitoring the U.S. EPA Science Advisory Board's Economy-Wide Modeling Panel discussions and recommendations, particularly on the macroeconomic modeling of non-market benefits. Retrospective studies, when feasible, will be considered as part of the implementation plan to enhance the uncertainty analysis.

REFERENCES

Abt Associates. 2014. “Review of the SCAQMD Socioeconomic Assesment.” Bethesda, MD: Abt Associates Inc.

Bell, Michelle L., Francesca Dominici, and Jonathan M. Samet. 2005a. “A Meta-Analysis of Time-Series Studies of Ozone and Mortality With Comparison to the National Morbidity, Mortality, and Air Pollution Study.” *Epidemiology* 16 (4): 436–45.

———. 2005b. “A Meta-Analysis of Time-Series Studies of Ozone and Mortality With Comparison to the National Morbidity, Mortality, and Air Pollution Study.” *Epidemiology (Cambridge, Mass.)* 16 (4): 436–45.

Beron, Kurt, James Murdoch, and Mark Thayer. 2001. “The Benefits of Visibility Improvement: New Evidence from the Los Angeles Metropolitan Area.” *The Journal of Real Estate Finance and Economics* 22 (2-3): 319–37. doi:10.1023/A:1007860017867.

Brandt, Sylvia, Felipe Vásquez Lavín, and Michael Hanemann. 2012. “Contingent Valuation Scenarios for Chronic Illnesses: The Case of Childhood Asthma.” *Value in Health* 15 (8): 1077–83. doi:10.1016/j.jval.2012.07.006.

CARB. 1987. “Effects of Ozone on Vegetation and Possible Alternative Ambient Air Quality Standards.” Sacramento, CA: California Air Resources Board (CARB).

———. 2010. “Estimate of Premature Deaths Associated with Fine Particle Pollution (PM2.5) in California Using a U.S. Environmental Protection Agency Methodology.” Sacramento, CA: California Air Resources Board (CARB).

———. 2015. “Draft Vision 2.0 Modeling System General Model Documentation.” Sacramento, CA: California Air Resources Board (CARB).

———. 2016a. “Mobile Source Strategy. Appendix A: Economic Impact Analysis.” Sacramento, CA: California Air Resources Board (CARB). https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc_appA.pdf

———. 2016b. “Proposed 2016 State Strategy for the State Implementation Plan. Appendix A: Economic Analysis.” Sacramento, CA: California Air Resources Board (CARB). https://www.arb.ca.gov/planning/sip/2016sip/2016statesip_econ.pdf

CDFA. 2015. “California Agricultural Statistics Review, 2014-2015.” Sacramento, CA: California Department of Food and Agriculture.

Chestnut, Lauraine G., Mark A. Thayer, Jeffrey K. Lazo, and Stephen K. Van Den Eeden. 2006. “The Economic Value of Preventing Respiratory and Cardiovascular Hospitalizations.” *Contemporary Economic Policy* 24 (1): 127–43. doi:10.1093/cep/byj007.

Council on Environmental Quality. 1997. “Environmental Justice: Guidance Under the National Environmental Policy Act.” Washington, D.C.: Executive Office of the President. https://www.epa.gov/sites/production/files/2015-02/documents/ej_guidance_nepa_ceq1297.pdf.

Cowell, F. A. 2011. *Measuring Inequality*. LSE Perspecitves in Economic Analysis. Oxford: Oxford University Press.

Cropper, Maureen L., and Alan J. Krupnick. 1990. *Social Costs of Chronic Heart and Lung Disease*. Quality of the Environment Division, Resources for the Future.

Cummings, R., H. Burness, and R. Norton. 1985. "Measuring Household Soiling Damages from Suspended Air Particulates: A Methodology Inquiry." Volume V of Methods Development for Environmental Control Benefits Assessment. Washington, D.C.: U.S. Environmental Protection Agency.

Curtis, E. Mark. 2014. "Who Loses Under Power Plant Cap-and-Trade Programs?" Working Paper 20808. National Bureau of Economic Research. http://www.nber.org/papers/w20808.

Delfino, Ralph J., Jun Wu, Thomas Tjoa, Sevan K. Gullesserian, Bruce Nickerson, and Daniel L. Gillen. 2014. "Asthma Morbidity and Ambient Air Pollution: Effect Modification by Residential Traffic-Related Air Pollution." *Epidemiology (Cambridge, Mass.)* 25 (1): 48–57. doi:10.1097/EDE.0000000000000016.

Dickie, Mark, and Bryan Hubbell. 2004. "Family Resource Allocation and the Distribution of Health Benefits of Air Pollution Control." *Association of Environmental and Resource Economists Workshop, Distributional Effects of Environmental Policy.*

Dockery, D W, J Cunningham, A I Damokosh, L M Neas, J D Spengler, P Koutrakis, J H Ware, M Raizenne, and F E Speizer. 1996. "Health Effects of Acid Aerosols on North American Children: Respiratory Symptoms." *Environmental Health Perspectives* 104 (5): 500–505.

Environmental Audit Inc., and Jeff Inabinet. 2016. "Draft Program Environmental Impact Report." Diamond Bar, CA: South Coast Air Quality Management District.

Fann, Neal, Henry A. Roman, Charles M. Fulcher, Mikael A. Gentile, Bryan J. Hubbell, Karen Wesson, and Jonathan I. Levy. 2011. "Maximizing Health Benefits and Minimizing Inequality: Incorporating Local-Scale Data in the Design and Evaluation of Air Quality Policies." *Risk Analysis* 31 (6): 908–22.

Greenstone, Michael. 2002. "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures." *Journal of Political Economy* 110 (6): 1175–1219. doi:10.1086/342808.

Harper, Sam, and John Lynch. 2016. "Health Inequalities: Measurement and Decomposition." In *Methods in Social Epidemiology*, 2nd ed. San Francisco, USA: Jossey-Bass.

Industrial Economics. 2016. "Exploring Alternate Definitions of Environmental Justice and Inequality Indicators for SCAQMD's 2016 Socioeconomic Report." Presentation presented at the May 25, 2016 STMPR Meeting. http://www.aqmd.gov/docs/default-source/Agendas/STMPR-Advisory-Group/may-2016/socio/3a_iec_explalts.pdf?sfvrsn=2.

Industrial Economics, Jonathan Levy, and Sam Harper. 2016. "Defining Environmental Justice Communities and Distributional Analysis for Socioeconomic Analysis of 2016 SCAQMD Air Quality Management Plan." Industrial Economics, Inc. http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/scaqmdfinalejreport_113016.pdf

Industrial Economics, and Lisa Robinson. 2016a. "Review of Mortality Risk Reduction Valuation Estimates for 2016 Socioeconomic Assessment." Memorandum. Massachusetts, MA: Industrial Economics, Inc. http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/iecmemos_november2016/scmortalityvaluation_112816.pdf

Industrial Economics, and Lisa A. Robinson. 2016b. "Review of Morbidity Valuation Estimates for Use in 2016 Socioeconomic Assessment." Cambridge, MA: Industrial Economics, Inc. http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/iecmemos_november2016/scmorbidityvaluation_112816.pdf

Industrial Economics, and George Thurston. 2016a. "Literature Review of Air Pollution-Related Health Endpoints and Concentration-Response Functions for Particulate Matter: Results and Recommendations." Memorandum. Massachusetts, MA: Industrial Economics, Inc. http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/iec_pmlitreview_092916.pdf

———. 2016b. "Literature Review of Air Pollution-Related Health Endpoints and Concentration-Response Functions for Ozone, Nitrogen Dioxide, and Sulfur Dioxide: Results and Recommendations." Memorandum. Cambridge, MA: Industrial Economics, Inc. http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/iec_gasplitreview_092916.pdf

Isen, Adam, Maya Rossin-Slater, and W. Reed Walker. Forthcoming. "Every Breath You Take – Every Dollar You'll Make: The Long-Term Consequences of the Clean Air Act of 1970." *Journal of Political Economy*

Jenkins, Stephen P. 2015. *INEQDECO: Stata Module to Calculate Inequality Indices with Decomposition by Subgroup*. Statistical Software Components. Boston College Department of Economics. https://ideas.repec.org/c/boc/bocode/s366002.html.

Jerrett, Michael, Richard T. Burnett, Bernardo S. Beckerman, Michelle C. Turner, Daniel Krewski, George Thurston, Randall V. Martin, et al. 2013. "Spatial Analysis of Air Pollution and Mortality in California." *American Journal of Respiratory and Critical Care Medicine* 188 (5): 593–99. doi:10.1164/rccm.201303-0609OC.

Jerrett, Michael, Richard T. Burnett, Renjun Ma, C. Arden Pope, Daniel Krewski, K. Bruce Newbold, George Thurston, et al. 2005. "Spatial Analysis of Air Pollution and Mortality in Los Angeles." *Epidemiology (Cambridge, Mass.)* 16 (6): 727–36.

Jones, Chuck. 2013. "Ecommerce Is Growing Nicely While Mcommerce Is on a Tear." *Forbes*, October 2.

Katsouyanni, Klea, Jonathan M. Samet, H. Ross Anderson, Richard Atkinson, Alain Le Tertre, Sylvia Medina, Evangelia Samoli, et al. 2009. "Air Pollution and Health: A European and North American Approach (APHENA)." *Research Report (Health Effects Institute)*, no. 142 (October): 5–90.

Krewski, Daniel, Michael Jerrett, Richard T. Burnett, Renjun Ma, Edward Hughes, Yuanli Shi, Michelle C. Turner, et al. 2009. "Extended Follow-up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality." *Research Report (Health Effects Institute)*, no. 140 (May): 5–114; discussion 115–36.

Lahr, Michael L. 2016. "Assessing Abt's Evaluation of REMI's Model for Measuring Impacts of QOL Changes." http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/lahr_evalmacroeconimpacts_041716.pdf?sfvrsn=2.

Larsen, Ralph I., and Walter W. Heck. 1976. "An Air Quality Data Analysis System for Interrelating Effects, Standards, and Needed Source Reductions: Part 3. Vegetation Injury." *Journal of the Air Pollution Control Association* 26 (4): 325–33. doi:10.1080/00022470.1976.10470257.

Lee, Won Chan, Michael C. Christensen, Ashish V. Joshi, and Chris L. Pashos. 2007. "Long-Term Cost of Stroke Subtypes among Medicare Beneficiaries." *Cerebrovascular Diseases (Basel, Switzerland)* 23 (1): 57–65. doi:10.1159/000096542.

Lepeule, Johanna, Francine Laden, Douglas Dockery, and Joel Schwartz. 2012. "Chronic Exposure to Fine Particles and Mortality: An Extended Follow-up of the Harvard Six Cities Study from 1974 to 2009." *Environmental Health Perspectives* 120 (7): 965–70. doi:10.1289/ehp.1104660.

Levy, Jonathan I., Susan L. Greco, Steven J. Melly, and Neha Mukhi. 2009. "Evaluating Efficiency-Equality Tradeoffs for Mobile Source Control Strategies in an Urban Area." *Risk Analysis : An Official Publication of the Society for Risk Analysis* 29 (1): 34–47. doi:10.1111/j.1539-6924.2008.01119.x.

Levy, Steve. 1994. "Comparison of REMI and SCAG Forecasts and Methodology." Palo Alto, CA: Center for Continuing Study of the California Economy.

Lieu, Sue, Shah Dabirian, and Greg Hunter. 2012. "Final Socioeconomic Report for the Final 2012 Air Quality Management Plan." Diamond Bar, CA: South Coast Air Quality Management District.

Lieu, Sue, Shah Dabirian, and Patricia Kwon. 2007. "Final Socioeconomic Report for the 2007 Air Quality Management Plan." Diamond Bar, CA: South Coast Air Quality Management District.

Maguire, Kelly, and Glenn Sheriff. 2011. "Comparing Distributions of Environmental Outcomes for Regulatory Environmental Justice Analysis." *International Journal of Environmental Research and Public Health* 8 (5): 1707–26.

Mar, Therese F., and Jane Q. Koenig. 2009. "Relationship between Visits to Emergency Departments for Asthma and Ozone Exposure in Greater Seattle, Washington." *Annals of Allergy, Asthma & Immunology* 103 (6): 474–79. doi:10.1016/S1081-1206(10)60263-3.

Mar, Therese F., Timothy V. Larson, Robert A. Stier, Candis Claiborn, and Jane Q. Koenig. 2004. "An Analysis of the Association Between Respiratory Symptoms in Subjects with Asthma and Daily Air Pollution in Spokane, Washington." *Inhalation Toxicology* 16 (13): 809–15. doi:10.1080/08958370490506646.

McConnell, Rob, Talat Islam, Ketan Shankardass, Michael Jerrett, Fred Lurmann, Frank Gilliland, Jim Gauderman, et al. 2010. "Childhood Incident Asthma and Traffic-Related Air Pollution at Home and School." *Environmental Health Perspectives* 118 (7): 1021–26. doi:10.1289/ehp.0901232.

Meng, Ying-Ying, Nadereh Pourat, Robert Cosway, and Gerald F. Kominski. 2010. "Estimated Cost Impacts of Law to Expand Coverage for Self-Management Education to Children With Asthma in California." *Journal of Asthma* 47 (5): 581–86. doi:10.3109/02770901003753314.

Moolgavkar, Suresh H. 2000. "Air Pollution and Hospital Admissions for Diseases of the Circulatory System in Three U.S. Metropolitan Areas." *Journal of the Air & Waste Management Association* 50 (7): 1199–1206. doi:10.1080/10473289.2000.10464162.

Morgenstern, Richard D., William A. Pizer, and Jhih-Shyang Shih. 2002. "Jobs Versus the Environment: An Industry-Level Perspective." *Journal of Environmental Economics and Management* 43 (3): 412–36. doi:10.1006/jeem.2001.1191.

Murray, D. R., M. A. Atwater, and J. Yocom. 1985. "Assessment of Material Damage and Soiling from Air Pollution in the South Coast Air Basin." Sacramento, CA: California Air Resources Board.

OEHHA. 2014. "California Communities Environmental Health Screening Tool, Version 2.0 (CalEnviroScreen 2.0)." Sacramento, CA: Office of Environmental Health Hazard Assessment (OEHHA). http://oehha.ca.gov/media/CES20FinalReportUpdateOct2014.pdf.

Olszyk, D. M., and C. R. Thompson. 1989. "Crop Loss from Air Pollutants Assessment Program: Status Report to the California Air Resources Board." Sacramento, CA: California Air Resources Board (CARB).

Oshima, R. J., M. P. Poe, P. K. Braegelmann, D. W. Baldwin, and V. Van Way. 1976. "Ozone Dosage-Crop Loss Function for Alfalfa: A Standardized Method for Assessing Crop Losses from Air Pollutants." *Journal of the Air Pollution Control Association* 26 (9): 861–65. doi:10.1080/00022470.1976.10470330.

Ostro, Bart D. 1987. "Air Pollution and Morbidity Revisited: A Specification Test." *Journal of Environmental Economics and Management* 14 (1): 87–98. doi:10.1016/0095-0696(87)90008-8.

Ostro, Bart D., and Susy Rothschild. 1989. "Air Pollution and Acute Respiratory Morbidity: An Observational Study of Multiple Pollutants." *Environmental Research* 50 (2): 238–47. doi:10.1016/S0013-9351(89)80004-0.

Ostro, B., M. Lipsett, J. Mann, H. Braxton-Owens, and M. White. 2001. "Air Pollution and Exacerbation of Asthma in African-American Children in Los Angeles." *Epidemiology (Cambridge, Mass.)* 12 (2): 200–208.

Polenske, Karen, Kelly Robinson, Yu Hung Hong, Lin Xiannuan, Judith Moore, and Bruce Stedman. 1992. "Evaluation of the South Coast Air Quality Management District's Methods for Assessing Socioeconomic Impacts of District Rules and Regulations." Cambridge, Massachusetts: Dept. of Urban Studies and Planning, Massachusetts Institute of Technology.

Pope, C. Arden, Michelle C. Turner, Richard T. Burnett, Michael Jerrett, Susan M. Gapstur, W. Ryan Diver, Daniel Krewski, and Robert D. Brook. 2015. "Relationships Between Fine Particulate Air Pollution, Cardiometabolic Disorders, and Cardiovascular Mortality." *Circulation Research* 116 (1): 108–15. doi:10.1161/CIRCRESAHA.116.305060.

Randall, M., and S. Soret. 1998. "Statewide Potential Crop Yield Losses from Ozone Exposure." Sacramento, CA: California Air Resources Board (CARB).

REMI. 2015a. "Data Sources and Estimation Procedures. PI+ v1.7." Amherst, MA: Regional Economic Models, Inc.

———. 2015b. "Demographic Component of the REMI Model." Amherst, MA: Regional Economic Models, Inc.

———. 2015c. "PI+ v1.7 Model Equations." Amherst, MA: Regional Economic Models, Inc. http://www.remi.com/download/documentation/pi+/pi+_version_1.7/PI+_v1.7_Model_Equations.pdf.

Robinson, Lisa A., and James K. Hammitt. 2016a. "Valuing Reductions in Fatal Illness Risks: Implications of Recent Research." *Health Economics* 25 (8): 1039–52.

———. 2016b. "Valuing Reductions in Fatal Illness Risks: Implications of Recent Research." *Health Economics* 25 (8): 1039–52. doi:10.1002/hec.3214.

RTI International. 2015a. "Environmental Benefits Mapping and Analysis Program – Community Edition, User Manual."

———. 2015b. "Environmental Benefits Mapping and Analysis Program – Community Edition, User Manual - Appendices."

Ruhm, Christopher J. 2000. "Are Recessions Good for Your Health?" *The Quarterly Journal of Economics* 115 (2): 617–50. doi:10.1162/003355300554872.

Russell, Mason W, Daniel M Hus, Shelley Drowns, Elizabeth C Hamel, and Stuart C Hartz. 1998. "Direct Medical Costs of Coronary Artery Disease in the United States 1." *The American Journal of Cardiology* 81 (9): 1110–15. doi:10.1016/S0002-9149(98)00136-2.

SCAG. 2016. "The 2016-2040 Regional Transportation Plan/Sustainable Communities Plan. Demographics & Growth Forecast Final Draft." Los Angeles, CA: Southern California Association of Governments. http://scagrtpscs.net/Documents/2016/final/f2016RTPSCS_DemographicsGrowthForecast.pdf

SCAQMD. 1989. "Appendix IV-D: Discount Cash Flow Method as Applied to the Cost Analysis of Control Measures." Final Air Quality Management Plan: 1989. Diamond Bar, CA: South Coast Air Quality Management District.

———. 2008. "Staff Report for Proposed Rule 1147 – NOx Reductions from Miscellaneous Sources." Diamond Bar, CA: South Coast Air Quality Management District.

———. 2015. "Multiple Air Toxics Exposure Study in the South Coast Air Basin (Final Report)." Diamond Bar, CA: South Coast Air Quality Management District.

Schwartz, J., and L. M. Neas. 2000. "Fine Particles Are More Strongly Associated than Coarse Particles with Acute Respiratory Health Effects in Schoolchildren." *Epidemiology (Cambridge, Mass.)* 11 (1): 6–10.

Sheriff, Glenn, and Kelly Maguire. 2013. "Ranking Distributions of Outcomes Across Population Groups." 13-04. Working Paper Series. Washington, D.C.: National Center for Environmental Economics. U.S. EPA.

Shin, Hwashin H., Neal Fann, Richard T. Burnett, Aaron Cohen, and Bryan J. Hubbell. 2014. "Outdoor Fine Particles and Nonfatal Strokes: Systematic Review and Meta-Analysis." *Epidemiology (Cambridge, Mass.)* 25 (6): 835–42. doi:10.1097/EDE.0000000000000162.

Smith, David H., Daniel C. Malone, Kenneth A. Lawson, Lynn J. Okamoto, Carmelina Battista, and William B. Saunders. 1997. "A National Estimate of the Economic Costs of Asthma." *American Journal of Respiratory and Critical Care Medicine* 156 (3): 787–93. doi:10.1164/ajrccm.156.3.9611072.

Smith, V. Kerry, and Laura L. Osborne. 1996. "Do Contingent Valuation Estimates Pass a 'Scope' Test? A Meta-Analysis." *Journal of Environmental Economics and Management* 31 (3): 287–301. doi:10.1006/jeem.1996.0045.

Stanford, Richard, Trent McLaughlin, and Lynn J. Okamoto. 1999. "The Cost of Asthma in the Emergency Department and Hospital." *American Journal of Respiratory and Critical Care Medicine* 160 (1): 211–15. doi:10.1164/ajrccm.160.1.9811040.

Stevens, Ann H., Douglas L. Miller, Marianne E. Page, and Mateusz Filipski. 2015. "The Best of Times, the Worst of Times: Understanding Pro-Cyclical Mortality." *American Economic Journal: Economic Policy* 7 (4): 279–311. doi:10.1257/pol.20130057.

Sullivan, Daniel, and Till von Wachter. 2009. "Job Displacement and Mortality: An Analysis Using Administrative Data*." *The Quarterly Journal of Economics* 124 (3): 1265–1306.

Sullivan, Jeffrey, Lianne Sheppard, Astrid Schreuder, Naomi Ishikawa, David Siscovick, and Joel Kaufman. 2005. "Relation between Short-Term Fine-Particulate Matter Exposure and Onset of Myocardial Infarction." *Epidemiology (Cambridge, Mass.)* 16 (1): 41–48.

Tekin, Erdal. 2015. "Unemployment and Health." Final Report Submitted to SCAQMD. Diamond Bar, CA: South Coast Air Quality Management District. http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/unemploymentandhealth_dec2015_012616.pdf.

Thurston, George D., Jiyoung Ahn, Kevin R. Cromar, Yongzhao Shao, Harmony R. Reynolds, Michael Jerrett, Chris C. Lim, Ryan Shanley, Yikyung Park, and Richard B. Hayes. 2016. "Ambient Particulate Matter Air Pollution Exposure and Mortality in the NIH-AARP Diet and Health Cohort." *Environmental Health Perspectives* 124 (4): 484–90. doi:10.1289/ehp.1509676.

U.S. DOE, EIA. 2015. "Annual Energy Outlook 2015." Washington, D.C.: U.S. Department of Energy. Energy Information Administration.

U.S. EPA. 2002. "EPA Air Pollution Control Cost Manual." Sixth Edition. Research Triangle Park, NC: U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards.

———. 2009. "2009 Final Report: Integrated Science Assessment for Particulate Matter." Reports & Assessments EPA/600/R-08/139F. U.S. EPA, Washington, DC. https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=216546.

———. 2010. "Guidelines for Preparing Economic Analyses." Washington, D.C.: U.S. Environmental Protection Agency, National Center for Environmental Economics.

———. 2011. "The Benefits and Costs of the Clean Air Act Fron 1990 to 2020." Washington, D.C.: U.S. Environmental Protection Agency.

———. 2012. "Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter." EPA-452/R-12-005. Washington, D.C.: U.S. Environmental Protection Agency.

———. 2013. "Integrated Science Assessment of Ozone and Related Photochemical Oxidants." EPA/600/R-10/076F. Washington, DC: U.S. Environmental Protection Agency.

———. 2015a. "Public Meeting of the Science Advisory Board Economy-Wide Modeling Panel." Washington, D.C.: U.S. Environmental Protection Agency. https://yosemite.epa.gov/sab/sabproduct.nsf/a84bfee16cc358ad85256ccd006b0b4b/165F936E2001C2C485257DFD00602CFB/$File/Minutes+7-15-15-pw.pdf

———. 2015b. "Regulatory Impact Analysis of the Final Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone." EPA-452/R-15-007. Washington, D.C.: U.S. Environmental Protection Agency.

———. 2016. "Guidelines for Preparing Economic Analyses." Washington, D.C.: U.S. Environmental Protection Agency.

van Kooten, G. Cornelis, Alison J. Eagle, James Manley, and Tara Smolak. 2004. “How Costly Are Carbon Offsets? A Meta-Analysis of Carbon Forest Sinks.” *Environmental Science & Policy* 7 (4): 239–51. doi:10.1016/j.envsci.2004.05.006.

Viscusi, W. Kip. 2015. “The Role of Publication Selection Bias in Estimates of the Value of a Statistical Life.” *American Journal of Health Economics* 1 (1): 27–52. doi:10.1162/AJHE_a_00002.

Wittels, Ellison H., Joel W. Hay, and Antonio M. Gotto. 1990. “Medical Costs of Coronary Artery Disease in the United States.” *The American Journal of Cardiology* 65 (7): 432–40. doi:10.1016/0002-9149(90)90806-C.

Young, Michael T., Dale P. Sandler, Lisa A. DeRoo, Sverre Vedal, Joel D. Kaufman, and Stephanie J. London. 2014. “Ambient Air Pollution Exposure and Incident Adult Asthma in a Nationwide Cohort of U.S. Women.” *American Journal of Respiratory and Critical Care Medicine* 190 (8): 914–21. doi:10.1164/rccm.201403-0525OC.

Zanobetti, Antonella, Meredith Franklin, Petros Koutrakis, and Joel Schwartz. 2009. “Fine Particulate Air Pollution and Its Components in Association with Cause-Specific Emergency Admissions.” *Environmental Health* 8: 58. doi:10.1186/1476-069X-8-58.

Zanobetti, Antonella, and Joel Schwartz. 2006. “Air Pollution and Emergency Admissions in Boston, MA.” *Journal of Epidemiology and Community Health* 60 (10): 890–95. doi:10.1136/jech.2005.039834.