MATES V

Multiple Air Toxics Exposure Study in the South Coast AQMD

FINAL REPORT
AUGUST 2021

South Coast
AQMD

**SOUTH COAST AIR QUALITY
MANAGEMENT DISTRICT**
12865 Copley Drive, Diamond Bar, CA 91765-4178
www.aqmd.gov • 1-800-CUT-SMOG

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South Coast Air Quality Management District
21865 Copley Drive
Diamond Bar, CA 91765

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AUTHORS AND CONTRIBUTORS

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Assistant Deputy Executive Officer
Science and Technology Advancement
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Assistant Deputy Executive Officer
Science and Technology Advancement
Aaron Katzenstein, PhD

AUTHORS

Faraz Ahangar, PhD	Air Quality Specialist
Mark Bassett, PhD	Air Quality Specialist
Rene Bermudez	Atmospheric Measurements Manager
Raul Dominguez, PhD	Senior Air Quality Chemist
Kevin Durkee	Quality Assurance Manager
Scott Epstein, PhD	Program Supervisor
Kyrstin Fornace, PhD	Air Quality Specialist
Sina Hasheminassab, PhD	Air Quality Specialist
Avi Lavi, PhD	Air Quality Specialist
Sang-Mi Lee, PhD	Program Supervisor
Christopher Lim, PhD	Air Quality Specialist
Melissa Maestas, PhD	Air Quality Specialist
Payam Pakbin, PhD	Program Supervisor
Andrea Polidori, PhD	Atmospheric Measurements Manager
Nico Schulte, PhD	Air Quality Specialist
Melissa Sheffer	Senior Meteorologist (until March 2021)

Mohammad Sowlat, PhD	Air Quality Specialist
Na Mon Trinh	Senior Air Quality Chemist
Sumner Wilson	Monitoring Operations Manager
Xinqiu Zhang, PhD	Air Quality Specialist

CONTRIBUTORS

Ethan Balagopalan	Air Quality Instrument Specialist II
Fabian Batista, PhD	Air Quality Chemist
Steven Boddeker	Air Quality Specialist
Catherine Buhl	Air Quality Chemist
Stephen Dutz	Principal Air Quality Chemist
Michelle Fairhurst, PhD	Air Quality Chemist
Henry Guan	Laboratory Technician
Eric Holden	Senior Air Quality Instrument Specialist
Justin Howell	Air Quality Instrument Specialist II
Judy Hwa	Air Quality Chemist
Bill Grant	Senior Air Quality Instrument Specialist
Amanda James	Air Quality Instrument Specialist II
Kayla Jordan	Assistant Air Quality Specialist
Mike Koch	Senior Air Quality Instrument Specialist
Jeffrey Komrosky	Air Quality Chemist
Xiang Li, PhD	Air Quality Specialist
Freyja Lopez	Senior Air Quality Chemist
Matthew Louie	Air Quality Chemist
Saagar Patel	Air Quality Chemist
Richard Poon	Air Quality Instrument Specialist II
Richard Rodgers	Air Quality Instrument Specialist II
James Rothschild	Air Quality Instrument Specialist II
Ken Sanchez	Senior Air Quality Chemist
Laura Saucedo	Principal Air Quality Chemist
Joe Skrzat	Temporary Air Quality Instrument Specialist I
Vipul Solanki	Air Quality Chemist
Yang Song, PhD	Air Quality Chemist
Vanessa Vergara	Laboratory Technician
Michael Walls	Temporary Air Quality Instrument Specialist I
Paul Williamson	Air Quality Chemist
Robert Wimmer	Senior Air Quality Instrument Specialist
Robert Yi	Senior Air Quality Chemist
Hang Zhang, PhD	Senior Air Quality Chemist

REVIEWERS

William Wong	Principal Deputy District Counsel

PRODUCTION

Sally Egan	Graphic Arts Illustrator II
Jennifer Nordbak	Administrative Secretary

MATES V Technical Advisory Group Roster

MEMBER NAME	AFFILIATION
Michael Benjamin	California Air Resources Board
Judy C. Chow, ScD	Desert Research Institute
Maria Costantini, PhD	Health Effects Institute
Kenneth Davidson, MEM, BA	U.S. Environmental Protection Agency
Rob Farber, PhD	Consultant
Dennis Fitz, MS	University of California, Riverside
Ramine Cromartie	Western States Petroleum Association
Scott Fruin, DEnv	University of Southern California
Scott Herndon	Aerodyne Research, Inc.
Uduak-Joe Ntuk	California Geologic Energy Management Division
Michael Kleinman, PhD	University of California, Irvine
Robert Krieger	California Air Resources Board
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Julia May	Communities for a Better Environment
Eduardo (Jay) Olaguer	Houston Area Research Council
John D. Budroe, PhD	Office of Environmental Health Hazard Assessment
Constantinos Sioutas, ScD	University of Southern California
Jochen Stutz	University of California, Los Angeles
Yifang Zhu, PhD	University of California, Los Angeles

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EXECUTIVE SUMMARY

Executive Summary

The Multiple Air Toxics Exposure Study V (MATES V) is a monitoring and evaluation study conducted in the South Coast Air Basin (Basin). The study is a follow up to previous air toxics studies in the Basin and is part of the South Coast Air Quality Management District (South Coast AQMD) Governing Board Environmental Justice Initiative.

The MATES V Study consists of several elements. These include a monitoring program, an updated emissions inventory of toxic air contaminants, and a modeling effort to characterize risk across the Basin. The study estimates air toxics cancer risks using a risk assessment approach.

Additionally, MATES V includes an exploratory analysis of chronic non-cancer health impacts (e.g. cardiovascular, respiratory, neurological health outcomes, etc.). The MATES analysis does not estimate impacts on mortality risk or other health effects from criteria air pollutant exposures; such analyses are instead conducted as part of the Air Quality Management Plans.

The first MATES I analysis began in 1986, but was limited due to the technology available at the time. Conducted in 1998, MATES II was the first MATES iteration to include a comprehensive monitoring program, an air toxics emissions inventory, and a modeling component. MATES III was conducted in 2004-2006 with MATES IV following in 2012-2013. The current study – MATES V – focuses on measurements during 2018 and 2019 with a comprehensive modeling analysis and emissions inventory based on 2018 data.

A network of 10 fixed sites was used to monitor toxic air contaminants once every six days for one year. The locations of the sites were generally the same as in MATES II, III, and IV to allow for comparisons over time. Several sites have been relocated over time due to site availability, however, relocated monitors were sited in nearby locations with similar air quality characteristics. The locations of the MATES V sites are shown in Figure ES-1.

Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Figure ES-1: Location of MATES V Monitoring Stations

As noted above, the study also includes computer modeling to estimate air toxic levels throughout the Basin and portions of the Coachella Valley. This allows estimates of air toxic cancer risks in all these geographic areas, as it is not feasible to conduct monitoring in all areas.

To provide technical guidance in the design of the study, a Technical Advisory Group was formed. The panel of experts from academia, environmental groups, industry, and public agencies provided valuable insight on the study design.

In the monitoring program, a comprehensive set of air pollutants were measured as part of MATES V. These are listed in Table ES-1. These include both gaseous and particulate species.

Table ES-1: Substances Measured in MATESV

Category	Sub-Categor	Measured Pollutants
Ultrafine Particles (UFPs)		UFPs
PM2.5	Ions	Ammonium Ion, Chloride, Nitrate, Potassium Ion, Sodium, Sulfate
	Sugars	Galactosan, Levoglucosan, Mannosan
	Metals	Aluminum, Antimony, Arsenic, Barium, Cadmium, Calcium, Cesium, Chlorine, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Molybdenum, Nickel, Phosphorus, Potassium, Rubidium, Samarium, Selenium, Silicon, Strontium, Sulfur, Thallium, Tin, Titanium, Uranium, Vanadium, Yttrium, Zinc
	Other	PM2.5 mass, Black Carbon (BC), Elemental Carbon (EC), Organic Carbon (OC), Total Carbon (TC)
Total Suspended Particulate (TSP)	Metals	Antimony, Arsenic, Barium, Beryllium, Cadmium, Calcium, Cesium, Chromium, Cobalt, Copper, Cr6+ (hexavalent chromium), Iron, Lead, Manganese, Molybdenum, Nickel, Potassium, Rubidium, Selenium, Strontium, Tin, Titanium, Uranium, Vanadium, Zinc
Volatile Organic Compounds (VOCs)	Carbonyls	2-Butanone (Methyl Ethyl Ketone), Acetaldehyde, Acetone, Benzaldehyde, Formaldehyde, Propionaldehyde
	Other	1,2-Dibromoethane, 1,2-Dichlorobenzene, 1,2-Dichloroethane 1,2-Dichloropropane, 1,3-Butadiene, 1,4-Dichlorobenzene, 2-Butanone (Methyl Ethyl Ketone), Acrolein, Acetone, Benzene, Bromomethane, Carbon Tetrachloride, Chloroform, Ethylbenzene, m+p-Xylene, Methyl tert-Butyl Ether (MTBE), Methylene Chloride, o-Xylene, Styrene, Tetrachloroethylene (Perchloroethylene), Toluene, Trichloroethylene, Vinyl Chloride
Polycyclic Aromatic Hydrocarbons (PAHs)		9-Fluorenone, Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(e)pyrene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Coronene, Cyclopenta(c,d)pyrene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Perylene, Phenanthrene, Pyrene, Retene

The monitored and modeled concentrations of air toxics were then used to estimate the carcinogenic risks from ambient levels. Chronic non-cancer health impacts were also estimated from the monitoring data. Annual average concentrations were used to estimate a lifetime risk from exposure to these levels, consistent with guidelines established by the Office of Environmental Health Hazard Assessment (OEHHA) of the California Environmental Protection Agency (CalEPA). Especially with the generally decreasing air pollution levels, ambient concentrations of some pollutants can sometimes be lower than what air quality monitoring instruments can detect. Therefore, statistical techniques are required to calculate average concentrations to provide an estimate of the actual levels. Modern statistical techniques were used to analyze the MATES V data, and to provide a comprehensive comparison of pollutant trends, MATES II, MATES III, and MATES IV measurements were re-analyzed using these same techniques.

What is Cancer Risk?
Cancer risk is expressed as the number of extra cancer cases occurring over a 70-year lifetime per one million people exposed to toxic air contaminants.

What are Chronic Non-Cancer Health Impacts?
The chronic non-cancer health impacts, typically expressed as a hazard index, is an indicator of whether non-cancer health effects can occur due to long-term exposure to toxic air contaminants. A hazard index that is less than or equal to one indicates that non-cancer health effects are not likely to occur over a lifetime of exposure.

Important Updates in MATES V

In addition to new measurements and updated modeling results, several key updates were implemented in MATES V. First, MATES V estimates cancer risks by taking into account multiple exposure pathways, which includes inhalation and non-inhalation pathways. See Chapter 1 for further details. This approach is consistent with how cancer risks are estimated under South Coast AQMD's programs such as permitting, Air Toxics Hot Spots (AB2588), and California Environmental Quality Act (CEQA). Previous MATES studies quantified the cancer risks based on the inhalation pathway only. The cumulative cancer risk accounting for inhalation and non-inhalation pathways is approximately 8% higher than the inhalation-only calculation for the MATES V data. Second, along with cancer risk estimates, MATES V includes information on the chronic non-cancer health impacts from inhalation and non-inhalation pathways for the first time. The cumulative chronic hazard index accounting for the inhalation and non-inhalation pathways is approximately twice the inhalation-only calculation for the MATES V data. Cancer risks and chronic non-cancer health impacts from MATES II through IV measurements have been re-examined using current OEHHA and CalEPA risk assessment methodologies and modern statistical methods to examine the trends over time.

Key results of the study are presented below.

Fixed Site Monitoring Results

The levels of air toxics continued to decline compared to previous MATES iterations (see below

Figure ES-3) with the air toxics cancer risk at the MATES V monitoring locations ranging from 585 to 842 per million. The average carcinogenic risks from the annual average levels of air toxics calculated from the fixed monitoring sites data are shown in Figure ES-2 along with the key pollutant contributors to overall cancer risk. This risk refers to the expected number of additional cancers over a 70-year lifetime in a population of one million individuals if they were continuously exposed to these levels for 30 years. In contrast to past MATES iterations where only exposure via inhalation was considered, this analysis considers additional exposure pathways. As in previous MATES iterations, diesel PM is the largest contributor to overall air toxics cancer risk. However, the average levels of diesel PM in MATES V are 53% lower at the 10 monitoring sites compared to MATES IV and 86% lower since MATES II based on monitored data. Based on other South Coast AQMD analyses of projected diesel PM emissions in future years,[1,2] significant decreases in diesel PM health impacts are expected within the next 5-10 years. These reductions reflect recent and continued efforts by the District, CARB and US EPA that reduce diesel PM emissions, especially from mobile sources. Carbonyl species, such as formaldehyde and acetaldehyde, contribute to 10% of the air toxics cancer risk in MATES V, compared to only 4% in MATES IV. However, the modeling results showed that formaldehyde and acetaldehyde primarily came from secondary formation[3] rather than direct emissions during this time period.

Figure ES-3 shows the cancer risk at the 10 monitoring sites and for the Basin average based on measurements conducted during MATES II through V using the same statistical techniques. The carcinogenic risk from air toxics in the Basin, based on the average concentrations at the 10 monitoring sites, is approximately 40% lower than the monitored average in MATES IV and 84% lower than the average in MATES II.

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[1] South Coast AQMD (2017). 2016 Air Quality Management Plan, Appendix III: Base and Future Year Emission Inventory. http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/final-2016-aqmp/appendix-iii.pdf.

[2] South Coast AQMD (2019). Methodology for Source Attribution Analyses for the first year AB 617 Communities in the South Coast Air Basin. https://www.aqmd.gov/docs/default-source/ab-617-ab-134/technical-advisory-group/source-attribution-methodology.pdf?sfvrsn=8.

[3] Secondary formation is defined as the formation of air pollutants through chemical reactions of pollutants in the atmosphere.

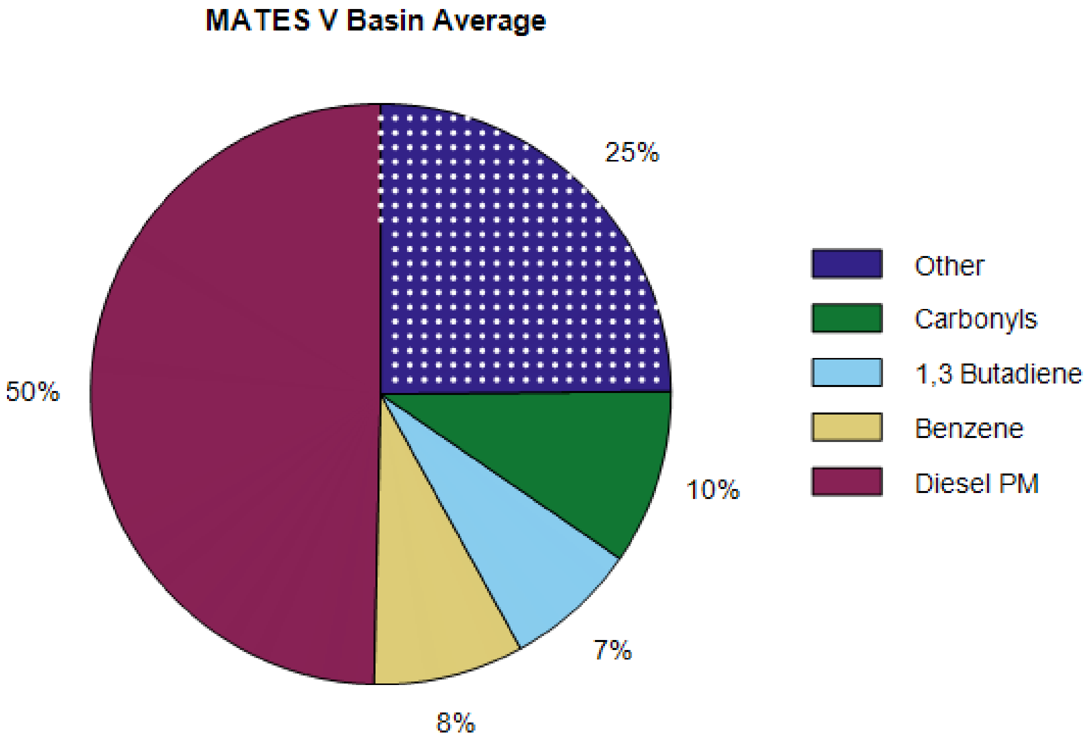

Figure ES-2: Average MATES V Cancer Risk at MATES Monitoring Sites by pollutant type. The “Other” category is marked with gray dots because some species in this category have higher uncertainty due to incomplete data or a large fraction of measurements below detection limits. Numbers may not sum to 100 due to rounding.

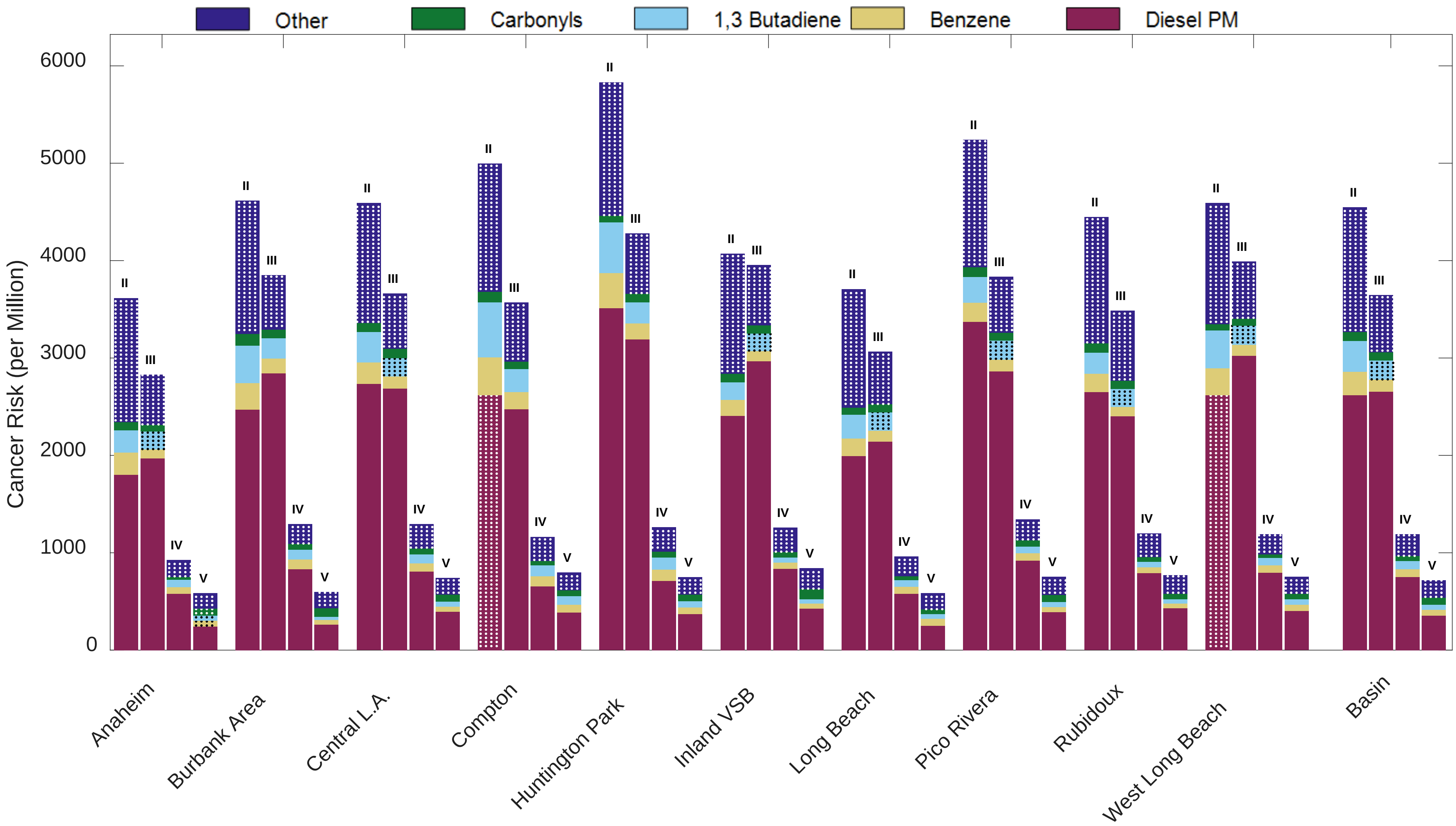

Figure ES-3: Trend in Average Cancer Risk at MATES Monitoring Sites. Segments marked with dots have higher uncertainty due to incomplete data or a large fraction of measurements below detection limits.

Recognizing that air toxics can have both cancer as well as non-cancer health effects, MATES V included an exploratory evaluation of chronic non-cancer health impacts using the measurement data. To assess the potential for chronic non-cancer health impacts, the average air toxics levels from the monitoring stations were used to calculate the hazard index (HI) for pollutants that have a chronic Reference Exposure Level (REL), using methods established by OEHHA. The HI is calculated separately for each target organ system. An HI that is less than one indicates that the air toxics levels are not expected to cause such health effects. An HI greater than one does not mean that such health effects are expected, but rather that the likelihood of experiencing adverse health effects increases. Although the likelihood of experiencing an adverse non-cancer health effect may not scale linearly with the HI, a larger HI would generally indicate a greater likelihood of experiencing those health effects in the exposed population.

The main drivers of chronic HI from the annual average levels of air toxics calculated from the fixed monitoring sites data is presented in Figure ES-4. This analysis identifies arsenic as the main driver of chronic HI throughout the Basin. Sources of arsenic include paved road dust, construction dust, mineral processes, metal processes, refineries and fuel combustion. The data also suggest that acrolein may be a large contributor to the chronic HI. However, the accuracy of measurement methods for acrolein have been called into question and there is no CARB-approved test method for acrolein from stationary sources.[4] Therefore, these data should be interpreted with caution.

Figure ES-5 shows the trend in chronic HIs based on the 10 fixed monitoring sites from MATES III through V. There were large decreases in chronic HI at all sites from MATES III to IV. However, changes from MATES IV through V were more modest, with a slight decline on average and small increases at three sites. Since MATES III, chronic HI has decreased,[5] but the overall chronic HI still exceeds one, indicating that these levels may increase the chances of adverse non-cancer health effects in the general population over a lifetime.

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[4] https://ww2.arb.ca.gov/acrolein-test-method-advisory-and-data

[5] Note that more than 80% of MATES II arsenic measurements were below detection limits, so it is difficult to conclude specific trends for this pollutant from that MATES iteration. An upper limit MATES II arsenic concentrations was calculated by substituting the method detection limit (MDL) for samples below detectible levels.

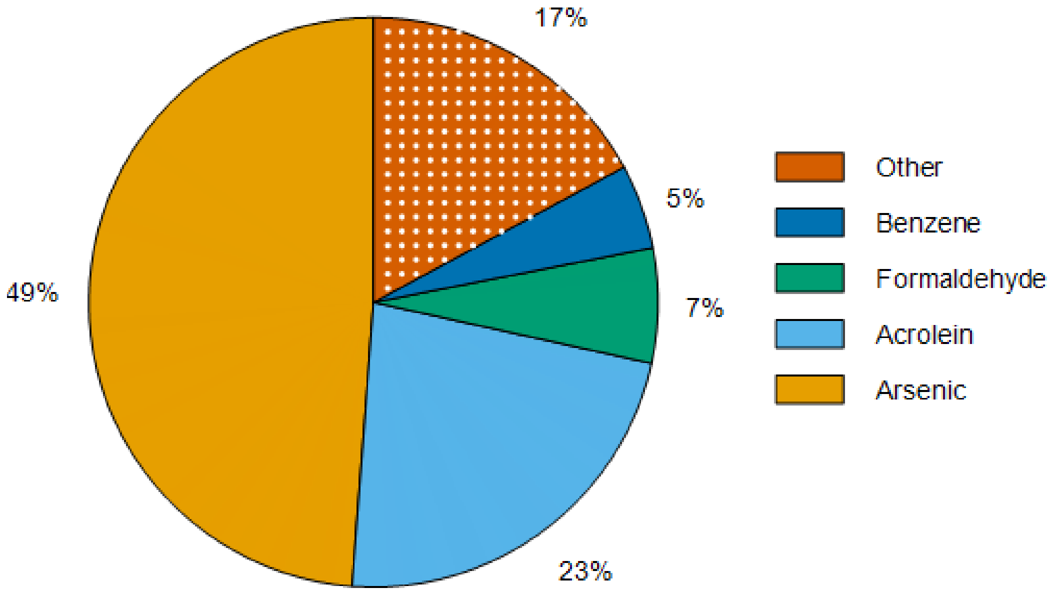


Figure ES-4: Relative contributions to the basin-wide chronic HI at the MATES V monitoring sites. The "Other" category is marked with gray dots because some species in this category have higher uncertainty due to incomplete data or a large fraction of measurements below detection limits. Numbers may not sum to 100 due to rounding.

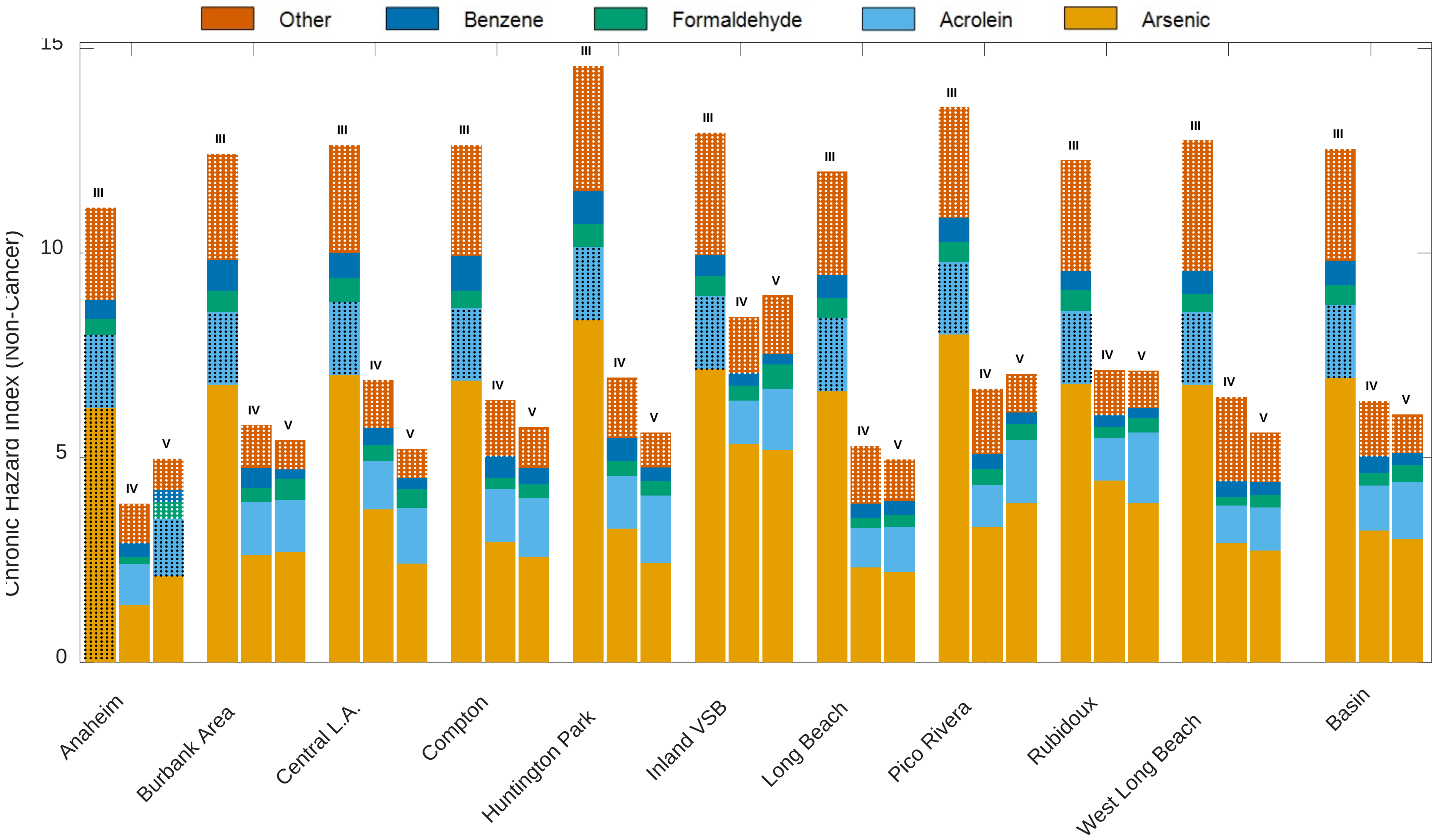


Figure ES-5: Chronic HI trends at MATES Monitoring Sites. Segments marked with dots have higher uncertainty due to incomplete data or a large fraction of measurements below detection limits.

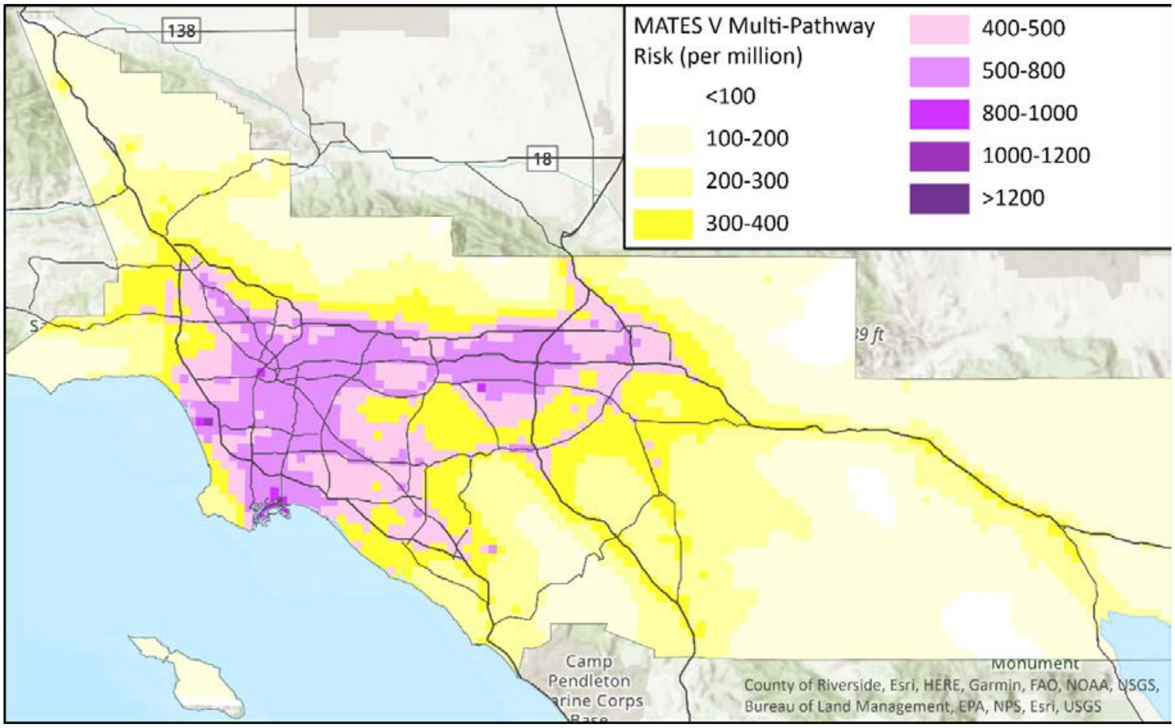
Modeling Results

This analysis uses regional air quality modeling to determine ambient air toxic concentrations throughout the Basin and portions of Coachella Valley due to air toxic emissions from all known sources where methods exist to quantify emissions. Using the risk assessment guidelines from OEHHA and consistent with how cancer risks were estimated from the monitoring data, the annual average modeled concentrations of air toxics was used to estimate cancer risks.

As in MATES IV, MATES V uses the Comprehensive Air Quality Model with Extensions (CAMx), enhanced with a reactive tracer modeling capability (RTRAC), as the dispersion and chemistry modeling platform used to simulate annual impacts of both gas and particulate air toxics in the Basin and portions of the Coachella Valley. The version of the RTRAC in CAMx used in the modeling simulations includes an air toxics chemistry module that is used to treat the formation and destruction of reactive air toxics.

Modeling was conducted on a domain that encompassed the Basin, the Coachella Valley and the coastal shipping lanes using a 2 km by 2 km grid size. Emissions data from the 2016 AQMP served as the primary platform for modeling to estimate the air toxics concentrations and associated risks. The 2016 AQMP emissions inventory was then projected to the year 2018 for the MATES V analysis. Since the actual measurements for MATES V spanned the dates May 1, 2018, to April 30, 2019, the MATES V modeling included adjustments to reflect day of week variations and meteorology that matched the actual measurement days. Additional details are available in Chapters 3 and 4.

Modeled cancer risks are depicted in Figure ES-6. As shown, the areas of higher air toxics cancer risk include those near the ports, Central Los Angeles and major transportation corridors. After scaling by cancer potency, about 88% of the carcinogenic air toxics emissions are attributed to mobile sources, with the remainder attributed to toxics emitted from stationary sources, which include large industrial operations such as refineries and power plants, as well as smaller businesses such as gas stations and chrome plating facilities.



County of Riverside, Esri, HERE, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPS, Esri, USGS

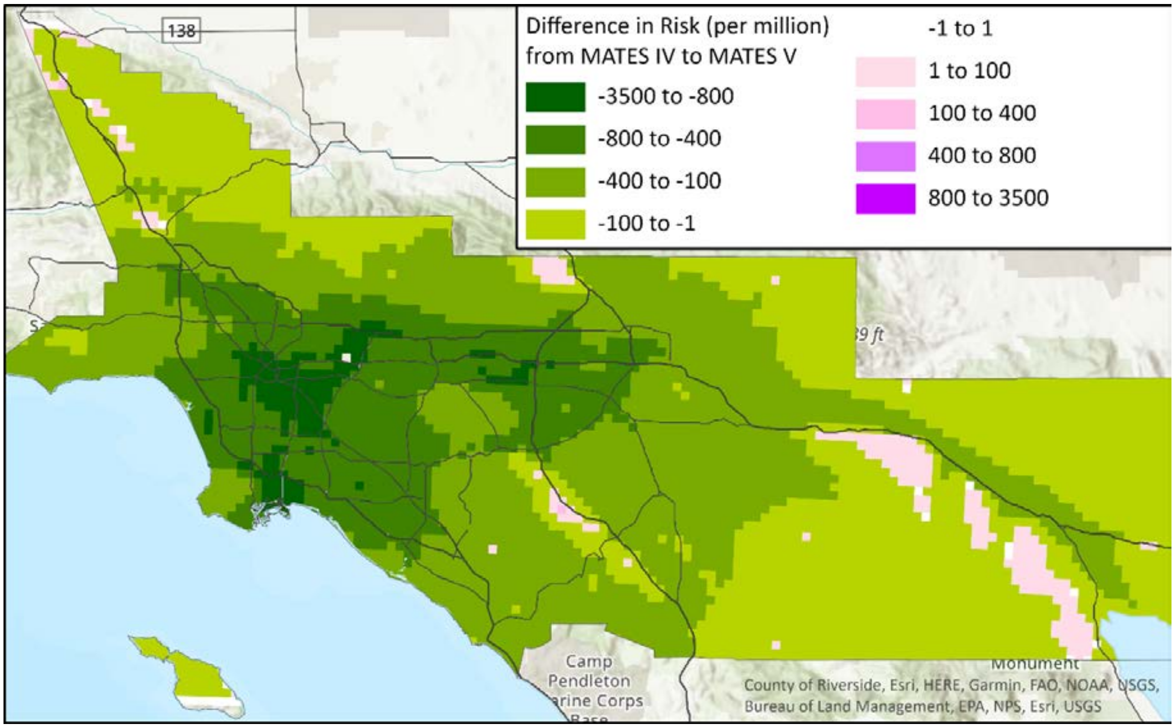
Figure ES-6: Modeled Air Toxics Cancer Risk for MATES V (multiple exposure pathways)

In the past MATES iterations, the air toxics cancer risks were evaluated based on inhalation exposures only. However, in MATES V, the methodology was updated to include multiple exposure pathways. Table ES-2 compares the estimated population-weighted risks from MATES IV and MATES V, using both the multiple exposure pathways as well as the inhalation pathway only. As shown in Table ES-2, accounting for multiple exposure pathways results in estimated air toxics cancer risk that is 7% higher in the Basin and 5% higher in the Coachella Valley. The population weighted risk was about 54% lower compared to the MATES IV period (2012) in the Basin and 30% lower in the Coachella Valley.

Table ES-2 Modeled Air Toxics Risk Comparisons Using the CAMx Model. Risks are weighted by population.

	Multiple exposure pathways			**Inhalation pathway only**		
	MATES IV	**MATES V**	**Change**	**MATES IV**	**MATES V**	**Change**
Air toxics cancer risk (per million)						
Basin	997	455	-54%	897	424	-53%
Coachella Valley	357	250	-30%	339	239	-30%

Figure ES-7 depicts the 2012 to 2018 change in estimated air toxics risk for each model grid cell estimated from the CAMx simulations. Overall, air toxics risk was reduced to varying levels across the Basin, with the largest improvements in the highest risk areas.



County of Riverside, Esri, HERE, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPS, Esri, USGS

Figure ES-7: Difference in Modeled Air Toxics Cancer Risk from MATES IV to MATES V (multiple exposure pathways)

For context, note that under the AB 2588 Air Toxics Hot Spots program, risks associated with facilities are considered significant if they are equal to or exceed one hundred in one million.

Caveats and Uncertainty

As with any scientific study, it is important to recognize study limitations to avoid over-interpreting the results. While these limitations may impact the accuracy of specific quantitative results, these limitations generally apply across all MATES iterations, and therefore, the long-term trends and geographic patterns of air toxics health risk still remain valid.

Technical limitations in pollution measurement methods are one source of uncertainty. There is no technique to directly measure diesel PM, the major contributor to cancer risk in this study, so indirect estimates based on components of diesel exhaust must be used. The modeling analysis estimated the ratio of diesel to elemental carbon concentrations at the grid cells where monitoring sites are located. This ratio was then applied to the annual averaged measured black carbon concentrations to estimate diesel PM concentrations at the measurement sites. While there is uncertainty in the monitoring-based calculation of cancer risks from diesel PM, arising from the conversion factor, these risk estimates also showed similar significant reductions in diesel PM risk. This indicates that, despite the uncertainties in estimating this risk, the model-derived EC-to-diesel PM conversion factor served the risk calculation reasonably well. The emissions inventory and numerical modeling contain uncertainties as well (additional detail is provided in Chapters 2 and 3). It is important to note that the modeling methods used in MATES are selected specifically to provide the best estimates of regional exposures to air toxics from the multitude of sources considered in the study. These methods are not designed to reflect near-source community impacts from any particular source; the modeling results are displayed on a 2km grid, which reflects this uncertainty. In some instances, these methods may underestimate near-source impacts. However, the study results do provide a best estimate of community-wide impacts, through both the modeling and monitoring analyses. The MATES program has focused on the measurements and modeling of a broad but finite list of known air toxics, and it is possible that additional air toxics contribute to health risks. However, MATES has included the known air toxics that are associated with health risks.

While the emissions inventory is based on the best established data and methods to quantify emissions from many diverse sources of air pollution, there may be circumstances where emissions are underestimated. This may be because there are sources of air toxics that have not yet been identified or fugitive emissions that are not otherwise accounted for in the inventory (often because an appropriate method has not been developed to quantify those emissions). Although some reported emissions data are based on source tests, much of the toxics emissions data reported are based on emissions calculations that are not as accurate as source test data. However, MATES also includes an air monitoring component that captures the levels of air toxic pollutants present in the ambient air, regardless of whether those were estimated in the emissions inventory. By using both an emissions inventory and monitoring approach to estimate air toxics levels, MATES provides a more complete picture of the impacts of air toxics in our region.

Air toxics levels that are very low result in measurements that are frequently below the detection limit. Due to limitations in measurement technology, it is not possible to quantify these compounds except to say that concentrations are between zero and the detection limit. For many compounds, the detection limits are low enough that even if concentrations are at this upper limit, risks are nominal and do not affect the overall estimated risks. However, there are some compounds where concentrations spanning zero to the detection limit produce large differences in risk values; this issue primarily occurs in the re-analysis of the MATES II and MATES III data. Since technology has improved over time, the detection limits for the MATES V data are generally much lower than for previous MATES studies. Chapter 2 provides additional details on this issue.

This study also aims to evaluate changes in estimated risk values from MATES II to MATES V based on measurement data. While most compounds driving both cancer risk and chronic non-cancer health impacts have been measured in each MATES iteration at each station, there are some compounds that were not measured in older MATES studies or at a particular station due to technical issues. In Chapter 2, we present a method to account for slight differences in the types of compounds measured when calculating trends in risk across multiple MATES studies. We find that evaluating trends in risk with several dissimilar methods still leads to the same overall conclusions.

This study used the risk assessment guidance recommended by OEHHA and the annual average measured or modeled air toxics concentration to calculate health risks. This methodology has long been used to estimate the relative risks from exposure to air toxics in California and is useful as a yardstick to compare potential risks from varied sources and emissions and to assess any changes in risks over time that may be associated with changing air quality.

The estimates of health risks are based on the state of current knowledge, and the process has undergone extensive scientific and public review. However, risk assessment requires the use of certain assumptions, which are consistent with current scientific knowledge and are designed to be conservative and health protective. As noted in the OEHHA risk assessment guidelines, sources of uncertainty in risk assessment include: (1) extrapolation of toxicity data in animals to humans (e.g. in the estimation of the cancer potency factors); (2) uncertainty in the estimation of emissions; (3) uncertainty in the air dispersion models; and (4) uncertainty in the exposure estimates. However, as additional scientific studies are published, these risk assessment values and methodologies may be refined to reflect updated knowledge. In addition to uncertainty, there is a natural range or variability in the human population in such properties as height, weight, and susceptibility to chemical toxicants. These uncertainties can under- or over-estimate actual risk. The uncertainties in the cancer potency factor for diesel PM also produces uncertainties in the overall cancer risk estimates, as diesel PM is the risk driver in this study.

Thus, the risk estimates should not be interpreted as actual rates of disease in the exposed population, but rather as estimates of potential risk, based on current knowledge and several assumptions. However, by using a consistent approach to risk assessment across MATES iterations, we can compare the health impacts of different sources, different substances, and different time frames to prioritize public health concerns and air quality progress.

Conclusions

The air toxics cancer risk continues to decline throughout the Basin with a 40% decrease in risk since MATES IV and an 84% decrease since MATES II, based on measurement data at the 10 fixed monitoring locations. The estimated Basin-wide population-weighted cancer risk calculated from the modeling data leads to a similar conclusion with a 54% decrease since MATES IV.

The change in modeled population-weighted cancer risk within communities experiencing environmental injustices (EJ communities) was evaluated using the SB535 definition of disadvantaged communities. Between MATES IV and MATES V, air toxics cancer risk decreased by 57% in EJ communities overall compared to a 53% reduction in non-EJ communities. Importantly, although air toxics cancer risks have decreased overall, and especially decreased substantially in EJ communities, people living in EJ communities in the SCAB continue to experience higher air toxics cancer risks compared to those in non-EJ communities.

MATES V was the first of these studies to explore chronic non-cancer health impacts across the

Basin using monitoring data. These measurements indicate that chronic non-cancer health impacts have decreased significantly since MATES III, however, the chronic HIs have remained similar at the fixed monitoring locations since MATES IV.

Policy Implications

While there has been substantial improvement in air quality regarding air toxics emissions and exposures, the health risks continue to be high, especially near sources of toxic emissions such as the ports and transportation corridors. Diesel PM, while also substantially reduced from past MATES, continues to dominate the overall cancer risk from air toxics. The reduction in diesel PM emissions has resulted in significant improvement in cancer risks in the areas adjacent to the ports which was the area with the highest cancer risks in previous MATES. Despite the overall improvement in air toxics emissions, air toxics cancer risks are still estimated to be about 4 to 5 times the significant risk levels established in the AB 2588 air Toxics Hot Spots program. In an exploratory analysis, chronic hazard indices based on monitoring data were found to be slightly above the AB 2588 significant risk levels, and arsenic was found to be the largest contribution to the chronic non-cancer health impacts in the South Coast Air Basin.

The results from this study support a continued focus on the reduction of toxic emissions, particularly from diesel engines.

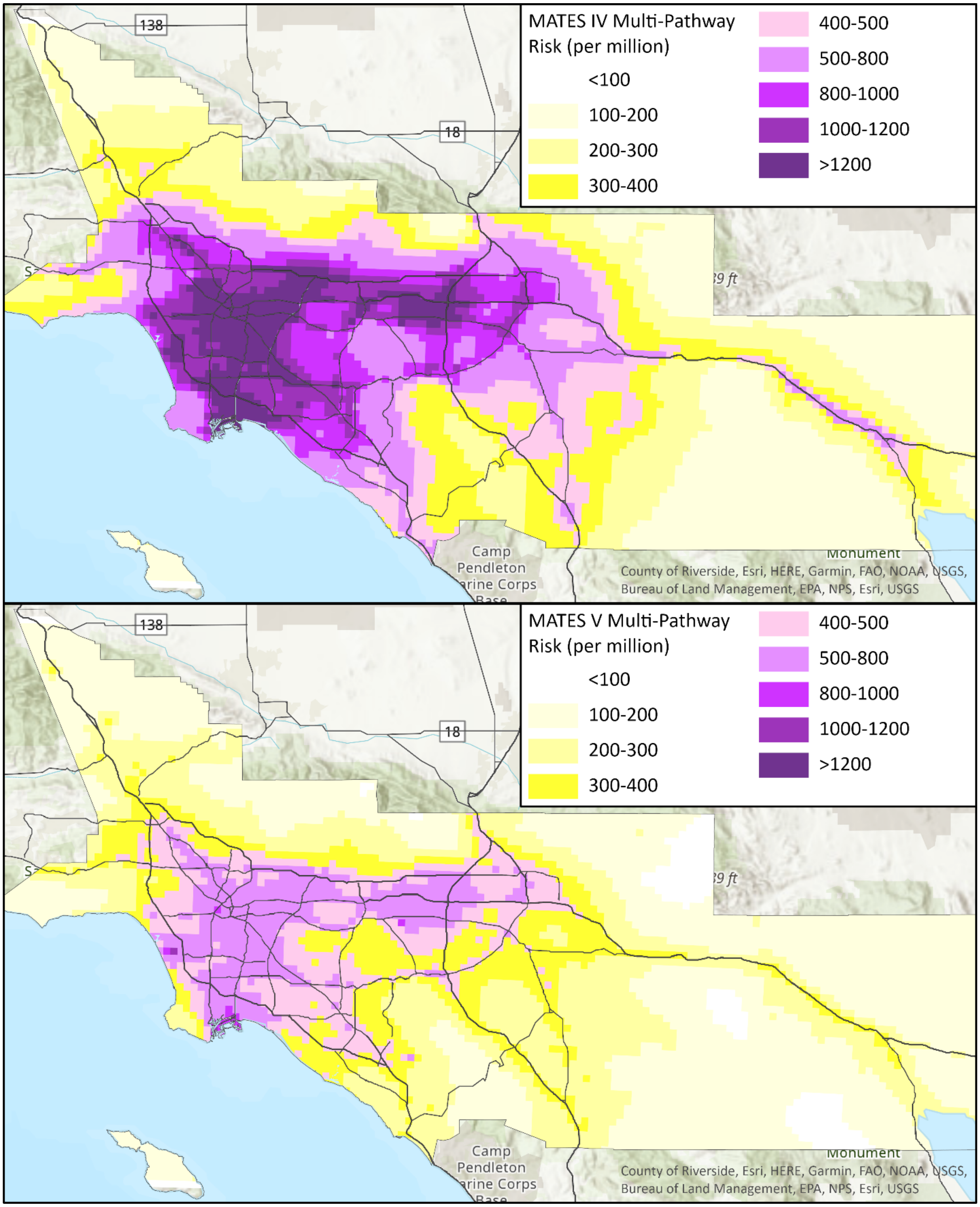


Figure ES-8: Modeled Air Toxics Cancer Risk for (top) MATES IV and (bottom) MATES V. Both maps use multiple exposure pathways in the risk assessment

CHAPTER 1

INTRODUCTION

Chapter 1. Introduction

1.1. Background

The South Coast Air Quality Management District (South Coast AQMD) includes portions of four large southern California counties and is home to about 17 million people and about 11 million motor vehicles. The South Coast Air Basin (Basin) is the highly urbanized portion of the South Coast AQMD in southern California, and contains some of the highest concentrations of industrial and commercial operations in the country. Air quality in the Basin is typically the most polluted in the U.S. The Multiple Air Toxics Exposure Study (MATES) is a unique environmental justice program that has spanned more than three decades and provides a detailed assessment of the impacts of a group of air pollutants known as “air toxics”, which are pollutants that can cause important health effects. Unlike the common “criteria air pollutants”, there are no state or federal standards for ambient concentrations of air toxics. Examples of air toxics include gases, such as benzene and 1,3-butadiene, as well as particles, such as arsenic and diesel particulate matter. The South Coast AQMD has several programs that are designed to reduce air toxics emissions, which provide public health benefits. State and federal regulatory agencies also work to reduce air toxics from a variety of sources, such as diesel trucks, locomotives, and ships.

In 1986, South Coast AQMD conducted the first MATES analysis to determine the Basin-wide risks associated with major airborne carcinogens. At the time, technological limitations only allowed for measurements of 10 known air toxic compounds. In 1998, a second study (MATES II) became one of the most comprehensive air toxics measurement programs conducted in an urban environment. MATES II included a monitoring program of 40 known air toxic compounds, an updated emissions inventory of toxic air contaminants, and a modeling effort to characterize health risks from hazardous air pollutants. A third study, MATES III, was conducted in the 2004-2006 timeframe. It consisted of a two- year monitoring program as well as updates to the air toxics emissions inventory and a regional modeling analysis of exposures to air toxics in the Basin. A fourth study, MATES IV, was conducted in the 2012-2013 timeframe. It consisted of a one-year monitoring program as well as updates to the air toxics emissions inventory and a regional modeling analysis of exposures to air toxics in the Basin.

The MATES program is designed to assess overall long-term trends in air toxics levels in the community. It has long been recognized that air toxics levels vary across communities, and the MATES program provides important information to examine these differences. A health risk assessment approach helps to estimate the potential extent of health impacts from these air toxics. In the MATES analysis, the health risk assessment evaluates chronic (long-term) non-cancer health impacts as well as cancer risks from air toxics. Although MATES is not able to evaluate acute non-cancer health impacts, other South Coast AQMD programs, such as the AB 2588 Air Toxics Hot Spots Program, do address acute health impacts. The current study, similar to the previous MATES studies, focuses on the carcinogenic risks from exposures to air toxics. Given the MATES program’s focus on air toxics, the study does not include an analysis of the health impacts from exposure to particulate matter or ozone. Studies of the health effects and impacts from criteria pollutants were summarized previously as part of the Air Quality

Management Plans.[1]

Since the MATES studies were first conducted, several emissions control programs have been implemented at the national, state, and local agency levels; and toxics emissions have been declining. However, there remains heightened awareness of toxic air contaminant exposures on a community level, that is, in areas that are close to sources of these pollutants. There are also concerns that although regulatory programs have reduced toxic emissions, the risks in environmental justice communities (i.e., communities experiencing environmental injustices), which often have many sources of air toxics, continues to exceed the risks in other communities.

This report provides the results of the fifth air toxics monitoring and exposure study conducted by the South Coast AQMD. It consists of a one-year monitoring study, as well as updates to exposures and risk estimated from air toxics. The objective is to update the characterization of ambient air toxic concentrations and potential exposures to air toxics in the Basin. MATES V also aims to harness modern tools for displaying air quality information for public audiences.

The MATES results can be used to examine the trends and spatial patterns of important air toxic pollutants in the Basin, assess the overall impacts of current air toxic control measures, and help inform appropriate control strategies for reducing exposures to air toxics associated with significant public health risks. We anticipate that the results of this study additionally would serve to inform an update of the South Coast AQMD's Air Toxics control plans.
There are four main components to the study, as listed below:

- Air Toxics Monitoring and Analyses
- Emissions Inventory Updates
- Air Toxic Modeling and Risk Assessments
- Interactive Data Dissemination Tools

The Air Toxics Monitoring and Analyses portion of the study includes a fixed-site monitoring program with ten stations to characterize long-term regional air toxics levels in residential and commercial areas. In addition to air toxics, the monitoring portion of the study includes measurements of black carbon and ultrafine particles. These components are further described in the chapters that follow.

Programs such as MATES are designed to monitor and characterize toxic emissions over the entire Basin. However, ambient monitoring is conducted at a limited number of locations, and modeling provides a spatial resolution of 2 km. Communities located very near industrial sources, major transportation corridors, or large mobile source facilities (such as marine ports, railyards and commercial airports) can be affected by higher air contaminant levels than can be captured in the typical MATES analysis. Near-road monitoring studies and dispersion modeling results for point sources indicate that exposure can vary greatly over distances much shorter than 2 km. Under the MATES V program, an Advanced Monitoring Studies component was added to provide high resolution, local-scale monitoring at or near petroleum refineries. The community areas chosen for monitoring were chosen based on proximity to these sources as well as environmental justice concerns. The results of the MATES V Advanced Monitoring Studies will be published in a separate report.

1.2. Health Effects of Air Toxics and Ultrafine Particles (UFPs)

Given the range of pollutants that are classified as air toxics, long-term exposures to these pollutants can cause a wide variety of health effects, with higher chances of health effects occurring at higher pollutant concentrations. For example, diesel PM is a known human carcinogen, with studies linking diesel PM exposure to increased lung cancer risks. Chronic exposure to diesel PM can also cause or worsen other lung diseases (including worsening asthma) and heart diseases. Benzene is also a known human carcinogen, but unlike diesel PM, the main types of cancers associated with benzene are blood cancers. Chronic benzene exposure can decrease blood cell formation in the bone marrow, which can lead to health conditions such as anemia.[1] Arsenic is a metal air toxic pollutant that can cause certain types of cancers of the lung, skin and bladder, as well as skin lesions, diabetes and high blood pressure.[2,3] All of these types of long-term health impacts are evaluated as part of the health risk assessment in MATES. Additional information about the various health effects associated with the specific air toxics evaluated in this study can be found on the Air Chemicals website (https://oehha.ca.gov/air/chemicals) developed by the Office of Environmental Health Hazard Assessment.

In addition to specific air toxics, beginning with the MATES IV study, the South Coast AQMD has measured ultrafine particles (UFPs) at the fixed monitoring stations. Ultrafine particles are typically defined as particulate matter with an aerodynamic diameter of ≤0.1µm (≤100 nm).

These very small particles are formed from combustion processes, with one major source being combustion engines, especially diesel engines.[4] Other important sources of UFPs include fuel used at stationary sources, other mobile sources, meat cooking and wood burning. Toxicological studies have found that UFPs can be inhaled more deeply into the lung tissues and take a longer time to be cleared from the lungs compared to larger inhalable particles (e.g. PM2.5, PM10).

UFPs can also translocate from the lungs into the blood and other organs, and can enter the brain tissues through the olfactory nerve.[5] There is currently no federal or state standard for UFPs. In

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[1] U.S. Department of Health and Human Services, "Agency for Toxic Substances and Disease Registry, Benzene – ToxFAQs," 2007. [Online]. Available: https://www.atsdr.cdc.gov/toxfaqs/tfacts3.pdf . [Accessed 11 March 2021].

[2] U.S. Department of Health and Human Services, "Agency for Toxic Substances and Disease Registry, Benzene – ToxFAQs," 2007. [Online]. Available: https://www.atsdr.cdc.gov/toxfaqs/tfacts3.pdf . [Accessed 11 March 2021].

[3] International Agency for Research on Cancer, "Arsenic, Metals, Fibres, and Dusts (Volume 100C)," 2012. [Online]. Available: https://monographs.iarc.fr/wp-content/uploads/2018/06/mono100C-6.pdf . [Accessed 31 March 2021].

[4] Health Effects Institute, "Understanding the Health Effects of Ambient Ultrafine Particles," January 2003. [Online]. Available: https://www.healtheffects.org/publication/understanding-health-effects-ambient-ultrafine-particles . [Accessed 12 March 2021].

[5] A. Peters, B. Veronesi, P. Calderon-Garcuduenas, P. Gehr, L. Chen, M. Geiser, W. Reed, B. RothenRutishauser, S. Schurch and H. Schulz, "Translocation and potential neurological effects of fine and ultrafine particles a critical

2019, the U.S. EPA classified the weight of scientific evidence for long-term UFP exposures was suggestive of a causal effect for neurological health effects; evidence for short-term UFP exposures were also suggestive of causal effects for neurological effects, as well as respiratory and cardiovascular effects.[6]

It is important to note that the criteria air pollutants, such as PM2.5 and ozone, also have important health effects, even though they are not the focus of the MATES program. The health effects of criteria air pollutants have been summarized in previous Air Quality Management Plans. Perhaps the most noteworthy health effect is the association between both short-term (24-hour) and long-term PM2.5 exposure and premature mortality, especially from cardiovascular causes. In the 2009 Integrated Science Assessment (ISA) for Particulate Matter, the U.S. EPA concluded that both short-term and long-term PM2.5 were causally associated with premature mortality. These causal associations were reaffirmed in the 2019 ISA.

1.3. Estimates of Risks

A health risk assessment evaluates the potential health impacts from exposures to substances released from a facility or found in the air. These assessments provide estimates of potential long-term cancer and non-cancer health impacts. The assessments do not collect information on specific individuals but are estimates of potential effects in a population at large.

Potential health risks were estimated using methodology consistent with the procedures recommended in the 2015 California Office of Environmental Health Hazard Assessment's (OEHHA) "Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments" (Guidance Manual).[7] As discussed in the Guidance Manual, the risk assessment process generally consists of four parts; namely hazard identification, exposure assessment, dose response assessment, and risk characterization. The risk assessment steps, as applied in this study, are briefly summarized below.

Hazard Identification

Hazard identification involves determination of whether a hazard exists; and, if so, if the substance of concern is a potential human carcinogen or is associated with other types of adverse health effects in humans. For this study, the list of air toxics in the 2015 OEHHA risk assessment guidelines[8] was used in conjunction with information on ambient levels of air toxics from previous studies, as well as input from the Technical Advisory Group, to determine which

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update," *Part Fibre Toxicol*, p. 3:13, 2006.

[6] U.S. Environmental Protection Agency, "U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019)," U.S. Environmental Protection Agency, Washington, DC, 2019.

[7] Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, "Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments," February 2015. [Online]. Available: https://oehha.ca.gov/air/crnr/notice-adoption-air-toxics-hot-spots-program-guidance-manual-preparation- health-risk-0 . [Accessed 1 October 2020].

substances to focus on for this assessment. This list is provided in Appendix I.

Exposure Assessment

The purpose of an exposure assessment is to estimate the extent of public exposure for a substance. This can involve quantification of emissions from a source, modeling of environmental transport and fate, and estimation of exposure levels over some period of time. In this study, annual averages of the air toxics of concern were estimated in two ways. For the fixed site monitoring station data, annual averages were calculated and used as an estimate of exposure, see Appendix XI for details. For the modeling analysis, emissions over the Basin and the Coachella Valley were estimated and allocated to 2 kilometer by 2 kilometer geographic grids, and a regional dispersion model was used to estimate the annual average concentrations in each grid cell.

Dose Response Assessment

The dose response assessment characterizes the relationship between exposure to a substance and the incidence of an adverse health effect in an exposed population. For estimating cancer risk, the dose-response is expressed in terms of a potency slope that is used to calculate the probability of cancer associated with a given exposure. These cancer potency factors are expressed as the 95th statistical upper confidence limit of the slope of the dose response curve assuming a continuous lifetime exposure to a substance at a dose of one milligram per kilogram of body weight. For non-cancer health effects, dose-response data are used to develop acute and chronic Reference Exposure Levels (RELs). The RELs are defined as the concentrations at or below which no adverse non-cancer health effects would be found in the general population. The acute RELs are designed to be protective for infrequent 1- hour exposures. The chronic RELs are designed to be protective for continuous exposure for at least a significant fraction of a lifetime.

For this study, the dose-response estimates developed by OEHHA[8] are used to estimate the potential for adverse health effects for chronic exposures. Note that these estimates sometimes differ from those developed by the U.S. EPA. For example, OEHHA has developed a cancer potency factor for diesel exhaust, whereas the U.S. EPA has elected not to do so. The U.S. EPA does state, however, that diesel exhaust is likely to be carcinogenic to humans and has adopted extensive regulations designed to reduce diesel exhaust exposure.[9] While some of the potency estimates OEHHA has developed for other air toxics produce different estimates of risks than

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[8] Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, "Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments," February 2015. [Online]. Available: https://oehha.ca.gov/air/crnr/notice-adoption-air-toxics-hot-spots-program-guidance-manual-preparation- health-risk-0 . [Accessed 1 October 2020].

[9] United States Environmental Protection Agency, "Learn About Impacts of Diesel Exhaust and the Diesel Emissions Reduction Act (DERA)," 2020. [Online]. Available: https://www.epa.gov/dera/learn-about-impacts- diesel-exhaust-and-diesel-emissions-reduction-act-dera . [Accessed 22 September 2020].

those that would be calculated using the U.S. EPA values, the risk from diesel exhaust calculated using OEHHA's cancer potency factor is the dominant contributor to the estimated air toxics cancer risk in this study.

Risk Characterization

In this step, the estimated concentration of a substance is combined with the cancer potency factors and RELs to determine the potential for health effects. This study multiplies the estimated or measured annual average levels for potential carcinogens by the cancer potency factor, molecular weight adjustment factor, combined exposure factor, and multi-pathway adjustment factor to determine cancer risks. The molecular weight adjustment factor is only used when a toxic metal has a cancer potency factor and applies only to the fraction of the overall weight of the emissions that are associated with health effects of the metal.[10] The combined exposure factor accounts for the exposure factor for each assigned age bin. Each assigned age bin is made up of the daily breathing rate, exposure duration of the age bin, fraction of time at home, and an age sensitivity factor. The daily breathing rate is calculated using the California Air Resources Board (CARB) and California Air Pollution Control Officer Association's Risk Management Policy (RMP) using the Derived Method methodology. The method assumes a 95th percentile breathing rate for children from the last trimester through age 2 and an 80th percentile daily breathing rate for other age groups. The multi-pathway adjustment factor is used to account for substances that may contribute to risk from exposure pathways other than inhalation, such as ingestion of soil or homegrown vegetables.[11] For chronic non-cancer health impact calculations, the estimated or measured annual average levels for each pollutant were multiplied by the molecular weight adjustment factor and multi-pathway adjustment factor, and then divided by the applicable chronic REL to determine a hazard quotient. The hazard quotients are then summed for each target organ for all applicable toxic substances, and the maximum hazard quotient from all the target organ is reported as the hazard index. A hazard index of less than one indicates that chronic non-cancer health effects are not expected to occur at those pollution levels.

The potential cancer risk for a given substance is expressed as the incremental number of potential cancer cases that could be developed per million people, assuming that the population is exposed to the substance at a constant annual average concentration over a presumed 30-year period. These risks are usually presented in chances per million. For example, if the incremental air toxics cancer risks were estimated to be 100 per million, the probability of an individual developing cancer due to a lifetime exposure would be increased by a hundred in a million above background levels of cancer risk (e.g. based on other factors, such as age, diet, genetics, etc).

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[10] California Office of Environmental Health Hazard Assessment, "Air Toxics Hot Spots Program Guidance Manual, Appendix L: OEHHA/ARB Approved Health Values for Use in Hot Spot Facility Risk Assessments," February 2015. [Online]. Available: https://oehha.ca.gov/media/downloads/crnr/2015gmappendiceslm.pdf . [Accessed 19 November 2020].

[11] South Coast Air Quality Management District, "Risk Assessment Procedures for Rules 1401, 1401.1, and 212," 1 September 2017. [Online]. Available: http://www.aqmd.gov/docs/default-source/permitting/rule-1401-risk-assessment/riskassessproc-v8-1.pdf?sfvrsn=12. [Accessed February 2021].

This would predict an additional 100 cases of cancer in a population of a million people over a 70-year lifetime period.

Perspectives of Risk

There are many factors that contribute to cancer risks and other health risks, including environmental pollution, behavioral risk factors (e.g. cigarette smoking, sedentary lifestyle), social and economic factors (e.g. racial injustices, social support, poverty, access to health care), genetic factors (e.g. specific genes that confer higher risk for certain diseases), and many others. To provide perspective, it is sometimes helpful to compare the risks estimated from assessments of environmental exposures to the overall rates of health effects in the general population. For example, it is estimated that in the U.S. population, the chances of developing cancer over a lifetime is 38.4%.[12] This translates into a risk of about 384,000 in a million over a lifetime. An estimated 19% of cancers in the United States are attributed to cigarette smoking, 4.7% are due to UV radiation, and 16.3% are related to excess body weight, alcohol intake, and physical inactivity.[13] These contributions of behavioral risk factors to cancer risk add up to 40%. Multiplying 40% by 384,000 indicates that approximately 153,600 in a million incidence of cancer over a lifetime may be related to these lifestyle risk factors. For comparison, the grid cell with the highest cumulative cancer risk from the pollutants in the MATES V is 1,141 in a million (see Chapter 4).

However, it is important to note that environmental risk factors such as outdoor air pollution deserve particular attention because they are involuntary risks and largely controlled by others. In other words, an individual cannot choose not to breathe air pollution in the neighborhood where they live, and that person often cannot make personal choices to directly reduce that air pollution. The health impacts of air pollution continue to be an important consideration, and reducing these involuntary risks helps to improve environmental equity in our communities.

Sources of Uncertainty in Health Risk Estimation

The estimates of health risks are based on the state of current knowledge, and the process has undergone extensive scientific and public review. However, there is uncertainty associated with the processes of risk assessment. This uncertainty stems from the lack of data in many areas, which necessitates the use of assumptions. The assumptions are consistent with current scientific knowledge, but are often designed to be conservative and on the side of health protection in order to avoid underestimation of public health risks.

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[12] National Cancer Institute, "Cancer Statistics," 27 April 2018. [Online]. Available: https://www.cancer.gov/about-cancer/understanding/statistics . [Accessed 24 June 2020].

[13] F. Islami, A. G. Sauer, K. D. Miller, R. L. Siegel, S. A. Fedewa, E. J. Jacobs, M. L. McCullough, A. V. Patel, J. Ma, I. Soerjomataram, W. D. Flanders, O. W. Brawley, S. M. Gaps and J. Ahmedin, "Proportion and Number of Cancer Cases and Deaths Attributable to Potentially Modifiable Risk Factors in the United States," *CA: A Cancer Journal for Clinicians,* vol. 68, pp. 31-54, 2018.

As noted in the 2015 OEHHA risk assessment guidance, sources of uncertainty, which may either overestimate or underestimate risk, include: (1) extrapolation of toxicity data in animals to humans (e.g. in the estimation of the cancer potency factors), (2) uncertainty in the estimation of emissions, (3) uncertainty in the air dispersion models, and (4) uncertainty in the exposure estimates. With the use of multiple exposure pathways in the estimation of cancer risks and chronic health impacts, there are additional uncertainties around estimating oral and dermal exposures based on the difficulty in estimating the transfer of particles from hand to mouth, surfaces to food, and other pathways. Uncertainty may be defined as what is not known and may be reduced with further scientific studies. In addition to uncertainty, there is a natural range or variability in the human population in such properties as height, weight, and susceptibility to chemical toxicants. The uncertainties in the cancer potency factor for diesel PM also produces uncertainties in the overall cancer risk estimates, as diesel PM is the risk driver in this study.

Due to this uncertainty, the risk estimates in this study should not be interpreted as actual rates of disease in the exposed population, but rather as estimates of potential risk, based on current knowledge and a number of assumptions. However, a consistent approach to risk assessment is useful to compare different sources and different substances to prioritize public health concerns.

Recognizing that science is never static, and that new data continues to emerge and enhance our understanding of the health effects of air pollution, we remain open to refining such evaluations as new knowledge becomes available. The MATES V study uses the most current OEHHA risk assessment guidance (2015) to estimate health risks as well as other newer statistical methods that help provide a picture of air toxics in our jurisdiction using the best available science. MATES studies have focused on the measurements and modeling of a broad but finite list of known air toxics, and it is possible that additional air toxics contribute to health risks. However, the MATES studies have included the known air toxics that primarily drive health risks from air pollution. The uncertainties in the cancer potency factor for diesel PM also produces uncertainties in the overall cancer risk estimates, as diesel PM is the risk driver in this study. However, by using a consistent approach in calculating air toxics health impacts, the MATES data can be used to examine the trends over time, across different geographical areas, and the relative contribution of various air toxics sources.

Determining Trends in Risk

Staff have updated the methods used for statistical calculations to be consistent with state-of-the-art methods. In particular, some pollutant concentrations are below the method detection limits, and staff followed guidance provided in Singh et al. (2006),[14] which is an in-depth U.S. EPA-commissioned report on the topic of handling environmental data below the detection limits and Helsel (2012)[15] for handling this type of data (see Appendix XI for details). Since this approach is

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[14] A. Singh, R. Maichle, Lee and S. E, "On the Computation of a 95% Upper Confidence Limit of Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations," US EPA, Washington DC, 2006.

[15] D. Helsel, Statistics for Censored Environmental Data Using Minitab and R, 2nd ed., Hoboken, New Jersey: John

different from the previous MATES, staff have re-analyzed MATES II through MATES IV data using consistent methods for all data that were available. This allows direct comparison of concentrations over time and allows the determination of trends in concentration and risk. For the risk estimates based on modeling data, staff used the model output from prior MATES iterations and applied the methods from the most current (2015) OEHHA risk assessment guidelines.

Wiley & Sons, Inc., 2012.

CHAPTER 2

AIR TOXICS MONITORING AND ANALYSIS

Chapter 2. Air Toxics Monitoring and Analysis

2.1 Substances Monitored

The chemical compounds (Table 2-1) monitored in MATES V include the airborne toxics found in previous studies posing the most significant contributions to health risks in the Basin, along with other compounds used to help identify sources. Additional measurements for MATES V included field-based measurements of total carbon, organic carbon, and ammonia at the Central Los Angeles and Rubidoux sampling sites, as well as ions, and black carbon (BC) at all fixed monitoring sites. Measurements of levoglucosan, mannosan, and galactosan were added at all fixed monitoring sites, as these sugars, formed from the combustion of cellulose, are indicators of biomass burning (see Appendix XII). The substances listed below in Table 2-1 exclude those measured in MATES V Refinery monitoring projects.

Table 2-1 Substances Monitored in MATES V

Pollutant Category		Measured Pollutants
Ultrafine Particles (UFPs)		UFPs
PM2.5	Ions	Ammonium Ion, Chloride, Nitrate, Potassium Ion, Sodium, Sulfate
	Sugars	Galactosan, Levoglucosan, Mannosan
	Metals	Aluminum, Antimony, Arsenic, Barium, Cadmium, Calcium, Cesium, Chlorine, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Molybdenum, Nickel, Phosphorus, Potassium, Rubidium, Samarium, Selenium, Silicon, Strontium, Sulfur, Thallium, Tin, Titanium, Uranium, Vanadium, Yttrium, Zinc
	Other	PM2.5 mass, Black Carbon (BC), Elemental Carbon (EC), Organic Carbon (OC), Total Carbon (TC)
Total Suspended Particulate (TSP)	Metals	Antimony, Arsenic, Barium, Beryllium, Cadmium, Calcium, Cesium, Chromium, Cobalt, Copper, Cr6+ (hexavalent chromium), Iron, Lead, Manganese, Molybdenum, Nickel, Potassium, Rubidium, Selenium, Strontium, Tin, Titanium, Uranium, Vanadium, Zinc
Volatile Organic Compounds (VOCs)	Carbonyls	2-Butanone (Methyl Ethyl Ketone), Acetaldehyde, Acetone, Benzaldehyde, Formaldehyde, Propionaldehyde
	Other	1,2-Dibromoethane, 1,2-Dichlorobenzene, 1,2-Dichloroethane, 1,2-Dichloropropane, 1,3-Butadiene, 1,4-Dichlorobenzene, 2-Butanone (Methyl Ethyl Ketone), Acrolein (2-Propenal), Acetone, Benzene, Bromomethane, Carbon Tetrachloride, Chloroform,

		Ethylbenzene, m+p-Xylene, Methyl tert-Butyl Ether (MTBE), Methylene Chloride, o-Xylene, Styrene, Tetrachloroethylene (Perchloroethylene), Toluene, Trichloroethylene, Vinyl Chloride
Polycyclic Aromatic Hydrocarbons (PAHs)		9-Fluorenone, Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(e)pyrene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Coronene, Cyclopenta(c,d)pyrene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Perylene, Phenanthrene, Pyrene, Retene

Since the toxic particulate bound components are all present within the PM2.5 and Total Suspended Particulate (TSP) size fractions, measurements of PM10 were not included under MATES V.

2.2 Monitoring Sites

Seven of the ten monitoring sites operated for MATES V are identical to those used in the MATES IV Study. The location of three sites (Long Beach, Huntington Park, and Burbank Area) were moved because the previous locations used in MATES IV were not available. The distances between the MATES V sites and the corresponding MATES IV sites are listed below.

- Burbank Area MATES V site approximately 8 miles NE of MATES IV site;
- Long Beach MATES V site approximately 2.3 miles SE of MATES IV site;
- Huntington Park MATES V site approximately .9 miles East of MATES IV site.

The MATES sites were originally selected to measure numerous air toxic compounds at different locations in the Basin to establish representative baseline regional-scale data for ambient air toxic concentrations and associated health risks. These sites were also selected to assist in the assessment of modeling performance accuracy.

The locations for the 10 fixed sites reflect a representative distribution within the Basin and are geographically dispersed, and generally selected to be residential or commercial areas in order to reflect air toxics exposures to the general public. Fixed site locations include areas that vary in land-use types, including areas that are closer to industrial and/or commercial sources of air toxics and areas that are primarily residential neighborhoods. The sites also reflect resource constraints and the leveraging of existing monitoring programs and the availability of specialized equipment. The sites used in MATES V are shown in Figure 2-1. Changes in station locations from MATES II through V are shown in Figure 2-2.

The 10 sites were originally selected with the input from the MATES II Technical Review Group and the Environmental Justice Task Force as well as with review from the MATES V technical advisory group; precise locations for MATES V stations are listed in Table 2-2. Appendix IV contains a table of the latitude and longitude for each MATES II through V station. The Central L.A. and Rubidoux sites were selected to provide continuity with CARB long-term trend sites. The Inland Valley San Bernardino, Long Beach, and Burbank sites were selected to provide geographic continuity with previous MATES studies. The Pico Rivera site was selected to leverage existing monitoring resources available from the U.S. EPA-sponsored PAMS Program which has provided well-characterized air monitoring data from this site since 2005. Anaheim was chosen for geographic equity, such that there was at least one site in each of the four counties. West Long Beach, Compton, and Huntington Park sites were selected to examine environmental justice concerns. Because the fixed-site locations are based on U.S. EPA guidelines for "neighborhood scale" monitoring, each of these sites may also be representative of adjacent communities. At each site, sampling equipment included particulate, VOC canister, and carbonyl samplers, as well as equipment for continuous measurement of black carbon, PM number concentration, and relevant meteorological parameters.

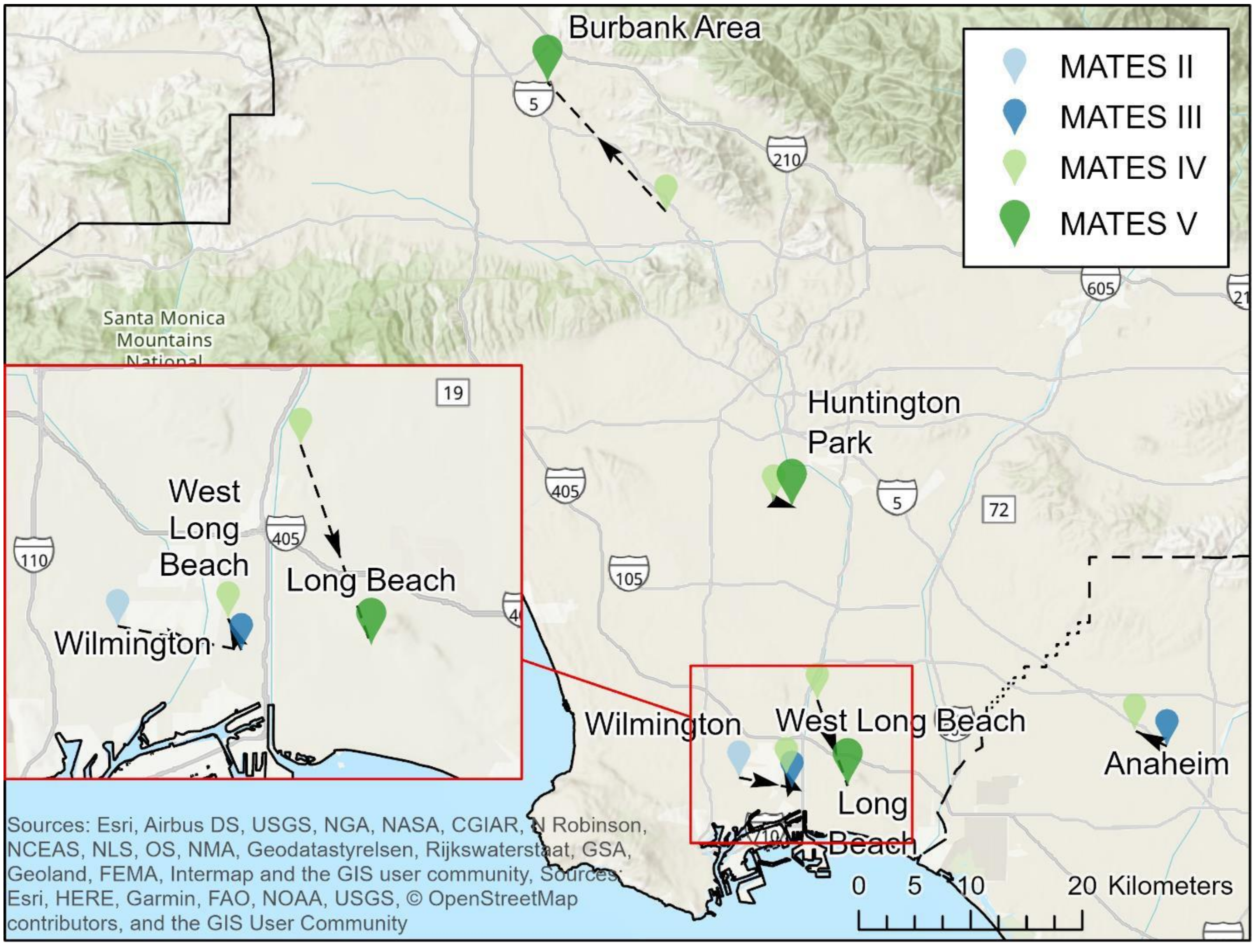
Table 2-2 MATES V Site Locations

Site	**Address**
Anaheim	1630 W. Pampas Ln., Anaheim, CA 92802
Burbank Area	Airpark Way, Pacoima, CA 91331 (0.5 miles NW of Osborne St.)
Compton	720 N. Bullis Rd., Compton, CA 90221
Inland Valley San Bernardino	14360 Arrow Route, Fontana, CA 92335
Huntington Park	2975 Zoe Ave., Huntington Park, CA 90255
Long Beach	1710 E. 20th St., Signal Hill 90755
Central Los Angeles	1630 N. Main St., Los Angeles, CA 90012
Pico Rivera	4144 San Gabriel River Pkwy., Pico Rivera, CA 90660
Rubidoux	5888 Mission Blvd., Riverside, CA 92509
West Long Beach	2425 Webster Ave., Long Beach, CA 90810

*Latitude and longitude of each station is shown in Appendix IV.

Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Figure 2-1 Location of MATES V Monitoring Locations.



Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Figure 2-2 Changes in Monitoring Locations.

2.3 Advanced Air Monitoring Efforts

Part of MATES V used advanced air monitoring technologies to complement and enhance fixed site monitoring, provide higher resolution air quality data, estimate emissions from petroleum refineries and better characterize air toxics levels in highly impacted areas. To this end, staff worked with contractors specializing in optical remote sensing and other state-of-the-art air monitoring methods to fully characterize refinery emissions and their potential impact on local communities. Flight-based measurements provided air toxics data across a large portion of the Basin where major refineries are located. This data helped guide selection of target areas for ground-level mobile monitoring and sensor deployments. Ground-level mobile monitoring allowed for VOC measurements at all major refineries in the South Coast AQMD. An “optical-tent” was developed and deployed at one of these refineries for long-term near-real time monitoring of benzene, toluene, and xylene (BTX) and to help identify leaks. A PM sensor network was deployed in one EJ community located near a major refinery to explore the capabilities of this emerging technology to complement existing ground-based measurements. Information from the various advanced technologies and project components complemented each other. Overall, the results of these advanced refinery measurements will provide unique information to inform community stakeholders about the air quality in these neighborhoods. The results of this advanced air monitoring portion of MATES V will be summarized and discussed in detail in a separate report.

In addition to the 10 fixed sites and the monitoring methods described above, mobile monitoring platforms focused on local scale studies at several locations for short durations were deployed. A unique set of rapidly deployable mobile air toxics monitoring platforms using the latest available technologies for continuous measurements were used. This was an important MATES V enhancement as continuous data, combined with continuous meteorological measurements, is extremely valuable in determining potential source locations and air pollutant variability.

Each of these platforms were equipped with a DustTrak DRX (TSI, Inc.); an instrument that continuously measures mass concentrations of different size fractions of PM. UFP measurements were achieved with a Condensation Particle Counter (CPC, model 3781; TSI, Inc.), which monitors the particle number concentrations down to 6 nm in size and up to concentrations of 500,000 particles per cubic centimeter (#/cm3). A portable Aethalometer (AE22; Magee, Inc.) for real-time measurements of black carbon (BC) was also installed as an indicator of diesel particulate matter (DPM).

The mobile monitoring efforts and results are summarized in Chapter 5.

2.4 Ambient Sampling Schedule

The MATES V project conducted air toxics monitoring at 10 locations over a one-year period beginning May 1, 2018 and ending April 30, 2019. Previous MATES monitoring dates are as follows: April 1998-March 1999 for MATES II, April 2004-March 2006 for MATES III, and July 2012-June 2013 for MATES IV. Sampling for MATES V followed a one-in-six day, 24-hour integrated-sampling schedule, identical to the U.S EPA federal programs sampling schedule. This type of sampling schedule is designed to provide a dataset that is representative of the overall levels in the area over the course of the year, including capturing day-of-week variations. Black carbon (BC) and ultrafine particles (UFP, particles smaller than 0.1 μm in size) were measured in addition to the air toxics. These measurements were conducted with continuous sampling methods as described below.

2.5 Monitoring and Laboratory Analysis

For MATES V, meteorological equipment and sampling equipment for canisters, TSP and PM2.5 filters, and carbonyl cartridges from the existing air monitoring network were used to the greatest extent possible. The South Coast AQMD laboratory provided analytical equipment and conducted analysis. The analytical methods used to measure ambient species are briefly described below and in Table 2-3. Detailed protocols are described in Appendix III.

Table 2-3 Sampling and Analysis Methods for MATES V

Species	Sampling	Laboratory Analysis
Ions in Particulate Matter	PM Filters	Water extracts were analyzed by ion chromatography (IC) with conductivity detection
Sugars (Levoglucosan, Mannosan, Galactosan)	PM Filters	Acetonitrile extracts were derivatized and then analyzed by gas chromatography – mass spectrometer (GC-MS)
TSP Metals	Cellulose Fiber Filters	Nitric acid extracts were analyzed by inductively coupled plasma mass spectrometry (ICP-MS)
PM2.5 Metals	PM Filters	Filters were analyzed by energy dispersive x-ray fluorescence spectrometry (XRF)
Hexavalent Chromium	Cellulose Fiber Filters	Bicarbonate extracts were analyzed via ion chromatograph (IC) equipped with post-column derivatization, and UV-visible spectroscopic detection
Elemental and Organic Carbon	PM Filters	Section of PM filter removed and analyzed on a laser corrected carbon analyzer
Carbonyls	DNPH Cartridge	Acetonitrile recovery and subsequent analysis via high performance liquid chromatography (HPLC) or ultra high performance liquid chromatography (UHPLC) with UV-visible spectroscopic detection
Volatile Organic Compounds	Silica-Lined Canisters	Canisters analyzed by gas chromatograph – mass spectrometer (GC-MS) with automated pre-concentration and cryo-focusing
Black Carbon	Continuous	Aethalometer
UFP	Continuous	Condensation Particle Counters (CPC)

Volatile Organic Compounds

Volatile organic compounds (VOCs) were measured from air samples collected in silica-lined canisters. VOCs were identified and quantified using pre-concentration and a gas chromatograph mass spectrometer (GC-MS) under the U.S. EPA TO-15 method.

Carbonyl Compounds

Carbonyl compounds were sampled by drawing air continuously through DNPH (2,4-Dinitrophenylhedrazine) impregnated cartridges. The carbonyl compounds undergo derivatization with DNPH, and the derivatives were extracted in acetonitrile and analyzed using high performance liquid chromatography (HPLC) or ultra high performance liquid chromatography (UHPLC) with UV-visible spectroscopic detection in accordance with U.S. EPA Method TO-11.

PAHS

Naphthalene and other polycyclic aromatic hydrocarbons (PAHs), components of both mobile source and stationary source emissions, were measured at two of the monitoring stations: Central Los Angeles and Rubidoux. Sample media were provided by the Eastern Research Group (ERG) and assembled into sampling cartridges by South Coast AQMD laboratory staff. Samples were collected by South Coast AQMD field staff and analyzed under the EPA NATTS Program by ERG after sampling cartridge deconstruction by South Coast AQMD laboratory staff. The Central Los Angeles and Rubidoux sites are part of the NATTS network.

Hexavalent Chromium

Hexavalent chromium (Chrome VI) was quantitated using ion chromatography (IC), post-column derivatization, and UV-visible spectroscopic detection. The filters are pre-treated with sodium bicarbonate to prevent conversion of Chrome VI to Chrome III. Chrome VI is extracted from the filter in sodium bicarbonate by sonication and subsequently analyzed using IC.

Particulate Matter

Total suspended particulates (TSP) and particulates less than 2.5 microns (PM2.5) were collected separately over a 24-hour period using size selective inlets according to U.S. EPA’s Federal Reference Methods (40CFR50).

Metals in Total Suspended Particulate (TSP) samples were extracted using nitric acid and the extracts were measured using ICP-MS. Metals in PM2.5 samples were determined by a non-destructive method, Energy Dispersive X-Ray Fluorescence Spectrometry. Identification of ions within the PM samples was performed by water extraction and analysis using Ion Chromatography with a conductivity detector.

Carbon analysis for Elemental Carbon (EC) and Organic Carbon (OC) was conducted by taking a small circular disk from sampled PM2.5 filters. The circular disk was placed into a carbon analyzer which utilizes a thermal optical transmittance method (IMPROVE A method) to measure the OC and EC content of the filter.

Particulate Sugars (Levoglucosan, Mannosan, Galactosan)

PM2.5 quartz filters are extracted in acetonitrile using sonication. The extracts are then derivatized and then analyzed using GC-MS. The method is further discussed in Appendix XII.

BC and UFP

BC measurements were carried out using Aethalometers. This instrument uses the light-absorbing properties of BC which is related to the particulate BC mass concentration.

UFP number concentration data were collected continuously (i.e. one-min. time resolution) using water-based Condensation Particle Counters. This instrument provides the total number concentration of particles above 7 nm in real-time.

Additional details of the methods are in Appendix VI.

Results for the BC and UFP monitoring are summarized in Chapter 5.

Diesel Particulate Matter

It is not possible to measure diesel particulate matter (PM) directly from ambient concentrations. However, one can use elemental carbon (EC) concentrations to estimate diesel PM concentrations. Since there are other non-diesel sources of EC, the ratio of EC to diesel concentrations are estimated from emissions or modeled concentration data. For MATES II and III, a single ratio representing the entire Basin for each study was calculated from emissions data; these methods are detailed in previous MATES reports. For MATES V, the ratio of modeled EC concentrations and modeled diesel PM concentrations was determined at each monitoring station. This ratio was then used to estimate the concentration of diesel PM from the measured EC concentrations at each station. To provide a consistent comparison, the same method was applied to the MATES IV data presented in this report. However, due to limited availability of modeling data, this method could not be applied to MATES II and III data. Table 2-4 shows the multiplication factors used to estimate diesel PM.

To ensure that the choice of methods to derive the multiplication factor did not bias the trend in diesel PM concentrations, basin-wide emission-based multiplication factors were also derived for MATES IV and MATES V. The use of these emission-based multiplication factors led to a very similar trend in diesel PM throughout each MATES study, establishing that the choice of methods does not influence the conclusions.

Table 2-4 Multiplication Factors for Estimating Diesel PM Concentrations.

		EC Multiply Factor	**Diesel Surrogate**
MATES II	All	1.04	PM10 Elemental Carbon
MATES III	All	1.95	PM2.5 Elemental Carbon
MATES IV	Anaheim	0.8597	PM2.5 Elemental Carbon
MATES IV	Burbank Area	0.8635	PM2.5 Elemental Carbon
MATES IV	Central L.A.	0.8792	PM2.5 Elemental Carbon
MATES IV	Compton	0.8282	PM2.5 Elemental Carbon
MATES IV	Huntington Park	0.7490	PM2.5 Elemental Carbon
MATES IV	Inland Valley San Bernardino	0.8268	PM2.5 Elemental Carbon
MATES IV	Long Beach	0.8654	PM2.5 Elemental Carbon
MATES IV	Pico Rivera	0.8803	PM2.5 Elemental Carbon
MATES IV	Rubidoux	0.9550	PM2.5 Elemental Carbon
MATES IV	West Long Beach	0.9502	PM2.5 Elemental Carbon
MATES V	Anaheim	0.7126	PM2.5 Elemental Carbon
MATES V	Burbank Area	0.7542	PM2.5 Elemental Carbon
MATES V	Central L.A.	0.7719	PM2.5 Elemental Carbon
MATES V	Compton	0.7053	PM2.5 Elemental Carbon
MATES V	Huntington Park	0.7347	PM2.5 Elemental Carbon

MATES V	Inland Valley San Bernardino	0.7702	PM2.5 Elemental Carbon
MATES V	Long Beach	0.7037	PM2.5 Elemental Carbon
MATES V	Pico Rivera	0.7167	PM2.5 Elemental Carbon
MATES V	Rubidoux	0.8658	PM2.5 Elemental Carbon
MATES V	West Long Beach	0.7668	PM2.5 Elemental Carbon

2.6 Quality Assurance and Quality Control

South Coast AQMD is committed to achieving high quality data of a known and defensible quality that meets the objectives for the MATES program, as well as other air monitoring programs. MATES V adopts a combination of existing quality assurance plans and activities from ongoing programs that provide comparability and consistency with MATES V goals. The South Coast AQMD is designated by U.S. EPA as a Primary Quality Assurance Organization (PQAO) with primary responsibility for ambient air monitoring and program satisfying data quality under its jurisdiction. The agency's Quality Management Plan (QMP[1]), approved by U.S. EPA in 2017, is the foundational document describing the agency's quality management system for air monitoring and laboratory analyses.

Quality Assurance (QA) encompasses all measures taken by management and staff to ensure that the quality of the finished product meets regulations, programmatic needs and the standards of the organization appropriate for the goals of the air measurement project. Major QA functions include review and oversight of program planning documents, records and procedures, as well as independent assessments of sampling procedures and instruments as well as performance testing of laboratory analyses. Quality Control (QC) encompasses the direct actions taken to achieve and maintain a desired level of quality including all the routine checks, maintenance and calibration verifications taken to achieve data reliability and measurement uncertainty.

Quality Assurance Project Plans (QAPPs) describe the required QA and QC steps and responsible entities, as well as plans for training, records management, and other related technical activities for the monitoring project or program. QAPPs incorporate Standard Operating Procedures (SOPs), which are specific directions for performing monitoring operations, support (maintenance, repairs, calibrations), lab analyses, and independent data quality assessment activities. The QAPP documents and summarizes plans for data review and validation, QA oversight, and the corrective action process that is used to document issues that may have significant or repeated impacts to data quality, completeness or safety, including the issue's resolution and steps to minimize recurrence.

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[1] The South Coast AQMD Quality Management Plan, Quality Assurance Project Plans (QAPPs) and related Standard Operating Procedures (SOPs) are available upon request through the South Coast AQMD Monitoring and Analysis Division, Quality Assurance Branch.

The gaseous and particulate pollutant measurements for MATES V are based on comparable measurements from ongoing federal and agency programs and use the same quality goals, QA/QC activities, and procedures described in South Coast AQMD QAPPs, as outlined below.

National Air Toxics Trends Stations (NATTS) Program

The MATES V quality goals and QA/QC activities for sampling and analyzing ambient levels of VOCs, carbonyls, hexavalent chromium, PAHs, and some metals were adopted from the U.S. EPA NATTS program. The South Coast AQMD NATTS QAPP was last revised in 2013 and is under revision to incorporate new elements in the October 2016 U.S. EPA revised NATTS Technical Assistance Document (TAD) and other recent changes to the program that have been implemented by South Coast AQMD.

Chemical Speciation Network Program (CSN)

The MATES V quality goals and QA/QC activities for monitoring and analyzing the components of fine particulate matter with diameters that are 2.5 micrometers and smaller (PM2.5), including Organic and Elemental Carbon (OC/EC), Anions, Cations, and trace metals, were adopted from the U.S. EPA CSN program. The requirements can be found in the South Coast AQMD PM2.5 Chemical Speciation Program QAPP, which was approved by U.S. EPA Region 9 in May 2014. This QAPP is also undergoing revision by staff to more fully incorporate both the U.S. EPA CSN Program process, where analyses are done by national contract laboratories, and changes in the South Coast AQMD supplemental chemical speciation program, where analyses are done by the South Coast AQMD laboratory (as done for MATES).

Criteria Pollutant Monitoring Program

The MATES V quality goals and QA/QC activities for monitoring and analyzing TSP-Lead (Pb) and PM2.5 fine inhalable particle mass were adopted from the U.S. EPA Criteria Pollutant Monitoring Program. These goals and requirements can be found in the South Coast AQMD Criteria Pollutant Monitoring Program QAPP, which, at the time of the MATES V monitoring, was last revised in 2016. This QAPP was recently revised again in April 2020 to incorporate new program elements and guidance, including that contained in the updated U.S. EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. II, Ambient Air Quality Monitoring Program (January 2017). This latest QAPP revision was approved by U.S. EPA Region 9 in July 2020.

Special Monitoring Programs

The South Coast AQMD Special Monitoring program provides air quality measurements in response to events such as wildfires, localized air quality concerns in communities, and pollutants from local sources, including rule compliance monitoring and rule development activities. The MATES V quality goals and QA/QC activities for monitoring and analyzing ultrafine particles (UFPs) and black carbon (BC) can be found in the South Coast AQMD Special Monitoring Program QAPP. It also describes the standardized practices and procedures followed by South Coast AQMD for monitoring other "non-criteria" pollutants and performing local-scale or facility focused measurement studies. The current version of this QAPP was last revised in 2013. This Special Monitoring QAPP is undergoing revision as a component of a new Special Monitoring and AB 617 Community Air Monitoring Programs QAPP.

2.7 MATES V Sampling Issues

Sampling manifold issues occurred during a portion of the May 2018 through April 2019 MATES V sampling period for VOC canister and carbonyl samples for three monitoring stations (Central Los Angeles, Rubidoux and Anaheim).[2] This was discovered during the South Coast AQMD Laboratory analysis and data validation process near the end of MATES V as staff identified anomalous carbonyls as compared to historic data. Lab staff informed the Quality Assurance Branch about the anomalous data with a Quality Assurance Alert (QAA), starting a corrective action process and the issuance of a Corrective Action Request (CAR) to trigger further investigation, evaluation, a data treatment plan, and corrective actions to resolve the issue and minimize the potential for future recurrence. Manifold flow testing at all ten MATES V stations, confirmed only minor leaks from loose manifold fittings at Rubidoux and Central Los Angeles and a more severe leak from a missing ferule on the manifold inlet at Anaheim. The leakage was especially indicated by unusually high formaldehyde and acetaldehyde concentrations associated with emissions from station building materials, such as flooring and wallboard. Since the leaks were associated with loose or missing fittings and not from completely disconnected sampling lines, the sampled air was still assessed to be predominantly ambient outdoor air. To further assess the impact of indoor air leakage on compounds of interest, staff conducted indoor/outdoor concurrent VOC canister and carbonyl sampling at each location. These samples were analyzed to identify potential for the leaks to bias data, by analyte.

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[2] Note that this sampling manifold issue also impacted other program samples on the same manifold at Central Los Angeles and Rubidoux, as follows: VOC and carbonyl sampling data for NATTS (same as MATES-V samples), PAMS, and CARB Air Toxics Program (VOC canister samples only).

Table 2-5 shows the time period of the manifold leaks at each station, along with the percentage of the MATES V period data invalidated. Due to the presence of significant outliers, all carbonyl data was invalidated during the leak period for all three stations. The invalidated analyte data was removed from the database and replaced with a null code (AQS Null Code BJ, Operator Error). When compared to historical data, the MATES VOC canister samples for Central Los Angeles and Rubidoux did not indicate outliers for those analytes; therefore, no results were invalidated. However, the data was flagged with a qualifier code (AQS Qualifier Code 3, Field Issue) to warn data users of potential data issues that could appear during data analysis. Due to the more severe magnitude of the manifold leak at Anaheim, all VOC data from this site was invalidated during the leak period.

Table 2-5 Manifold Leak Periods and Percentages of VOC and Carbonyl Data Invalidated by Site during the 1-Year MATES V Sampling Period

	Rubidoux	Central Los Angeles	Anaheim
MATES V Sampling Period (1 Year): 5/1/2018 – 4/30/2019			
MATES V Manifold Leak	5/1/2018 – 2 /19/2019	8/18/2018 – 4/25/2019	5/1/2018 – 4/30/2019
Percent of Invalidated VOC Samples	0% (0 of 61 samples)	0% (0 of 61 samples)	100% (61 of 61 samples)
Percent of Invalidated Carbonyl Samples	80%*	69%	100%

* Includes 2 Rubidoux carbonyl samples that invalidated due to other sampler run issues

2.8 Air Toxics Cancer Risk Estimates

Air toxic cancer risks are estimated using the risk assessment methodologies defined in the OEHHA Air Toxics Hot Spots Program Risk Assessment Guidelines (March 2015).[3] Although there are inherent uncertainties in risk assessment, as discussed in Chapter 1, risk assessment remains the most useful tool to estimate the potential health risks due to low level environmental toxics exposures. This risk assessment tool is also useful as a yardstick to measure progress towards improving air quality.

The MATES II and III reports relied on the 2003 OEHHA risk assessment guidance. In March 2015, OEHHA updated the methods for estimating cancer risks.4 The revised methodology includes utilizing age sensitivity factors to weigh early life exposure higher, as well as updated assumptions on breathing rates, and length of residential exposures. When combined together, staff estimates that risks for the same inhalation exposure level are about 2.5 times higher than using the 2003 OEHHA risk assessment methods.5 The MATES V analysis used the 2015 OEHHA guidance.

Two important updates were implemented for MATES V. First, previous MATES have calculated cancer risks from inhalation pathways only. MATES V estimates cancer risks

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[3] California Environmental Protection Agency Office of Environmental Health Hazard Assessment, Air Toxics Hot Spots Program Risk Assessment Guidelines. The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments. August 2003.

[4] California Environmental Protection Agency Office of Environmental Health Hazard Assessment, Air Toxics Hot Spots Program Risk Assessment Guidelines. The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments, February, 2014.

[5] In the May 2015 Final MATES IV Report, the increased in risk estimates was given as a 2.7 fold increase. This was based on using the 90th percentile of breathing rate distribution. In anticipation of CARB guidance for risk management, we have used the 80th percentile of the breathing rate distribution for ages greater than 2 years. This resulted in a 2.45 fold change in the estimate of risk.

resulting from both inhalation and non-inhalation pathways based on the 2015 OEHHA risk assessment guidance. Exposure from non-inhalation pathways result from substances that deposit on the ground in particulate form and contribute to risk through the ingestion of soil or homegrown crops, or through dermal absorption.[6] This methodology is consistent with how cancer risks are estimated in South Coast AQMD's programs such as permitting, Air Toxics Hot Spots (AB2588), and CEQA. Secondly, cancer risks from MATES II through IV measurements have been re-examined using the 2015 OEHHA risk assessment guidance and modern statistical methods to provide a consistent comparison of cancer risk trends.

2.9 Chronic Non-Cancer Health Impacts

Some toxic air contaminants are known to cause certain non-cancer health effects. To characterize these health impacts, hazard quotients (HQs) were calculated for air toxics that have existing chronic Reference Exposure Levels (RELs) established by OEHHA. A REL is defined as the concentration below which no adverse non-cancer health effects are anticipated for one or more target organ systems (reference: OEHHA Hot Spots, section 8.3). The HQ is calculated based on the long-term average concentration of a specific pollutant. An HQ of 1.0 or less indicates that adverse non-cancer health effects are not expected to result from long-term exposure to that concentration of that pollutant. As the HQ increases above 1.0, the likelihood of experiencing an adverse health effect increases. However, an HQ above one does not necessarily mean that health impacts will occur, because uncertainty factors are used in deriving the RELs. Additionally, the likelihood of experiencing an adverse non-cancer health effect may not scale linearly with the HQ. Both inhalation and non-inhalation pathways were used in calculating the HQs for this study.

Because many pollutants may affect the same target organ system, a hazard index (HI) is calculated by summing the HQs that impact the same target organ system. For each station, the largest HI is shown in the report.

Procedure for calculating chronic non-cancer hazard quotients and hazard indices at a measurement station

1. For each measured species:
    a. Calculate the product of the annual average concentration and a multi-pathway factor that considers exposures in addition to inhalation (soil, dermal, mother's milk, and homegrown crops)
    b. Calculate the multi-pathway hazard quotient by dividing the product from step 1a by the REL
    c. Apply the multi-pathway hazard quotient to all applicable impacted target organ systems (respiratory system, alimentary system, endocrine system, hematologic system, reproductive and development system, cardiovascular system, central nervous system, eyes, kidney, bone and teeth, immune

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[6] South Coast Air Quality Management District, Risk Assessments for Rules 1401 and 212. Risk Assessment Procedures for Rules 1401, 1401.1, and 212, Version 8.1, September 1, 2017. http://www.aqmd.gov/home/permits/risk-assessment.

system, skin)

2. For each target organ system:
    a. Calculate a hazard index by summing the multi-pathway hazard quotient of all species with impacts to the particular target organ
3. The target organ system with the maximum hazard index represents the chronic non-cancer health impact value at the measurement station

Chronic non-cancer health impact trends for MATES II through IV measurements were also calculated for this study using the 2015 OEHHA risk assessment methodologies. This provides a consistent comparison across studies for chronic non-cancer health impact values between previous MATES and the current study. Maximum hazard indices from all target organ systems are displayed in the Findings section below.

2.10 Findings

The findings are presented in terms of the annual average (Kaplan-Meier mean) concentrations of air toxics measured at each site as well as Basin-wide and by the estimated cancer risk and chronic HI resulting from exposures to these average concentrations. See Appendix XI for a description of the statistical handling of data below the method detection limit (MDL) and description of the Kaplan-Meier (KM) mean. In addition to the MATES V data, the data for MATES II through IV were re-analyzed as described in Appendix XI to assess trends in levels of air toxics in the Basin within a consistent analytical framework. In the following charts, the error bars denote the 95% confidence interval of the average based on bootstrap methods. See Chapter 1 for a description of the methods for calculating the cancer risk and chronic HI calculations. Appendix IV contains the results in tabular form, along with plots of the geographic distribution of our findings. Appendix IV also contains a table of the MDLs.

The KM mean cannot be reliably calculated if more than 80% of measurements within a data sample are below the MDL. When the KM mean cannot be calculated, upper and lower bound estimates of the average are provided instead. The lower bound estimate is found by substituting zero for all data below the MDL and calculating the average. The upper bound estimate is found by substituting the MDL for all data below the MDL and calculating the average. This uncertainty is shown in the bar graphs below by shading (diagonal lines on the bars) between the lower and upper bound estimates. The 95% confidence intervals are calculated for the zero-substituted mean using bootstrapping, which is a method of randomly sampling data and re-calculating the mean. 95% confidence intervals are also calculated for the MDL-substituted mean using bootstrapping. In the bar graphs below, the reported lower-bound of the 95% confidence interval is taken from the zero-substituted mean calculations and the upper-bound of the 95% confidence interval is taken from the MDL-substituted mean calculations when the KM mean could not be calculated.

In general, concentrations of most air toxics were substantially lower in MATES V compared to previous MATES. Graphs of the air toxics levels measured in MATES V with health risk assessment values for cancer risk or chronic HQ are shown below. Tables of results for all measured air toxics are provided in Appendix IV, as well as bar graphs for analytes that do not have risk or health impact calculations.

Diesel PM

Diesel PM estimates are shown in Figure 2-3, and illustrate the continuation of a trend of decreasing diesel PM over time at all stations. PM10 elemental carbon was used as the diesel PM surrogate for MATES II (see Table 2-4) and is shown in Figure 2-4. PM2.5 elemental carbon was used as the diesel PM surrogate for MATES III-V (see Table 2-4) and is shown in Figure 2-5. Error bars for diesel PM for MATES IV and V were calculated by propagating the uncertainties from the PM2.5 elemental carbon KM means and the linear fit of the model data used to calculate the elemental carbon to diesel PM conversion factor.[7]

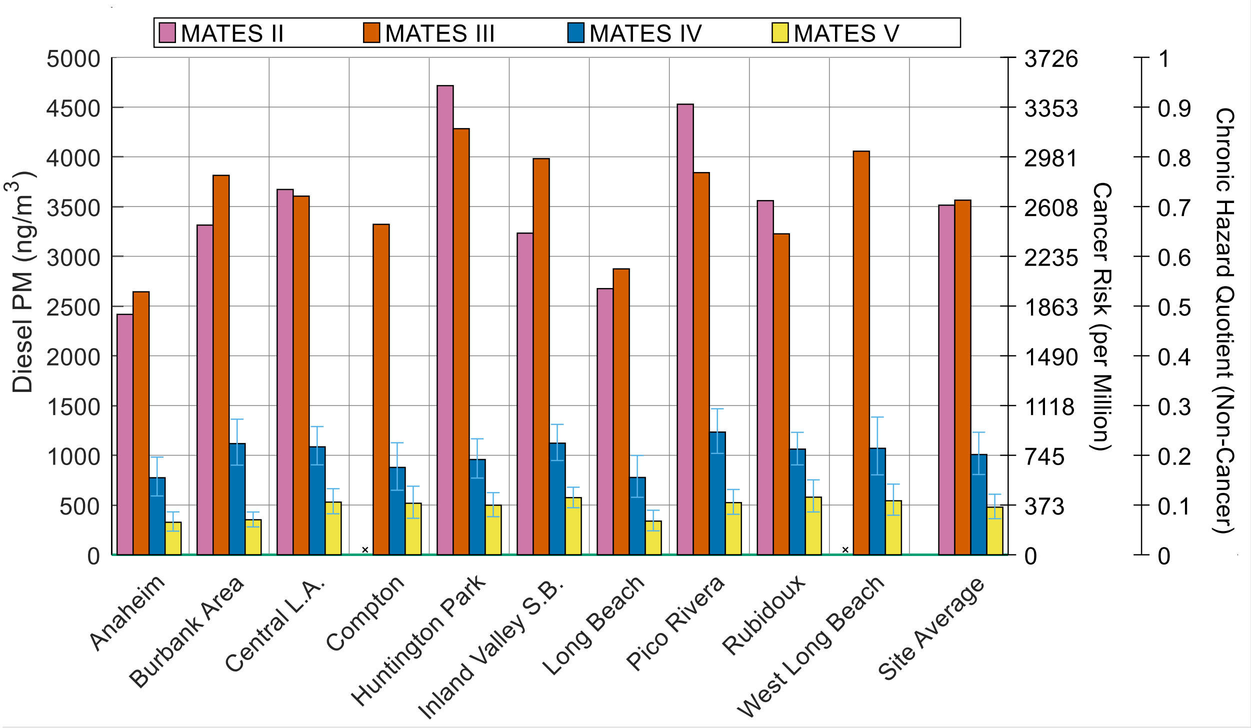

Figure 2-3 Diesel PM Concentration Estimates. "x" indicates that there is no data for a given station/MATES iteration.

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[7] Propagation of uncertainties methods from "An Introduction to Error Analysis, Second Edition" by John R. Taylor, 1997.

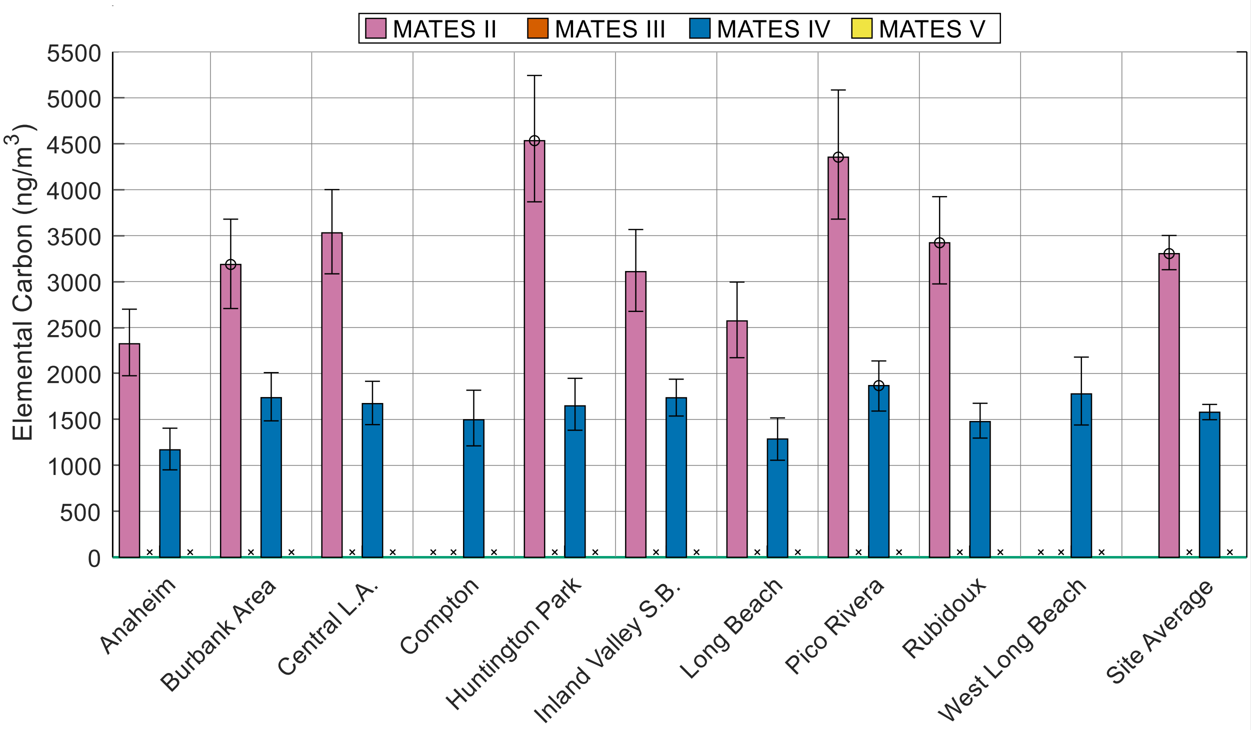

Figure 2-4 Annual Average Concentrations of Elemental Carbon in the PM10 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “o” indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. “x” indicates that there is no data for a given station/MATES iteration. Error bars denote the 95% confidence interval.

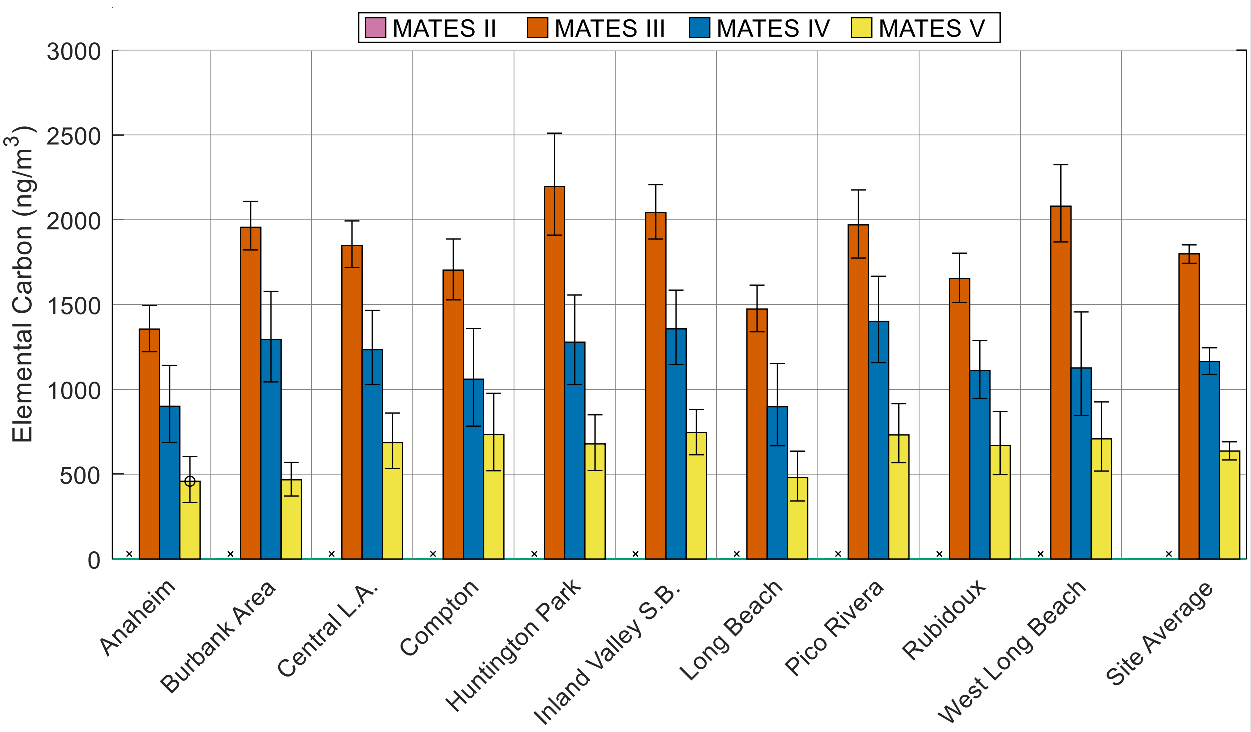

Figure 2-5 Annual Average Concentrations of Elemental Carbon in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. "x" indicates that there is no data for a given station/MATES iteration. Error bars denote the 95% confidence interval.

Volatile Organic Compounds (VOCs) and Carbonyls

Figure 2-6 and Figure 2-7 present levels for benzene and 1,3-butadiene, which are emitted predominantly from gasoline-powered mobile sources. Both benzene and 1,3-butadiene show a continuing reduction in annual average levels. These decreases are likely reflective of reduced emissions from vehicle fleet turnover to newer vehicles and use of reformulated gasoline. Concentrations of toluene are shown in Figure 2-8. Toluene also shows a continuing decreasing trend. Cancer risks are not shown for toluene because there is insufficient evidence that it is carcinogenic, and therefore OEHHA has not established cancer potency values for this pollutant.

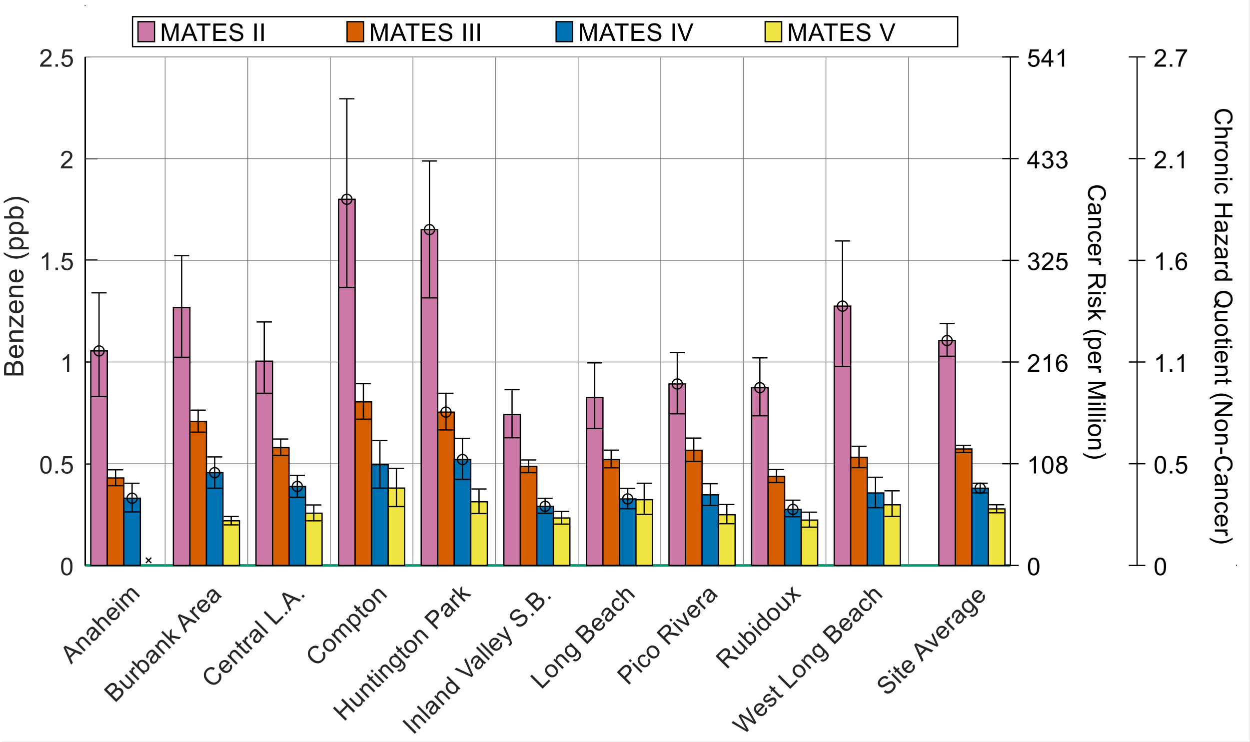

Figure 2-6 Average Concentrations of Benzene. "x" indicates that there is no data for a given station/MATES iteration. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

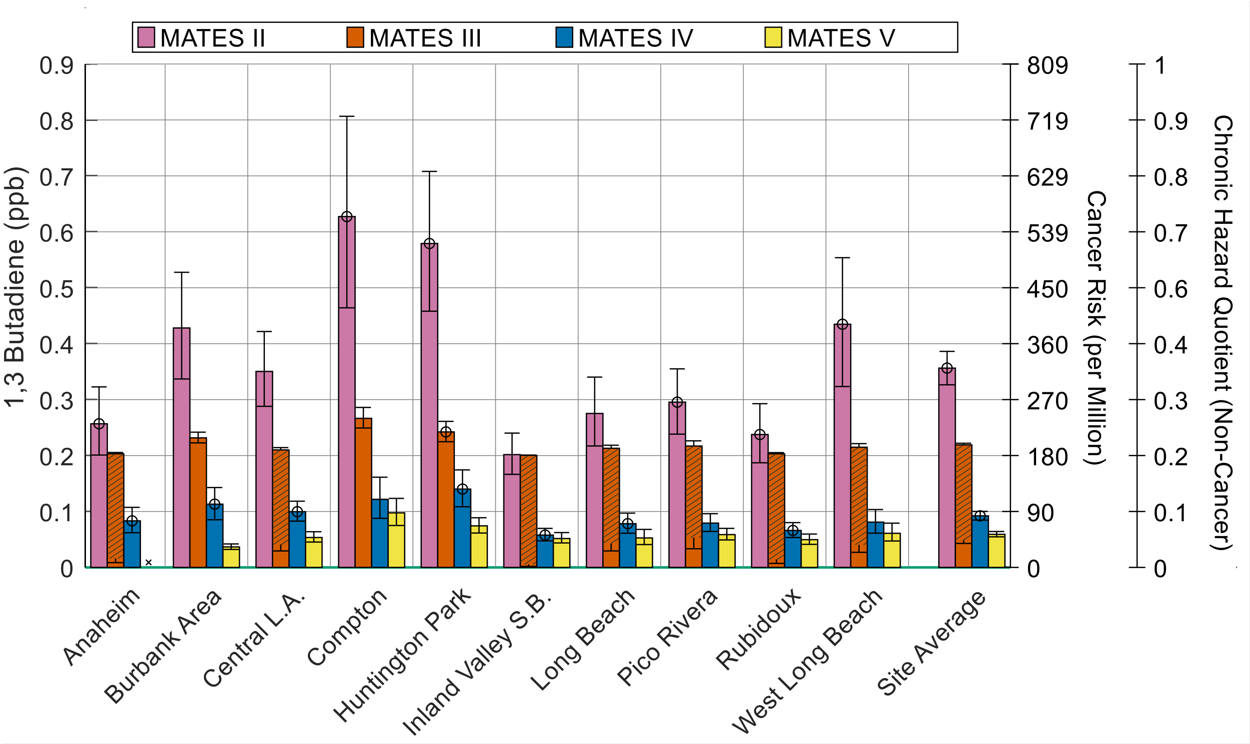

Figure 2-7 Average Concentrations of 1,3 Butadiene. The diagonal lines (shading) on some of the bars for the MATES III stations indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

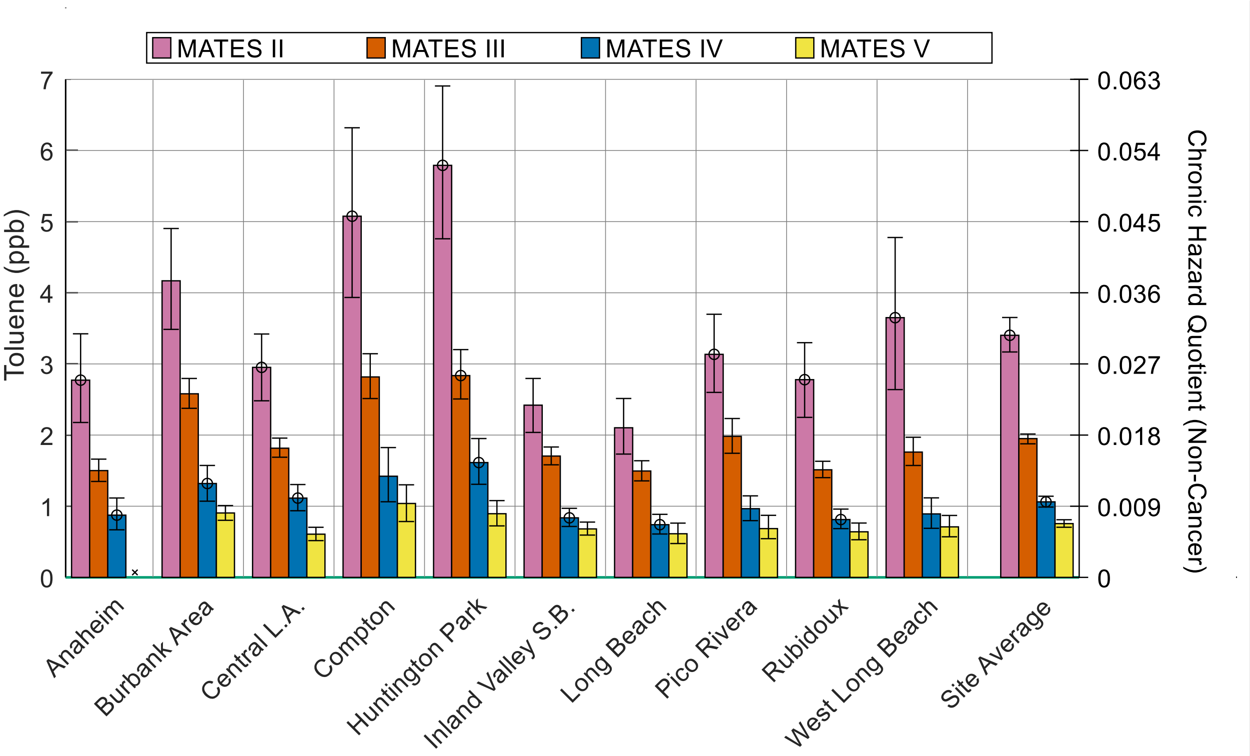

Figure 2-8 Average Concentrations of Toluene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Levels of the chlorinated solvents perchloroethylene and methylene chloride are shown in Figure 2-9 and Figure 2-10. Perchloroethylene shows a continuing reduction in levels, likely a result of a number of air quality regulations leading to the gradual phase-out of its use as an industrial and dry cleaning solvent in the South Coast AQMD jurisdiction. Methylene chloride shows a generally downward trend over time, but the trend is not consistent across all stations. The Rubidoux station continued to have the highest levels of methylene chloride, although the levels measured in MATES V are substantially lower than the high levels detected in MATES IV. These levels likely reflect its use as a solvent and may be influenced by specific activities near the monitoring locations.

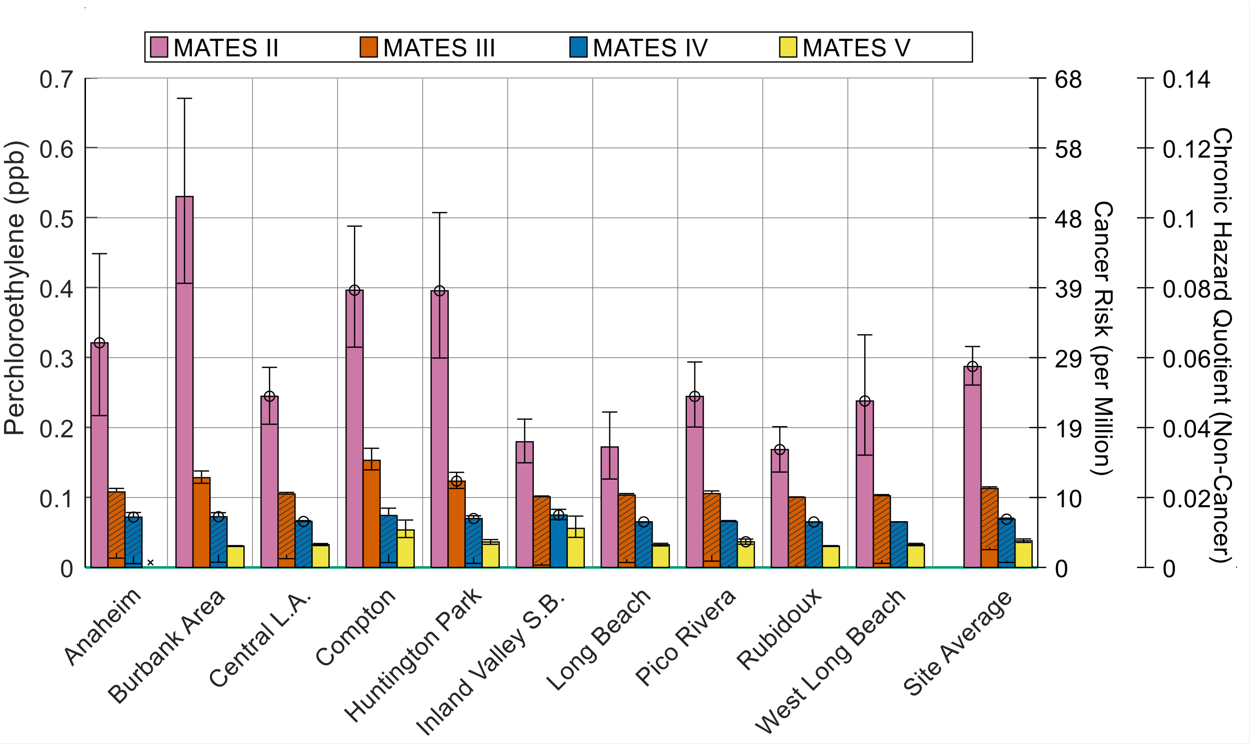

Figure 2-9 Average Concentrations of Perchloroethylene. The diagonal lines (shading) on some of the bars for the MATES III stations indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

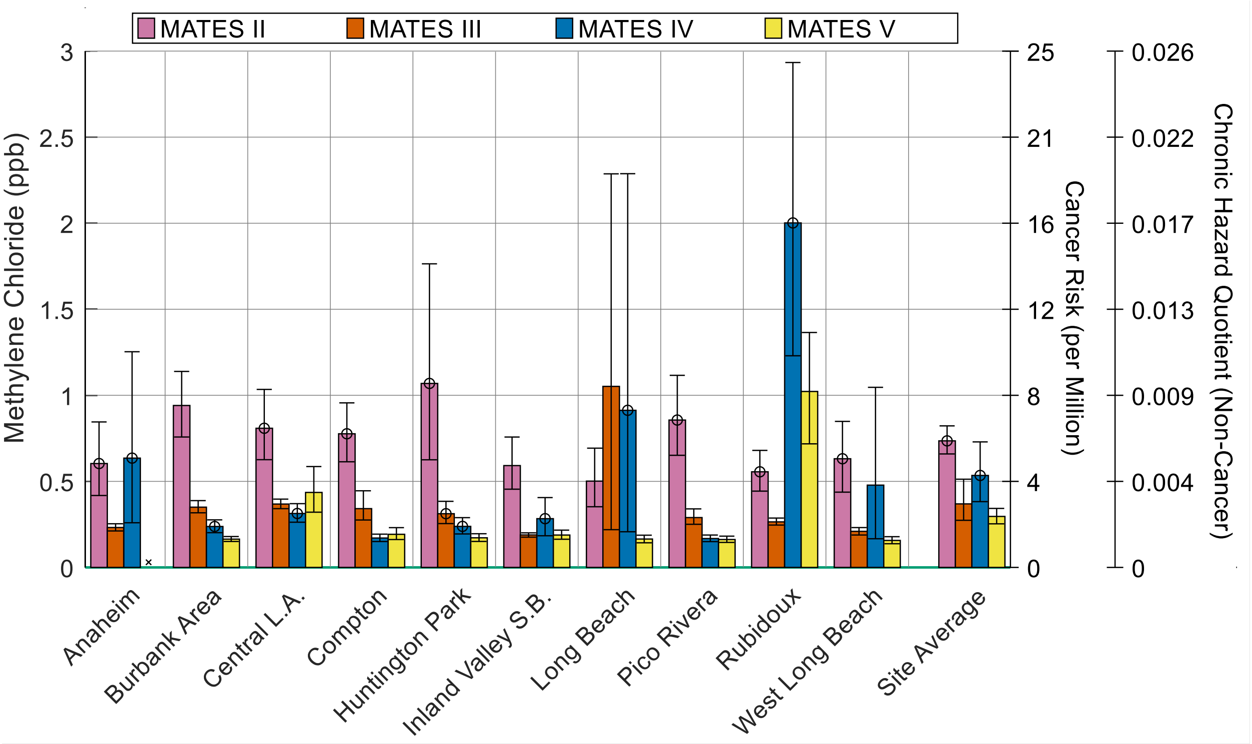

Figure 2-10 Average Concentrations of Methylene Chloride. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Formaldehyde and acetaldehyde concentrations are shown in Figure 2-11 and Figure 2-12. While MATES IV and V formaldehyde concentrations were generally lower than concentrations measured during MATES II and III, formaldehyde concentrations have increased slightly since MATES IV at the majority of stations. Formaldehyde is emitted from mobile sources and is also formed as a secondary pollutant through chemical reactions of VOCs in the atmosphere. Since secondary formation is a significant source of formaldehyde, it is not possible to ascribe changes to a particular source. Acetaldehyde concentrations do not exhibit a consistent trend over time throughout the Basin. Acetaldehyde is produced by combustion sources and throughout the chemical and food industry.

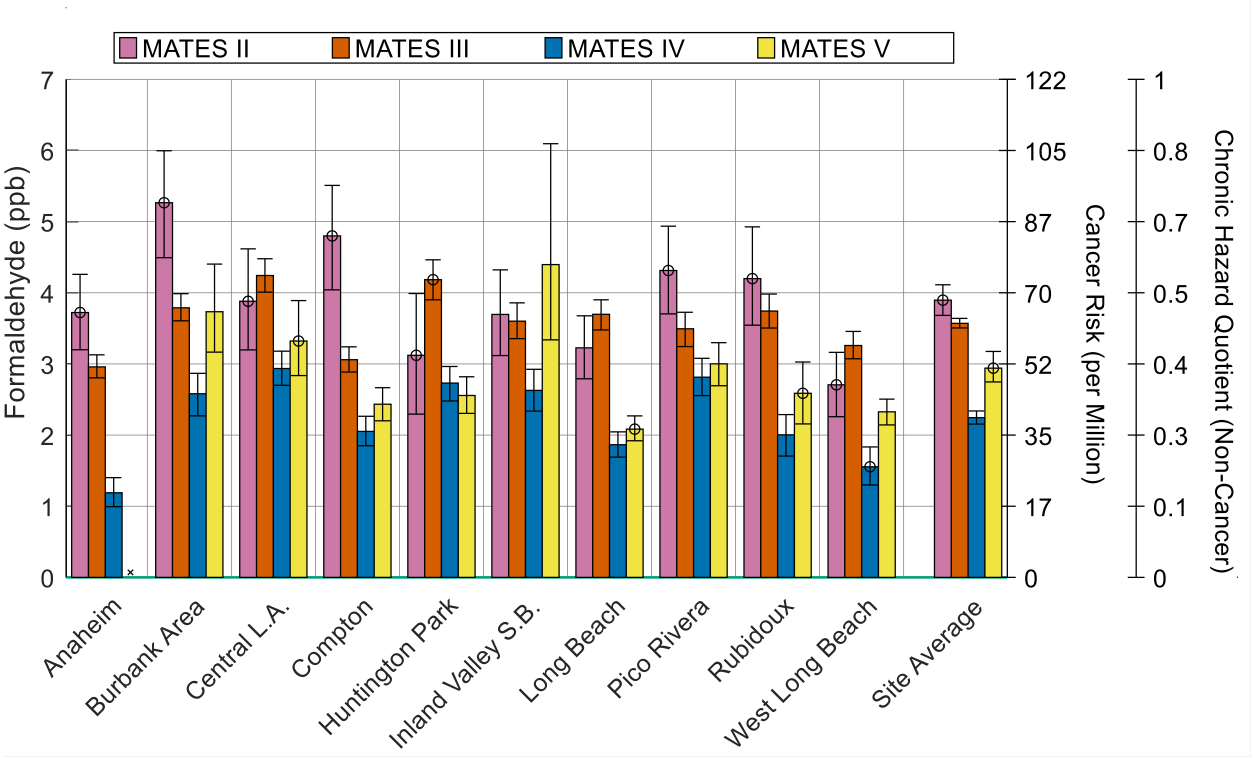

Figure 2-11 Average Concentrations of Formaldehyde. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

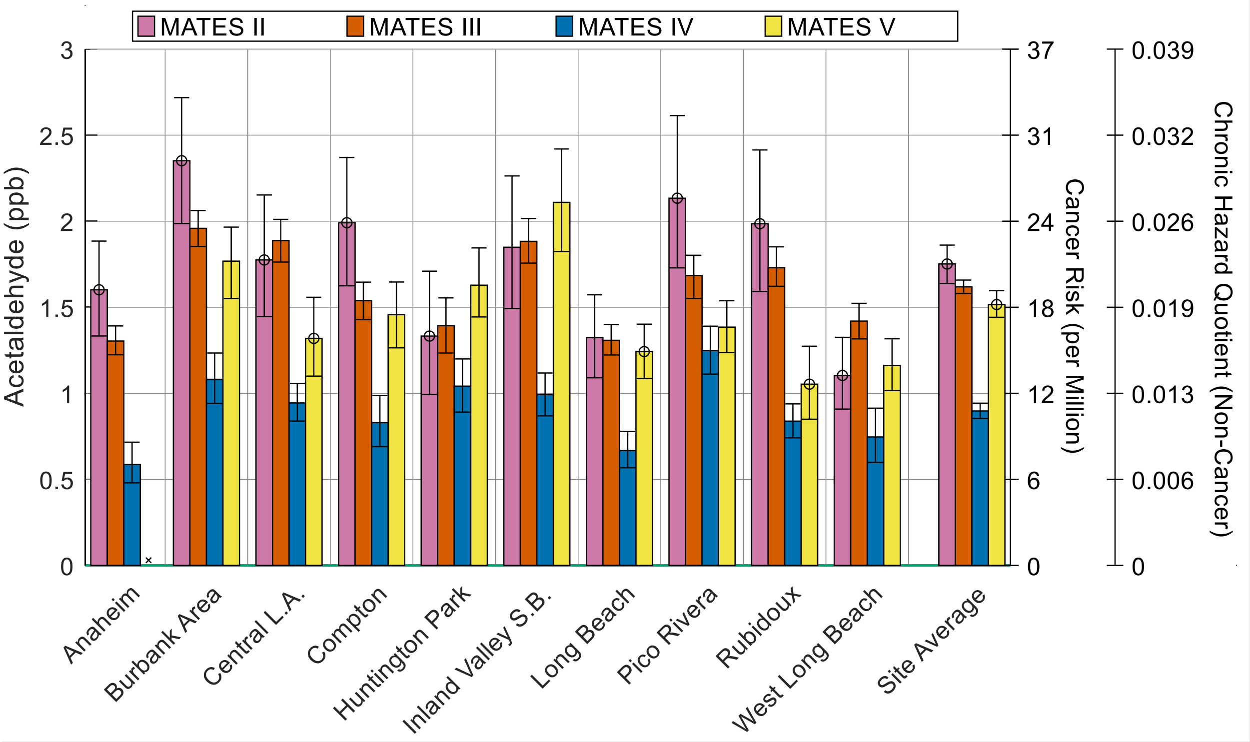

Figure 2-12. Average Concentrations of Acetaldehyde. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Carbon tetrachloride concentrations are shown in Figure 2-13. While uses of carbon tetrachloride as a solvent, in fire extinguishers and in other applications such as cleaning agents has largely been eliminated, some local emissions from industrial sources remain.[8] In addition, a long atmospheric lifetime of 85 years and previous widespread use results in a global background concentration of approximately 0.07 ppb.[9,10]

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[8] https://www.epa.gov/sites/production/files/2020-10/documents/1_ccl4_risk_evaluation_for_carbon_tetrachloride.pdf
[9] https://cdiac.ess-dive.lbl.gov/pns/current_ghg.html
[10] https://www.esrl.noaa.gov/gmd/hats/combined/CCl4.html

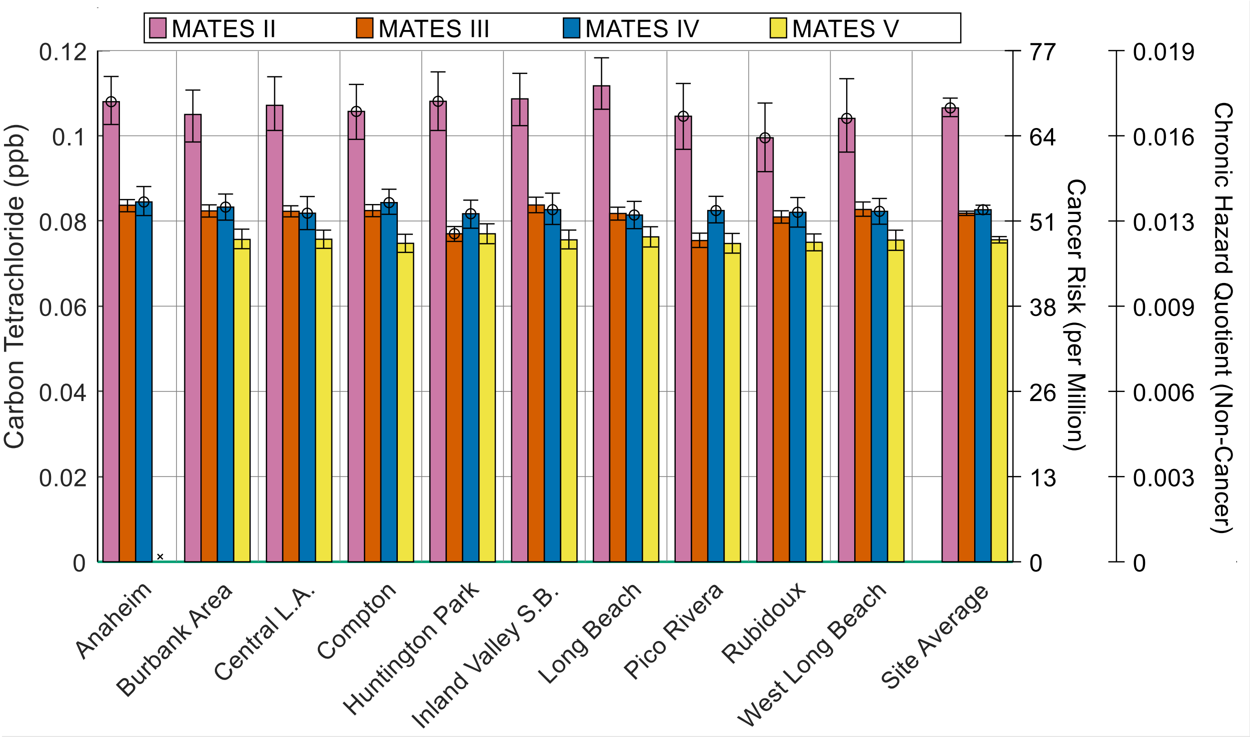

Figure 2-13 Average Concentrations of Carbon Tetrachloride. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of ethyl benzene are shown in Figure 2-14. Ethyl benzene shows a continuing reduction in levels at most stations, likely due to reductions of this aromatic compound in fuels, improved vehicle vapor/emission controls, and reduced usage as a solvent. Concentrations of xylene (m-, p-) are shown in Figure 2-15. Similar to ethyl benzene, xylene (m-, p-) and xylene (o-) show a continuing reduction in concentrations for all stations except for the unusually high levels found in MATES IV at the Central L.A. station. Xylene (o-) concentrations are shown in Figure 2-16. Xylene (o-) also had an increase in concentration in MATES IV followed by a decrease in MATES V at Central L.A. The higher average levels of ethyl benzene, xylene (m-, p-), and xylene (o-) at the Central L.A. station during MATES IV were largely due to higher levels observed on a handful of days during the summer of 2012. Such high levels did not recur in MATES V, and the Central L.A. station showed levels of these VOCs that were similar to the other locations. Most stations show reductions in levels of xylene (o-) during MATES II through IV, however MATES V xylene (o-) concentrations are similar to those of MATES IV at most stations. Cancer risks are not shown for xylene (m-, p-) and xylene (o-) because OEHHA has not established cancer risk potency values for xylene (m-, p-) and xylene (o-).

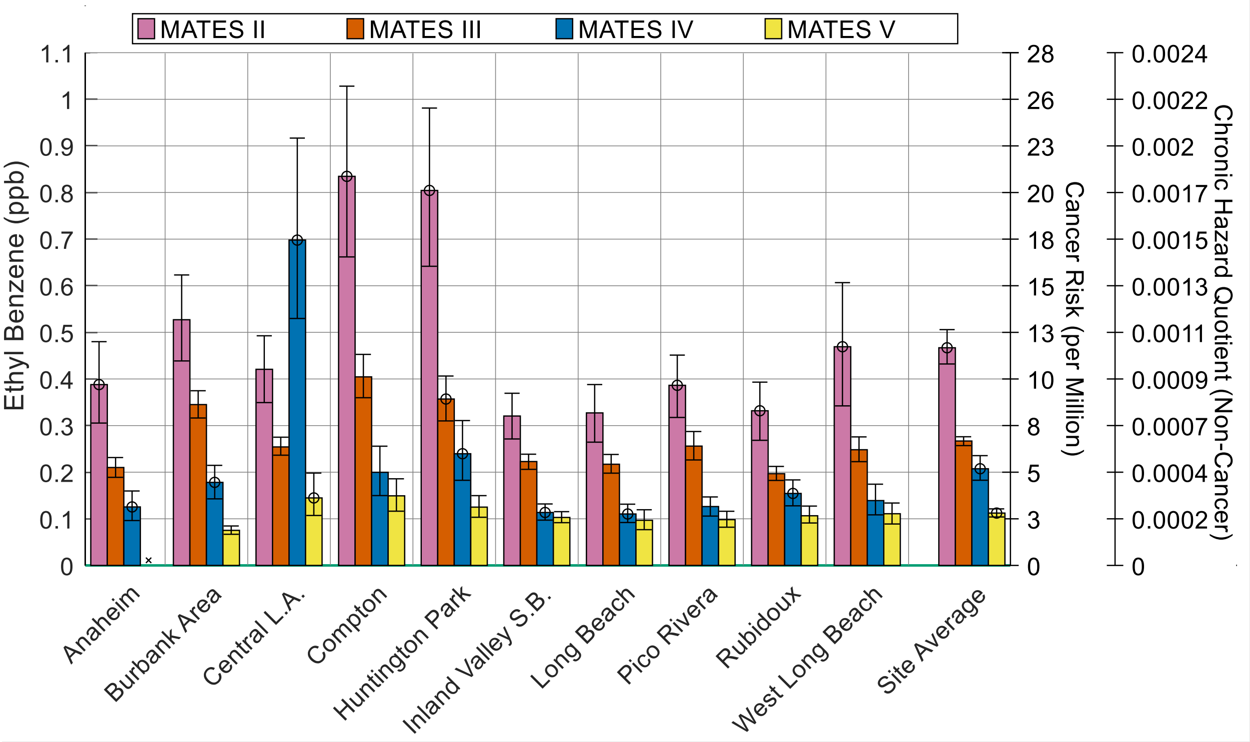

Figure 2-14 Average Concentrations of Ethyl Benzene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

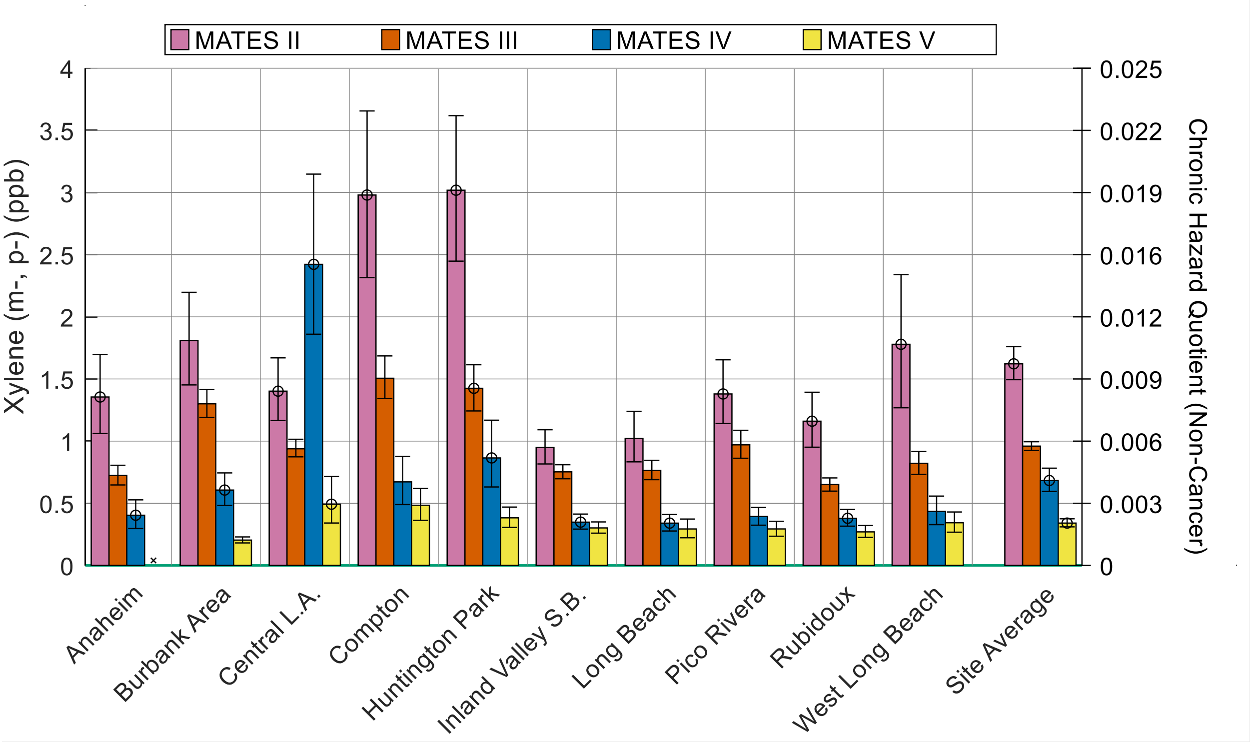

Figure 2-15 Average Concentrations of Xylene (m-, p-). “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

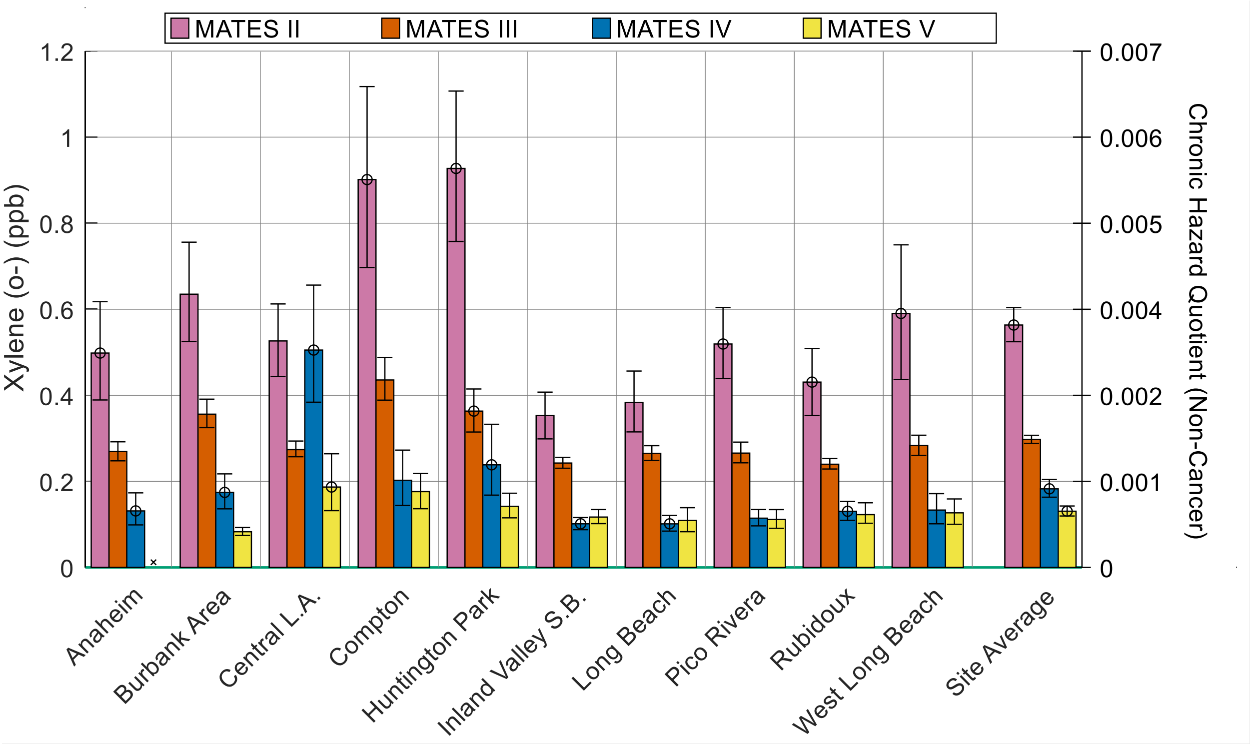

Figure 2-16 Average Concentrations of Xylene (o-). "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of acrolein (2-propenal) are shown in Figure 2-17. Concentrations of acrolein increased at most stations from MATES IV to V. Acrolein was not measured during MATES II or III. Acrolein is formed from combustion processes and reaction of other VOCs in the atmosphere. Cancer risks are not shown for acrolein because OEHHA does not have cancer risk assessment values for this pollutant.

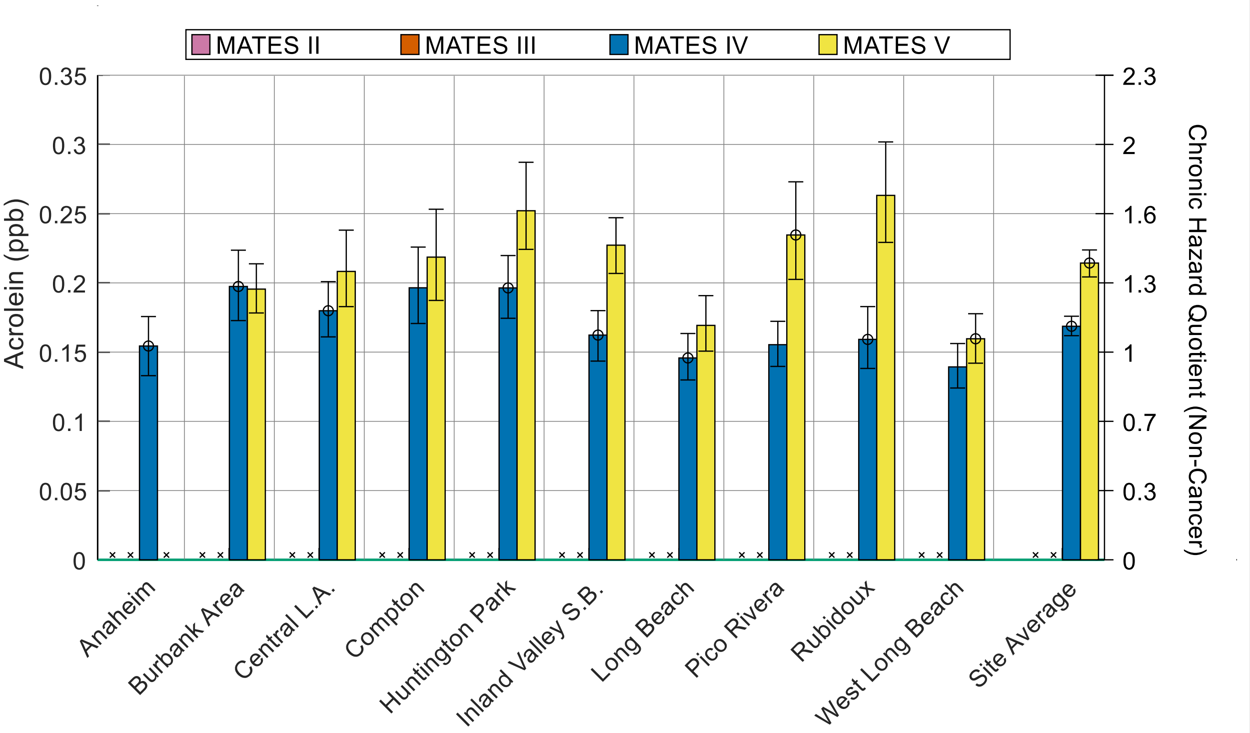

Figure 2-17 Average Concentrations of Acrolein. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of bromomethane (methyl bromide) are shown in Figure 2-18. Bromomethane was not measured in previous MATES projects. The concentrations at West Long Beach are substantially higher than all other stations. Bromomethane is used as a fumigant for agricultural products, and some fumigation facilities are located near the ports. One such facility is located a few hundred feet west of the West Long Beach MATES station; these localized emissions could have influenced the levels detected in this location. Cancer risks are not shown for bromomethane because there are no cancer potency values for bromomethane established by OEHHA. Figure 2-19 shows the same bromomethane data with narrower y-axis limits to show the values of stations with lower concentrations more clearly.

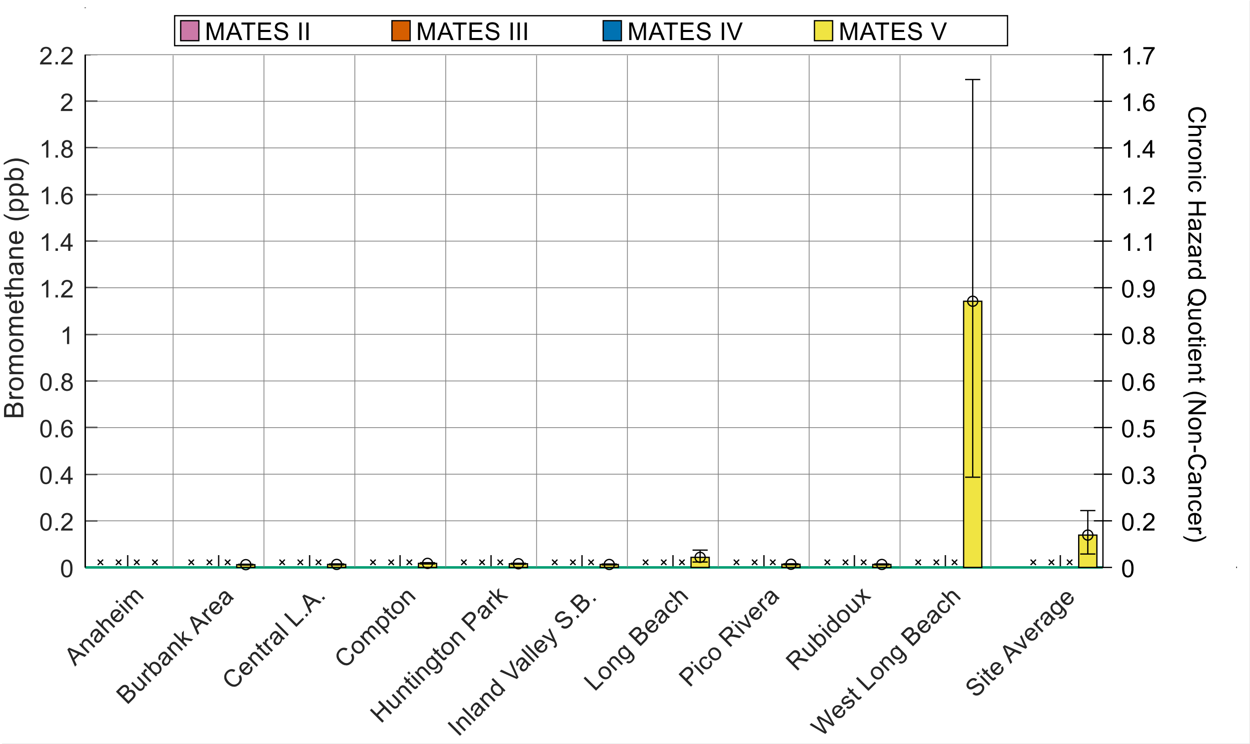

Figure 2-18 Average Concentrations of Bromomethane. "x" indicates that there is no data for a given station/MATES iteration. Note that bromomethane measurements began on August 12, 2018 and therefore, do not constitute a complete year of measurements. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

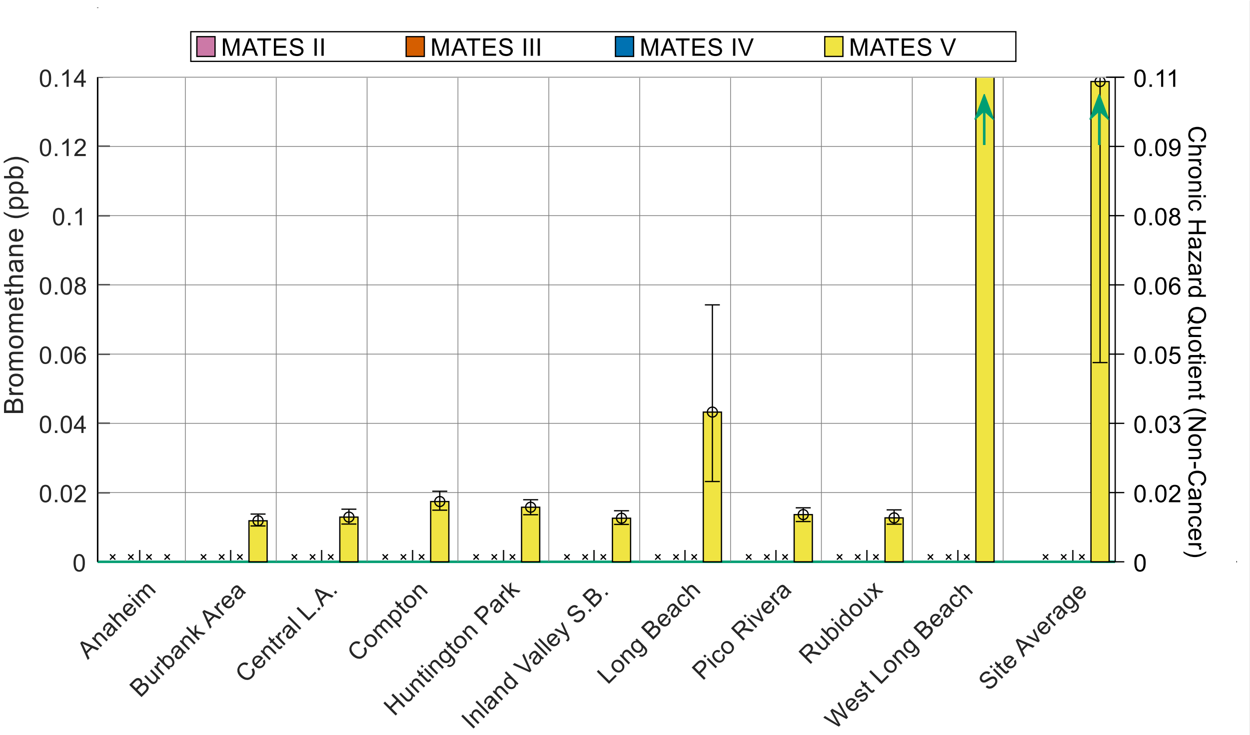

Figure 2-19 Average Concentrations of Bromomethane. "x" indicates that there is no data for a given station/MATES iteration. Note that bromomethane measurements began on August 12, 2018 and therefore, do not constitute a complete year of measurements. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

Concentrations of 1,4-Dichlorobenzene are shown in Figure 2-20. The shading on a bar indicates that more than 80% of the data used to calculate that bar were below detection limit. Caution should be used when interpreting trends with shaded bars since the height of shaded bars represent upper bound estimates using MDL substitution for data below the detection limit. However, since the KM mean was calculated for the MATES II data (i.e., those bars are not shaded) and the upper bound estimates of the MATES V data are substantially lower than the MATES II KM means, we conclude that there has been a substantial decline in 1,4-Dichlorobenzene concentrations from MATES II to MATES V.

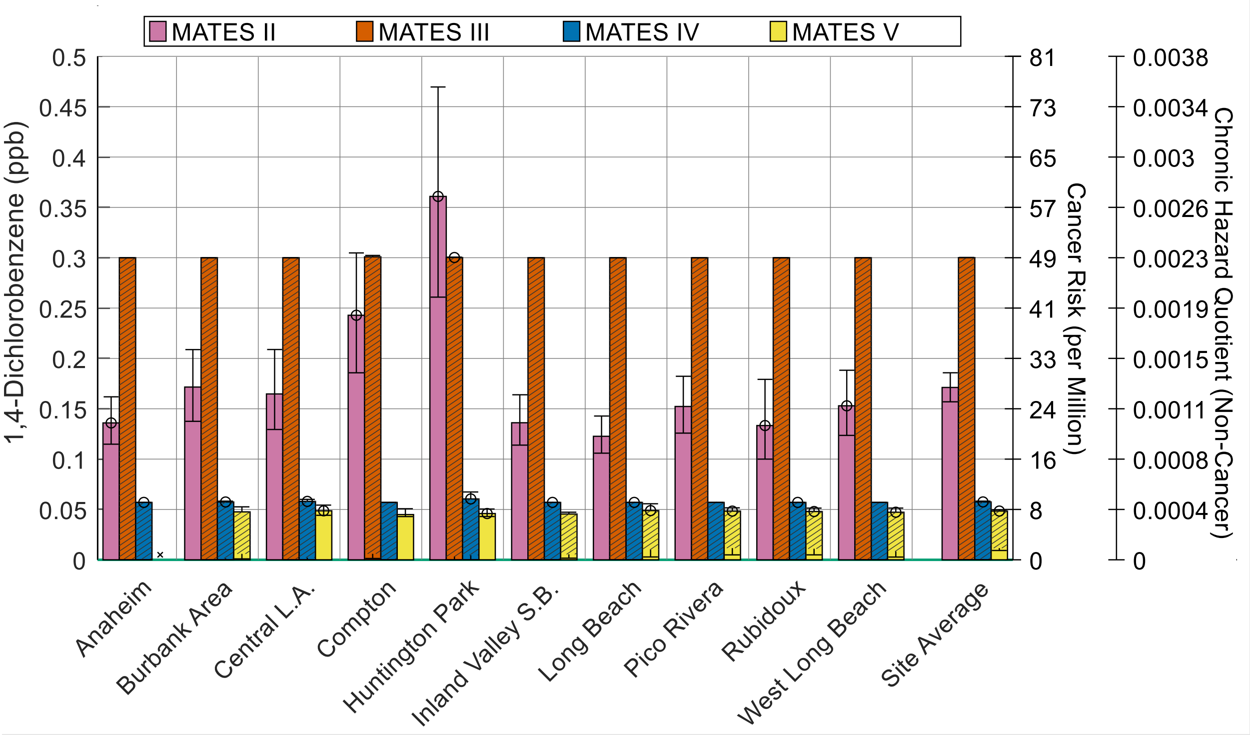

Figure 2-20 Average Concentrations of 1,4-Dichlorobenzene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of trichloroethylene are shown in Figure 2-21. The shading on a bar indicates that more than 80% of the data used to calculate that bar were below detection limit. Caution should be used when interpreting trends with shaded bars since the height of shaded bars represent upper bound estimates using MDL substitution for data below the detection limit. However, since the KM mean was calculated for the MATES II data (i.e., those bars are not shaded) and the upper bound estimates of the MATES V data are lower than the MATES II KM means at most stations, we conclude that there has been a decline in trichloroethylene concentrations from MATES II to MATES V at most stations.

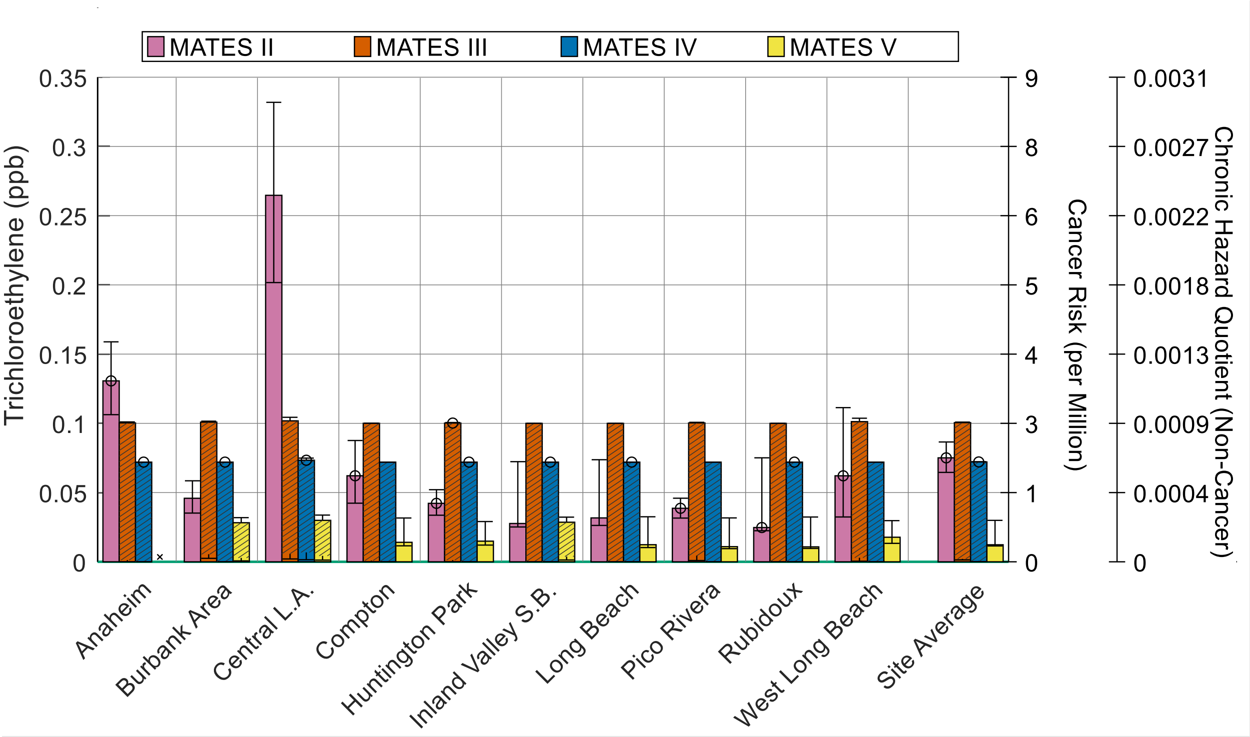

Figure 2-21 Average Concentrations of Trichloroethylene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Styrene concentrations are shown in Figure 2-22. Styrene concentrations have decreased at all stations since MATES II.

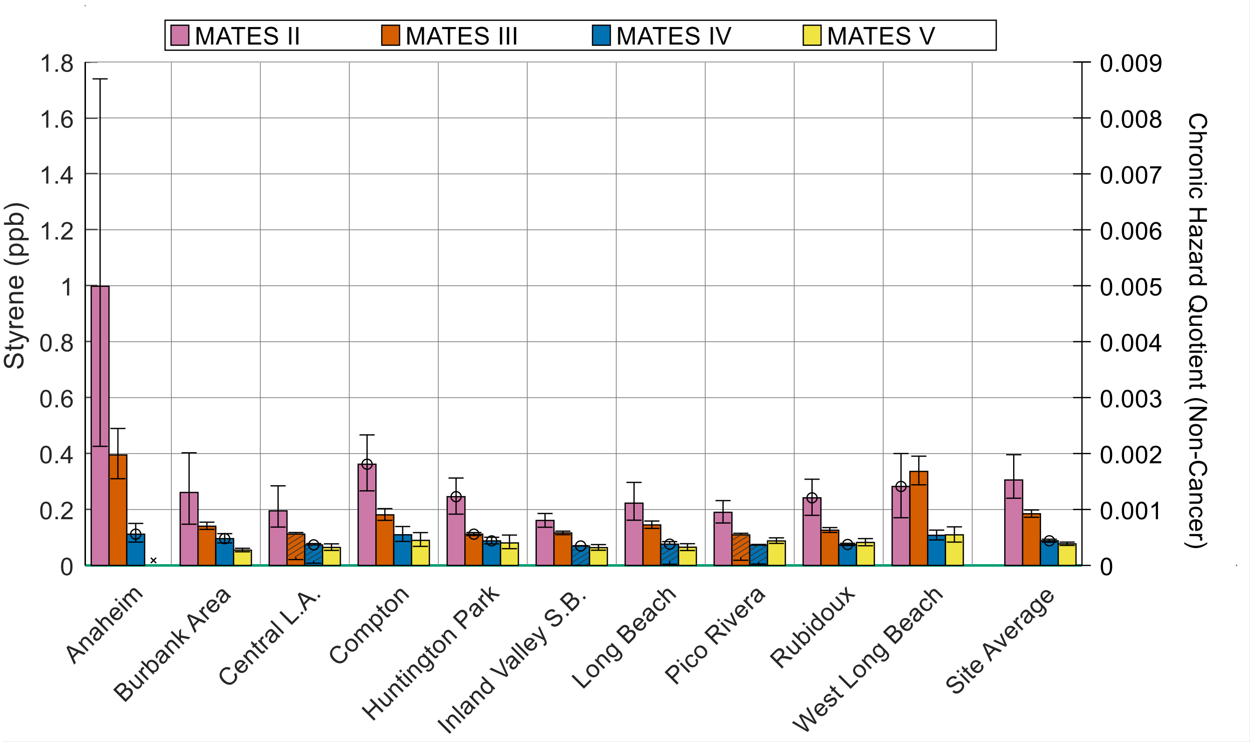

Figure 2-22 Average Concentrations of Styrene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of chloroform are shown in Figure 2-23. Chloroform concentrations have declined substantially from MATES II to MATES V at Burbank Area and Huntington Park stations, with modest declines at most other stations. More than 80% of measurements at most stations were below the MDL during MATES III and IV, as indicated by the shaded bars in Figure 2-23. The height of the shaded bars indicates upper bound estimates of the average annual concentrations.

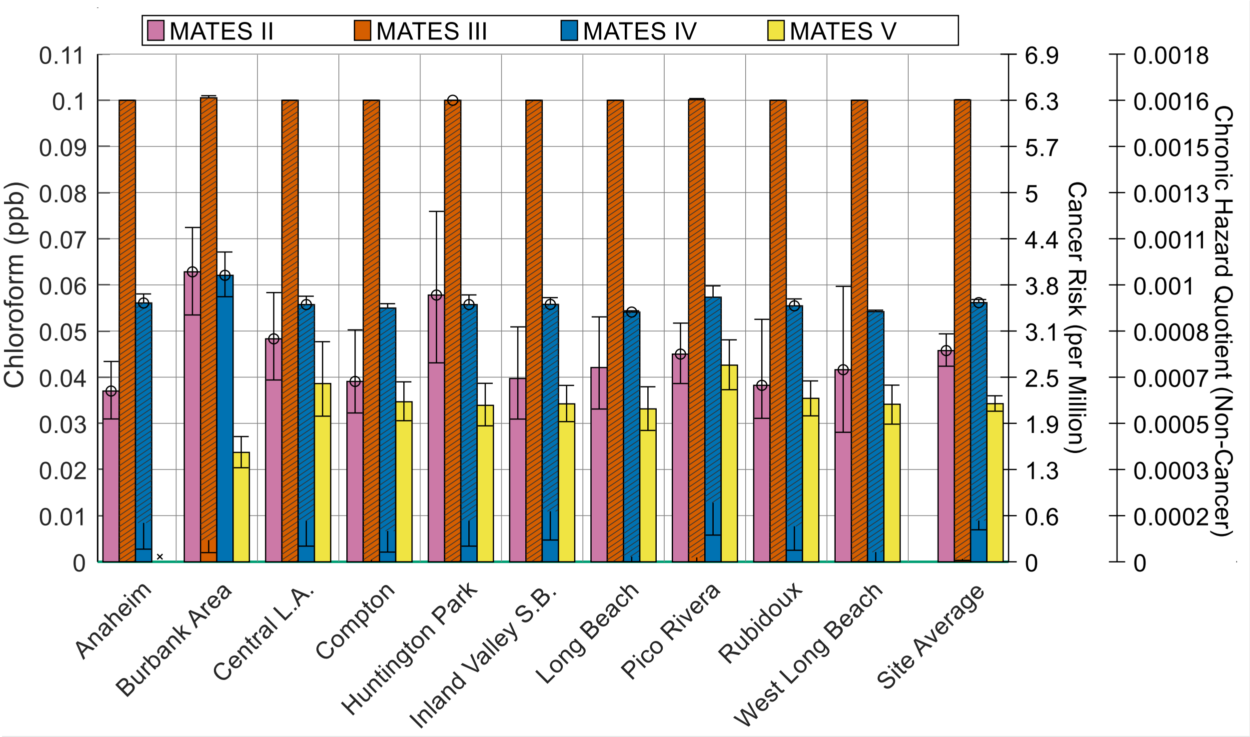

Figure 2-23 Average Concentrations of Chloroform. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of 1,2-Dichloroethane are shown in Figure 2-24. The shading on the bars indicates that 80% of the data were below their MDL at all stations for most of the MATES projects (all except MATES V). This means that changes in the height of the bars over time are primarily reflective of changes of MDLs over time, and trends in concentrations over time cannot be determined from these data. The data do provide lower and upper bound estimates of average annual concentrations.

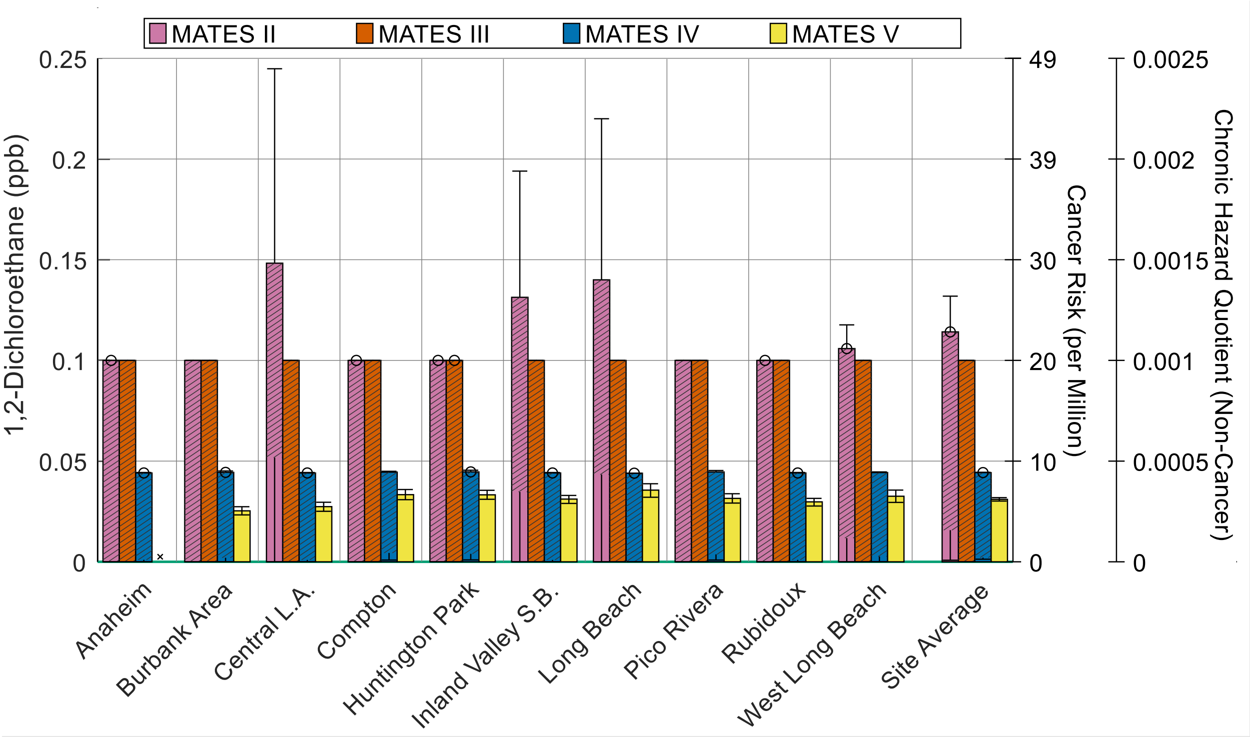

Figure 2-24 Average Concentrations of 1,2-Dichloroethane. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

More than 80% of the measurements of vinyl chloride and Methyl tertiary-butyl ether (MTBE) were below their MDLs at all stations for all MATES studies. All measurements of 1,2-Dibromoethane were below their MDLs at all stations for all MATES studies. Therefore, the MATES studies are not able to provide significant information on trends in these pollutant concentrations over time.

Metals

Airborne arsenic levels are shown in Figure 2-25. The shading on all of the MATES II bars in Figure 2-25 indicates that more than 80% of all measurements were below their MDLs at all stations for MATES II. The heights of the MATES II bars provide upper bound estimates of the average annual concentrations and cannot be used for determining trends over time. Figure 2-25 indicates the TSP arsenic concentrations have decreased between MATES III and MATES V in nine out of ten stations. More than 80% of the MATES III Anaheim measurements were below the MDL and cannot be used for determining trends. There is an increase in TSP arsenic concentrations from MATES IV to V at Anaheim, although the levels at this station are lower than the other MATES stations. There is a decline in TSP arsenic at Central L.A. from MATES IV to MATES V. Other stations show little change in TSP arsenic from MATES IV to MATES V. Sources of arsenic include paved road dust, construction dust, mineral processes, metal processes, refineries and fuel combustion.

The TSP arsenic concentrations from MATES V are consistent with or lower than those measured at most of the 79 sites in 13 states around the U.S. in the Ambient Monitoring Archive (AMA) for 2017 (https://www3.epa.gov/ttn/amtic/toxdat.html#data). South Coast AQMD staff analyzed the 2017 AMA data using the same methods used for the MATES data (see Appendix XI). One site in Pennsylvania has a 95% confidence interval entirely lower than the 95% confidence intervals observed for the SoCAB for MATES V. Several sites around the nation have 95% confidence intervals that are entirely above the 95% confidence intervals seen in MATES V. All other sites in the AMA data have 95% confidence intervals that overlap with those of MATES V (see Appendix IV).

The Bay Area Air Quality Management District’s CARE study[11] reported that arsenic and mercury were major contributors to the chronic non-cancer health impacts related to the nervous system, based on three years of monitoring data (2010-2013) from a site in Cupertino located half a mile from a cement plant. While this site is likely not representative of most residential locations, it does provide a point of comparison. Average arsenic levels found in the CARE study Cupertino site was 0.12 ng/m3, which is lower than the average levels found in MATES V.

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[11] https://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/CARE%20Program/Documents/CARE_Retrospective_April2014.ashx?la=en

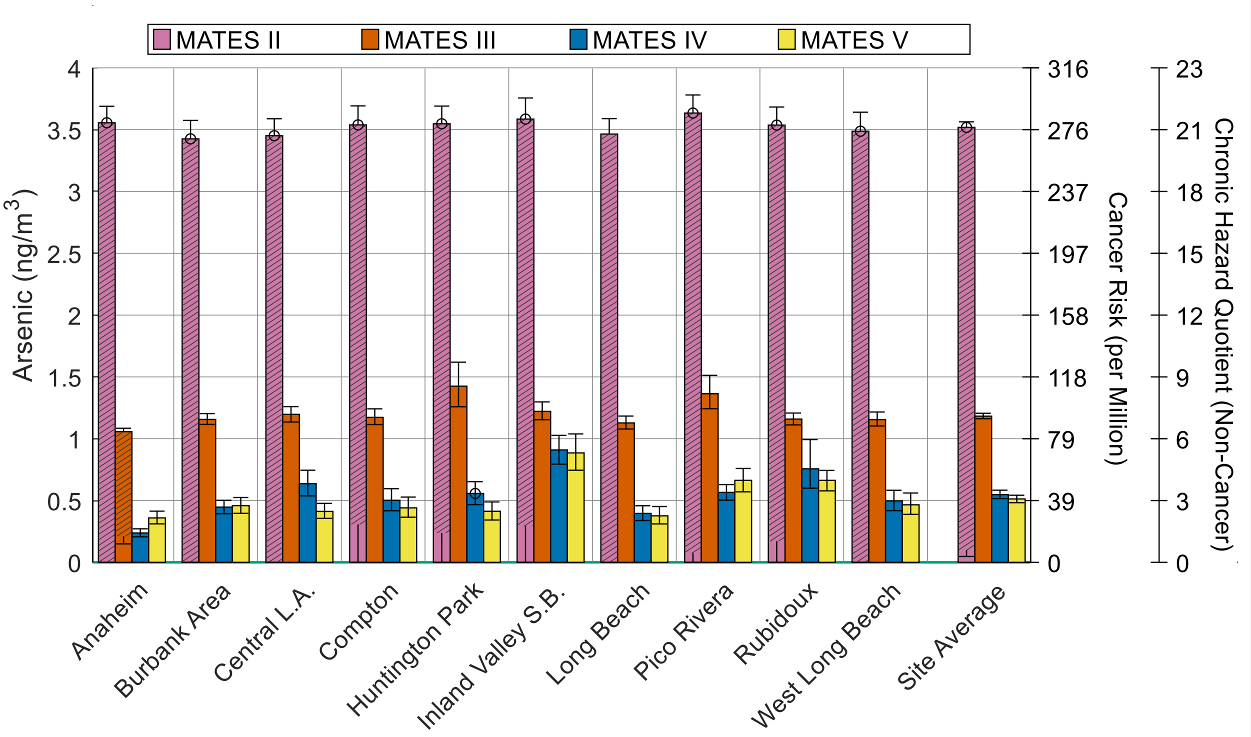

Figure 2-25 Average Concentrations of Arsenic in Total Suspended Particulate (TSP). The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

Figure 2-26 and Figure 2-27 show TSP cadmium. Figure 2-27 shows the same TSP cadmium data as Figure 2-26 with narrower y-axis limits to show the values of stations with lower concentrations more clearly. Figure 2-26 indicates that more than 80% of the measurements were below their MDLs at all stations in MATES II. The heights of the MATES II bars provide upper bound estimates of the average annual concentrations and cannot be used for determining trends over time. Figure 2-27 shows that the KM means for Huntington Park, Inland Valley San Bernardino, Rubidoux, and West Long Beach are much lower in MATES IV and MATES V compared to MATES III. Of these stations, MATES V is higher than MATES IV for Huntington Park, Rubidoux, and West Long Beach, while Inland Valley San Bernardino is similar between MATES IV and MATES V. For the remaining stations, more than 80% of the MATES III data were below detection limits. The lower edge of the shading is the mean using zero-substitution for the data that were below detection limit and the lower edge of the corresponding error bar represents the lower 95% confidence limit based on zero-substitution (in order to give lower-bound estimates). For the Anaheim, Central L.A., Compton, Long Beach, and Pico Rivera, the

MATES V data is clearly lower than the lower-bound estimates for the MATES III data. TSP cadmium concentrations increased from MATES IV to MATES V at Anaheim and decreased at Long Beach. Trends from MATES IV to MATES V are less significant at Burbank Area, Central L.A., Compton, and Pico Rivera since the error bars overlap.

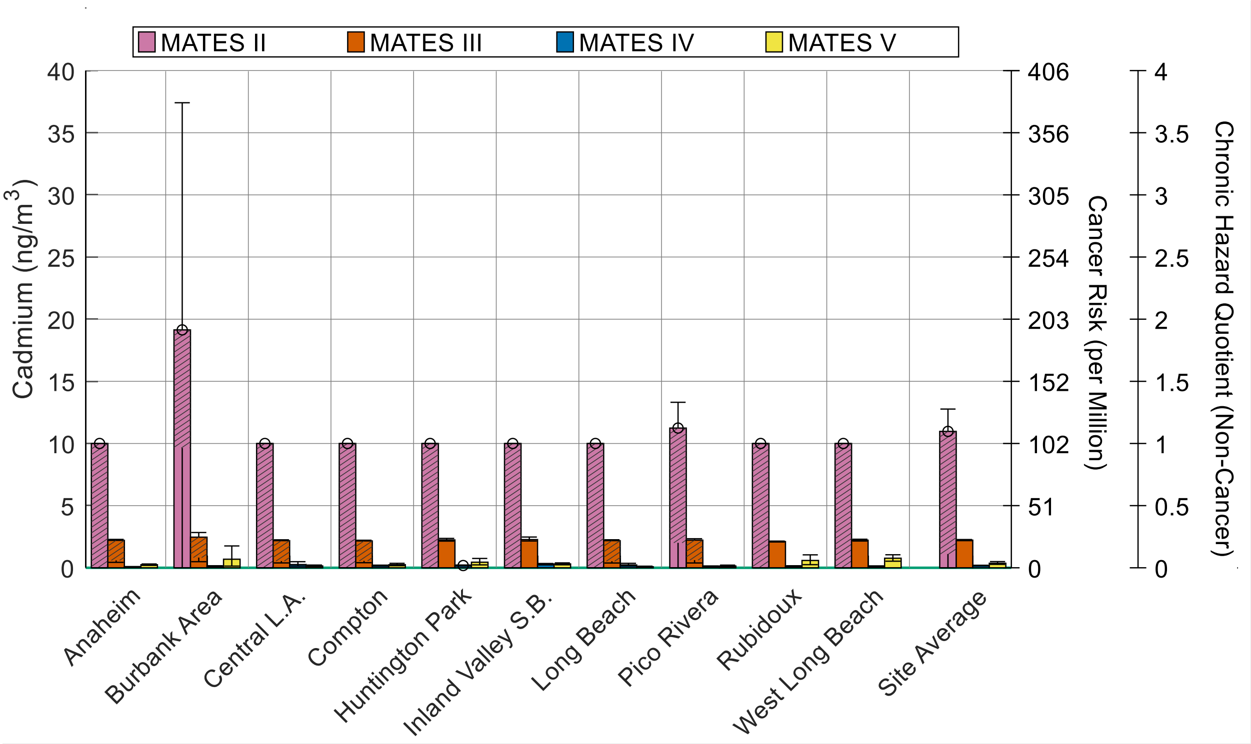

Figure 2-26 Average Concentrations of Cadmium in Total Suspended Particulate (TSP). The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “o” indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

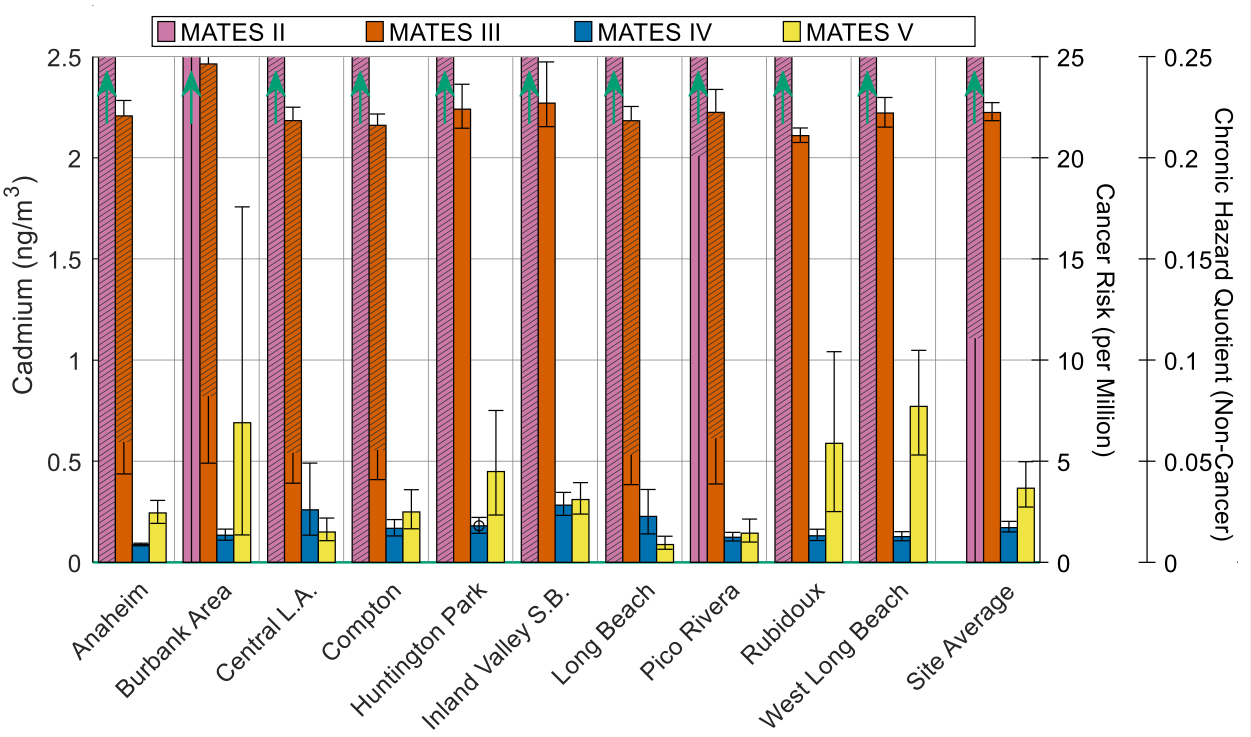

Figure 2-27 Average Concentrations of Cadmium in Total Suspended Particulate (TSP). The upward arrows indicate that the data extends above the y-axis shown. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “o” indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

Figure 2-28, Figure 2-29, and Figure 2-30 show the levels of two more air toxics, lead and nickel. Figure 2-29 shows the same TSP lead data as Figure 2-28 with narrower y-axis limits to show the values of stations with lower concentrations more clearly. Lead concentrations were reduced in MATES IV and MATES V compared to MATES II and MATES III, and the values are well below the National Ambient Air Quality Standard of 150 ng/m3. Lead concentrations decreased at Central L.A. from MATES IV to MATES V. Other stations do not show significant trends in lead concentrations from MATES IV to MATES V since the error bars overlap. Nickel concentrations also decreased over time Basin-wide and at most sites. Inland Valley San Bernardino is the only station to show insignificant declines in nickel concentrations between MATES II and MATES V.

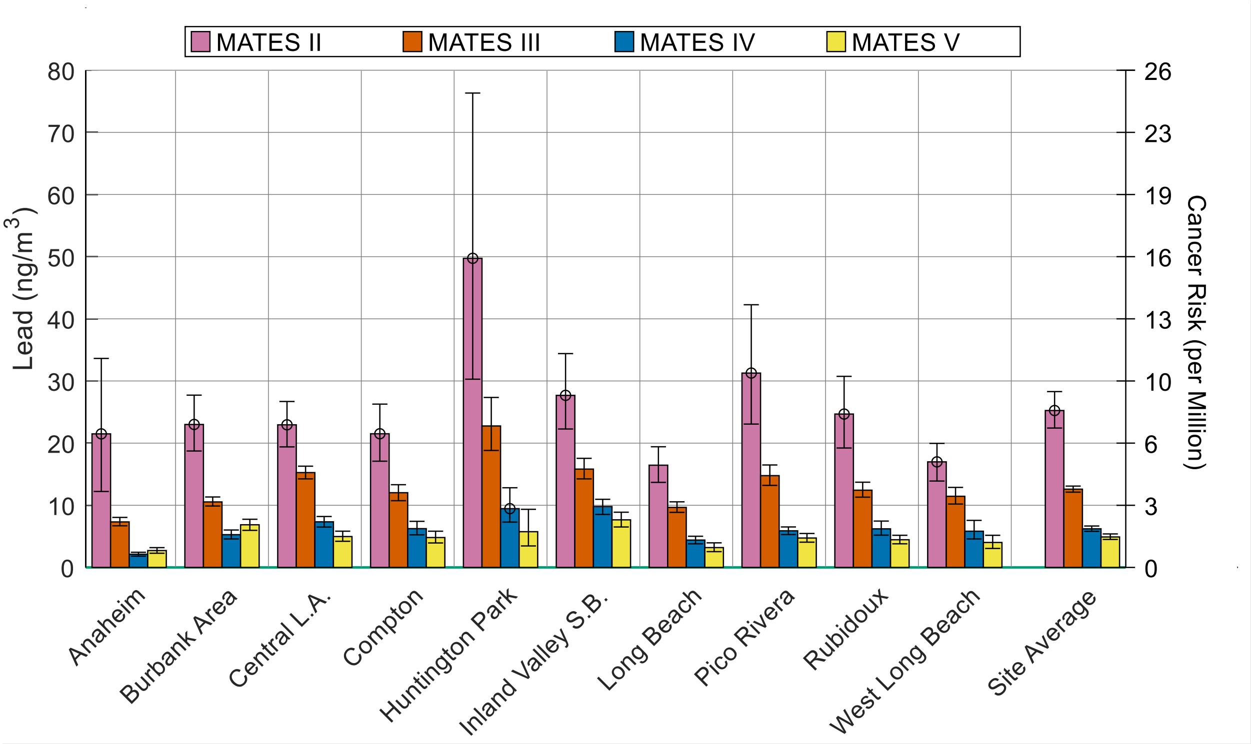

Figure 2-28 Average Concentrations of TSP Lead. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

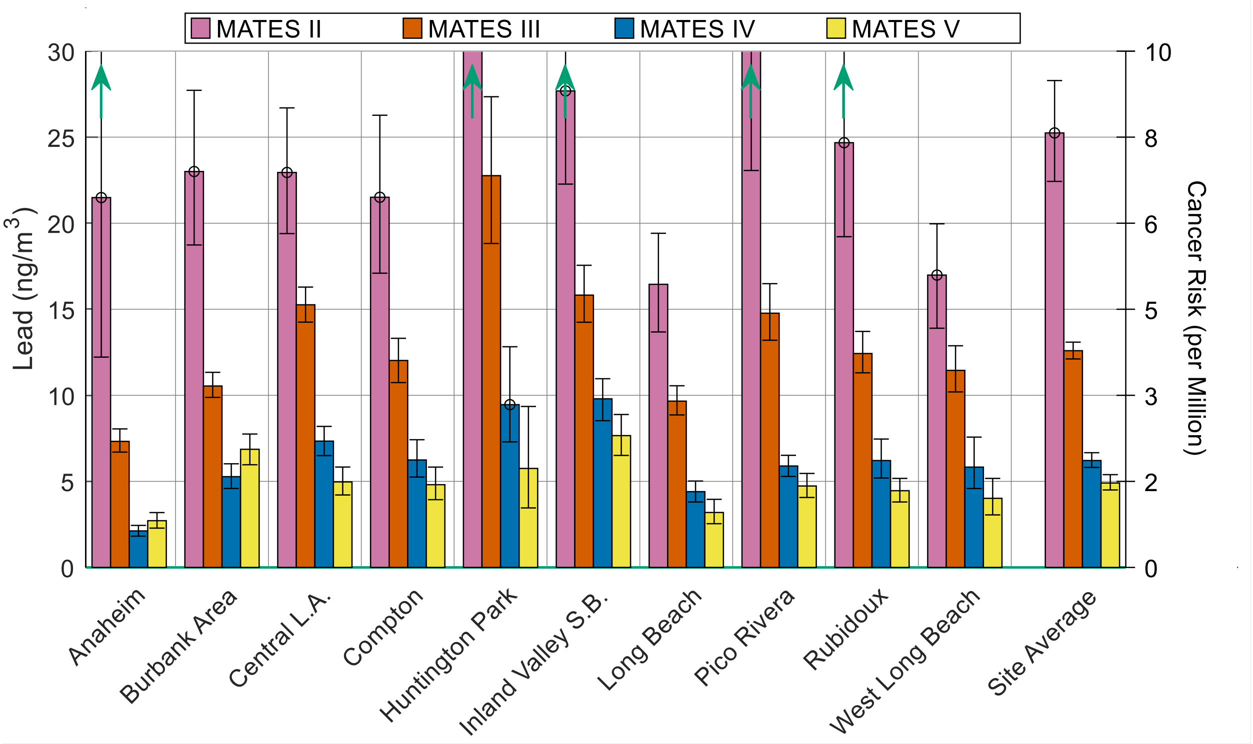

Figure 2-29 Average Concentrations of TSP Lead. The upward arrows indicate that the data extends above the y-axis shown. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

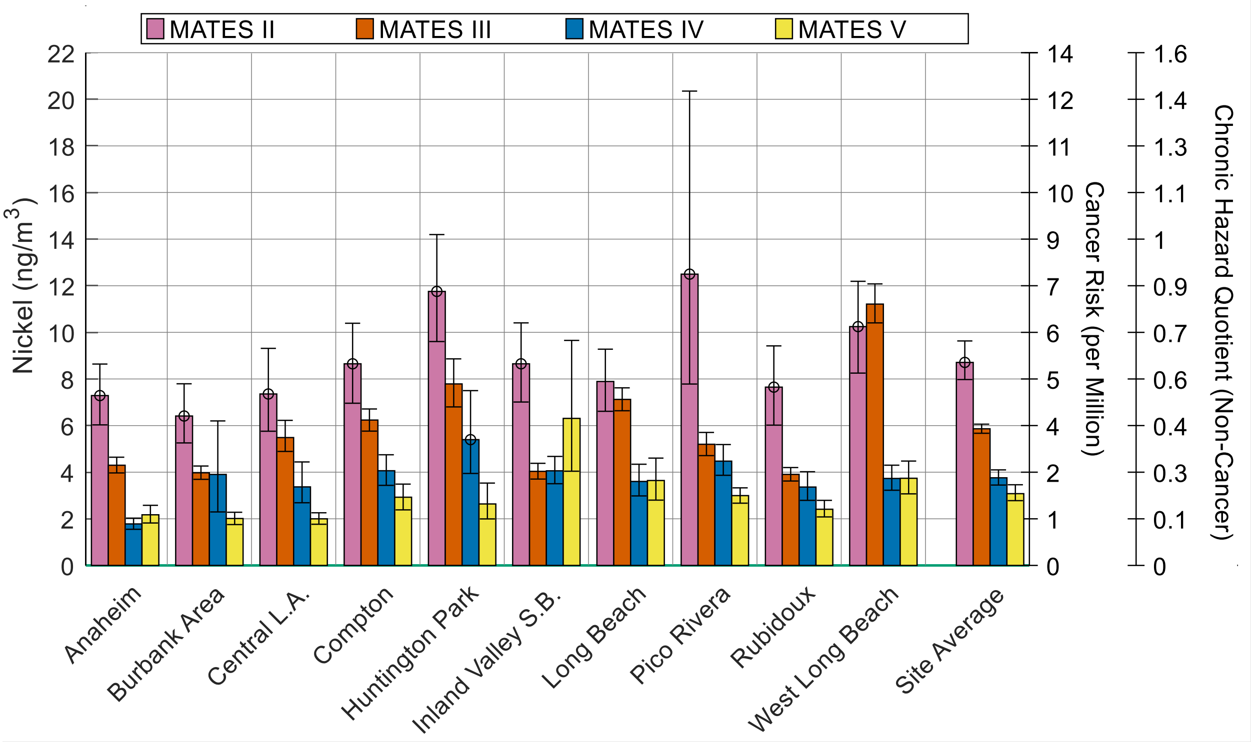

Figure 2-30 Average Concentrations of TSP Nickel. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

Hexavalent chromium concentrations are shown in Figure 2-31 and Figure 2-32. Figure 2-32 shows the same hexavalent chromium data as Figure 2-31 with narrower y-axis limits to show the values of stations with lower concentrations more clearly. Note as found in previous studies, localized increases in hexavalent chromium can occur near facilities using hexavalent chromium-containing materials, such as metal platers, facilities using chromate paints, or cement manufacturing and batch plants. The monitoring locations in this study, however, are intended to measure regional levels of air toxics rather than air toxics levels near area sources. Thus, localized areas of enhanced exposure may not be reflected in these monitoring efforts. For most locations, the annual averages at the monitored locations were substantially lower in MATES IV and MATES V than in previous MATES. For MATES III, the Rubidoux site showed an increase in average hexavalent chromium levels which were eventually traced to cement plants in the region. This led to the adoption of amendments to South Coast AQMD rules for cement facilities addressing hexavalent chromium emissions. The level reductions from MATES IV and MATES V reflect these rule changes as well as reduced activity at the cement plants with hexavalent chromium levels greatly reduced and now comparable to those of other sites. Ongoing regulatory programs also help to reduce hexavalent chromium emissions from stationary sources, such as metal processing facilities.

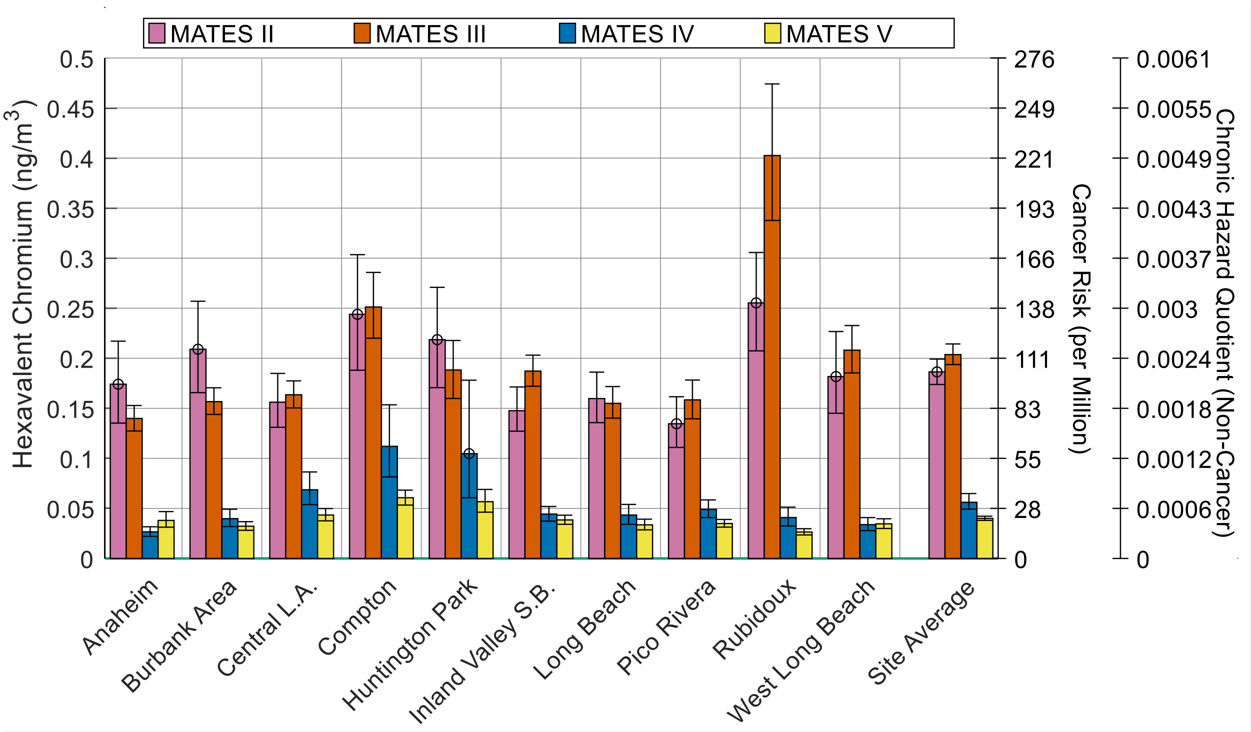

Figure 2-31 Average Concentrations of TSP Hexavalent Chromium. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

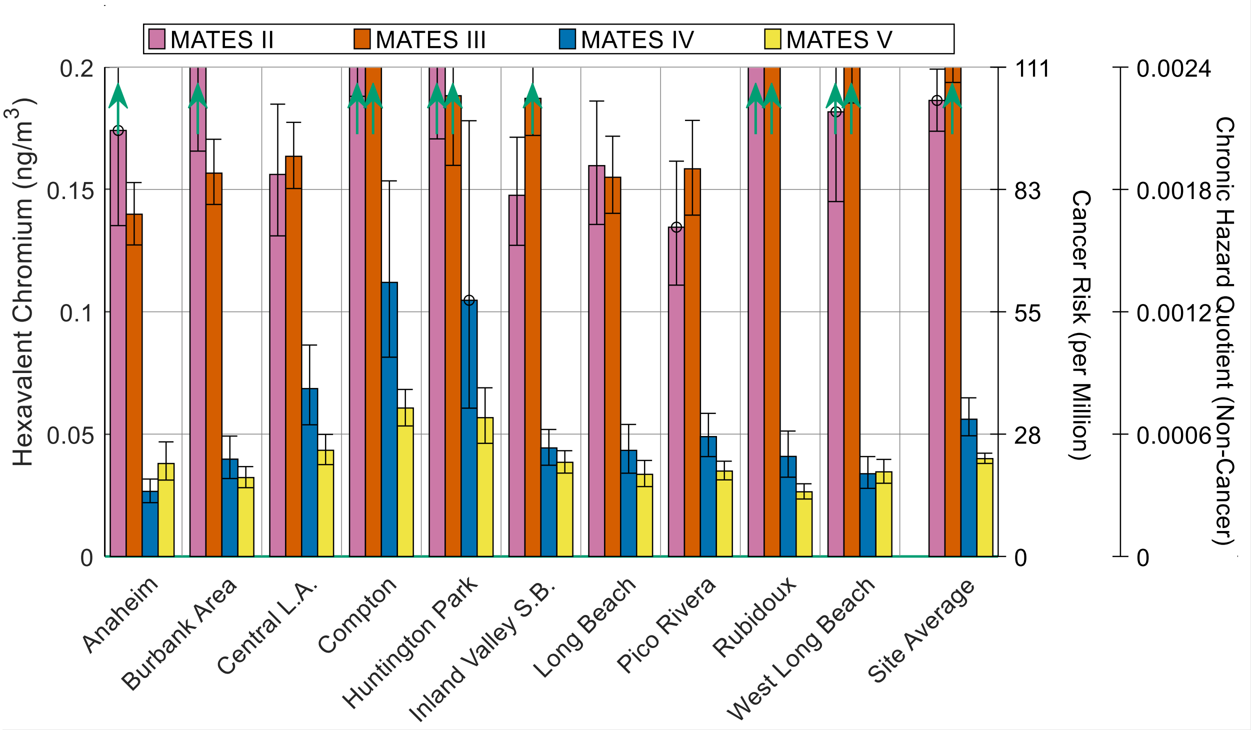

Figure 2-32 Average Concentrations of TSP Hexavalent Chromium. The upward arrows indicate that the data extends above the y-axis shown. “o” indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

Concentrations of TSP Manganese are shown in Figure 2-33. TSP Manganese shows a decrease in concentration from MATES II to MATES V at Compton, Huntington Park, and Rubidoux. Anaheim and Pico Rivera both show decreases in TSP Manganese from MATES II to MATES IV followed by an increase in MATES V. Other stations show no significant trends.

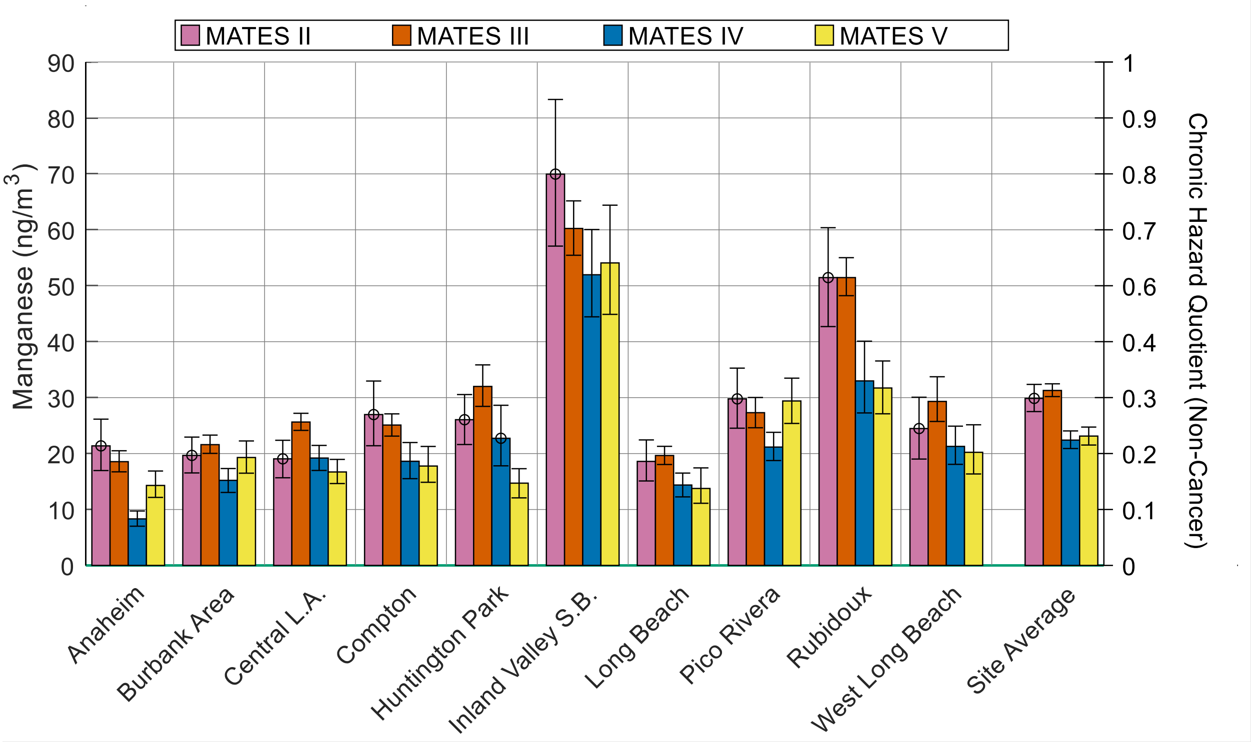

Figure 2-33 Average Concentrations of TSP Manganese. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

Concentrations of TSP Beryllium are shown in Figure 2-34. TSP Beryllium was not measured during MATES II and MATES III. The shading on most of the bars in Figure 2-34 indicates that more than 80% of all measurements were below their MDLs at all stations in MATES IV and seven out of ten stations in MATES V. Changes in the heights of the shaded bars indicate changes in the MDLs over time and do not provide information about the trends in concentration over time. The heights of the shaded bars provide upper bound estimates of the average annual concentrations.

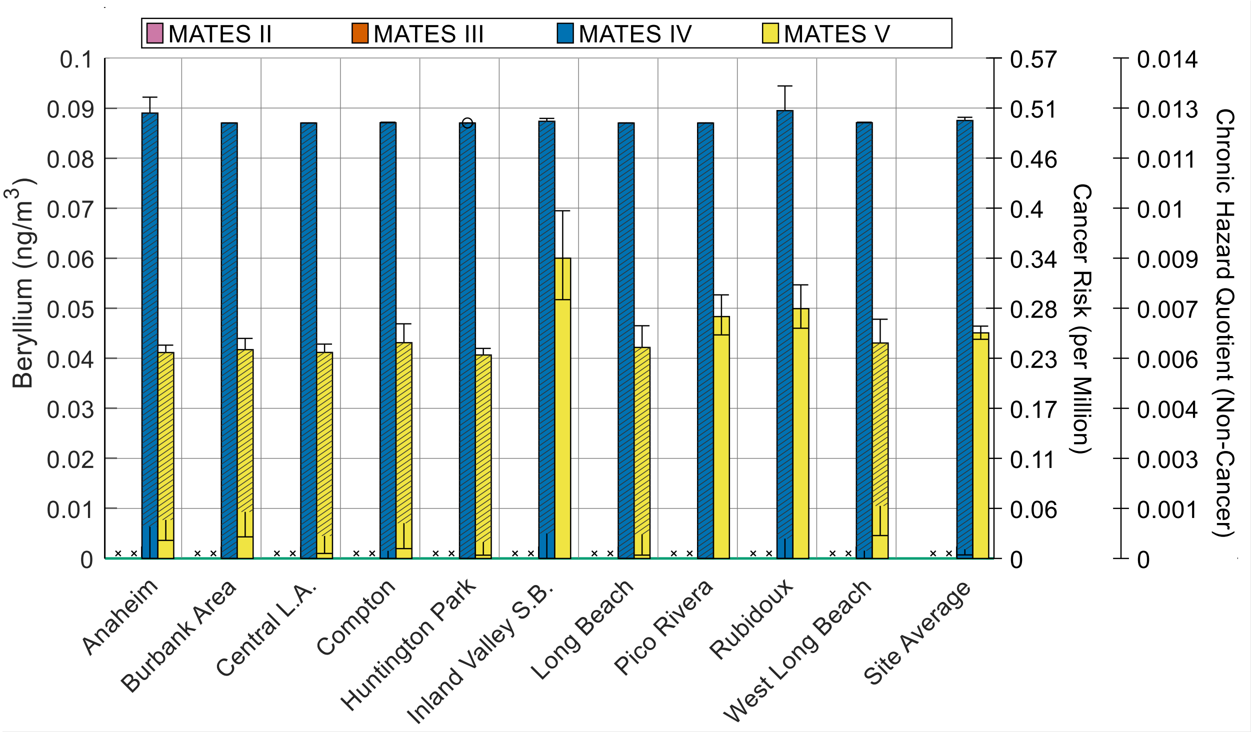

Figure 2-34 Average Concentrations of Beryllium. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of TSP selenium are shown in Figure 2-35. The shading on a bar indicates that more than 80% of the data used to calculate that bar were below detection limit. Caution should be used when interpreting trends with shaded bars since the height of shaded bars represent upper bound estimates using MDL substitution for data below the detection limit. However, since the KM mean was calculated for the MATES II data for all stations except Rubidoux and the upper bound estimates of the MATES V data or KM means are substantially lower than the MATES II KM means, we conclude that there has been a substantial decline in TSP selenium from MATES II to MATES V at those stations. At Rubidoux, the KM mean for MATES IV is higher than the upper bound estimate for MATES V, which indicates that Rubidoux also has a decreasing trend.

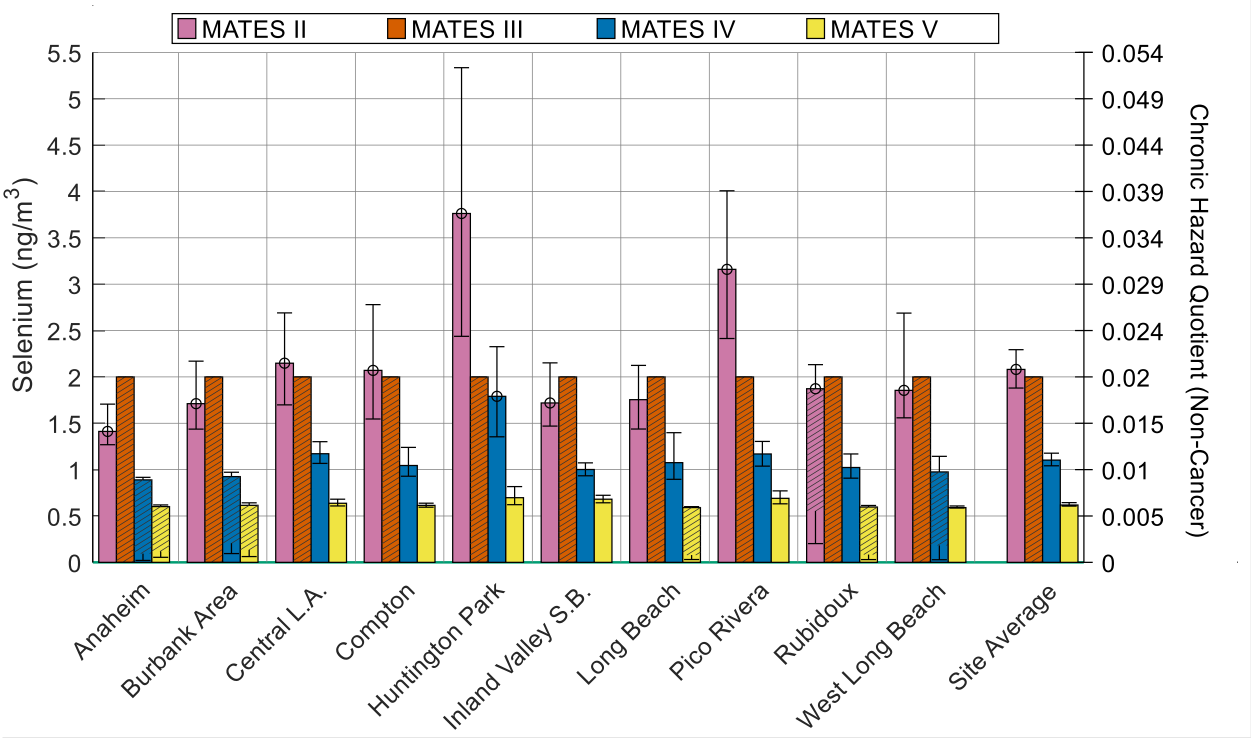

Figure 2-35 Average Concentrations of TSP Selenium. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

Concentrations of PM2.5 chlorine are shown in Figure 2-36. PM2.5 chlorine was not measured in MATES II and MATES III. PM2.5 chlorine shows a decrease in concentrations from MATES IV to MATES V at Pico Rivera and West Long Beach, with insignificant changes at other sites.

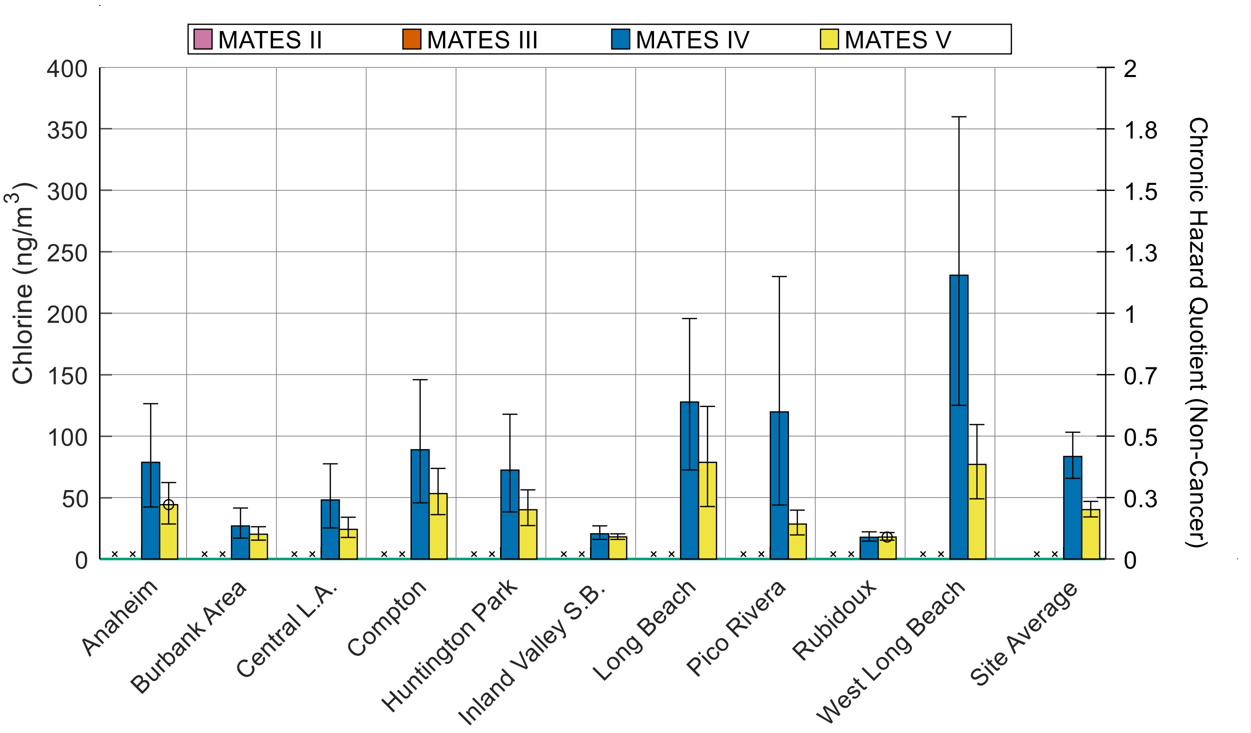

Figure 2-36 Average Concentrations of PM2.5 Chlorine. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Figure 2-37 shows concentrations of TSP cobalt. Figure 2-38 shows the same TSP cobalt data with narrower y-axis limits to show the lower concentrations of MATES IV-V more clearly.

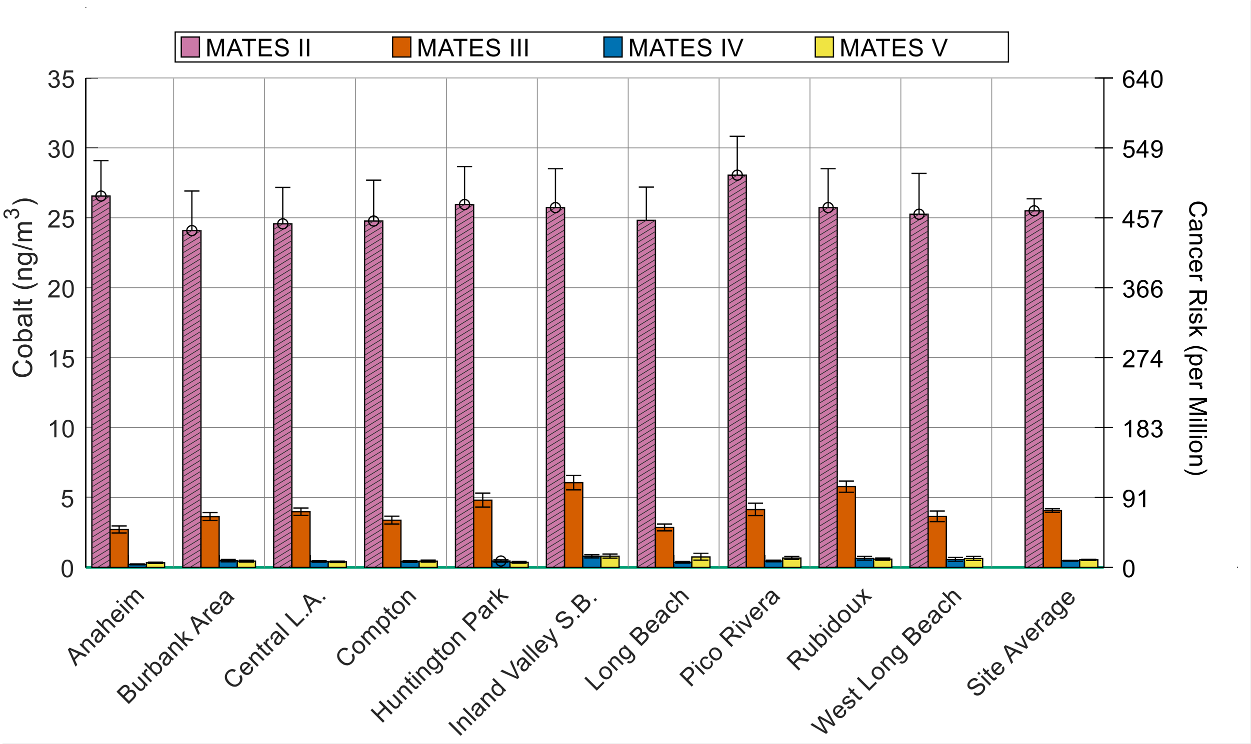

Figure 2-37 Average Concentrations of TSP Cobalt. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

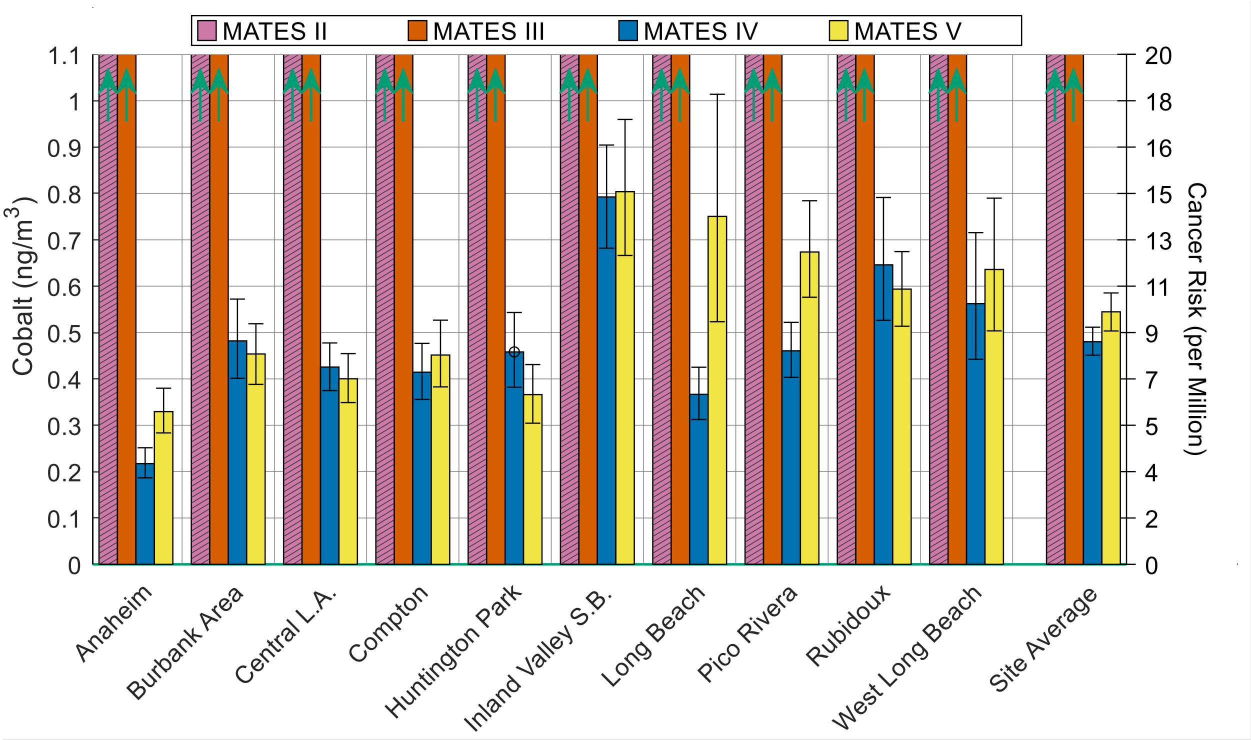

Figure 2-38 Average Concentrations of TSP Cobalt. The upward arrows indicate that the data extends above the y-axis shown. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

Naphthalene and Other PAH Compounds

Measurements of naphthalene and several other PAHs (polycyclic aromatic hydrocarbons) were taken at some sites, as shown in the figures below. These substances are regularly monitored on a one in six day basis under the federal NATTS program for Central LA and Rubidoux. PAHs are mainly formed from the incomplete combustion of organic materials.

Concentrations of Naphthalene are shown in Figure 2-39. Concentrations of Naphthalene decreased significantly from MATES III to V at Central L.A. and Rubidoux.

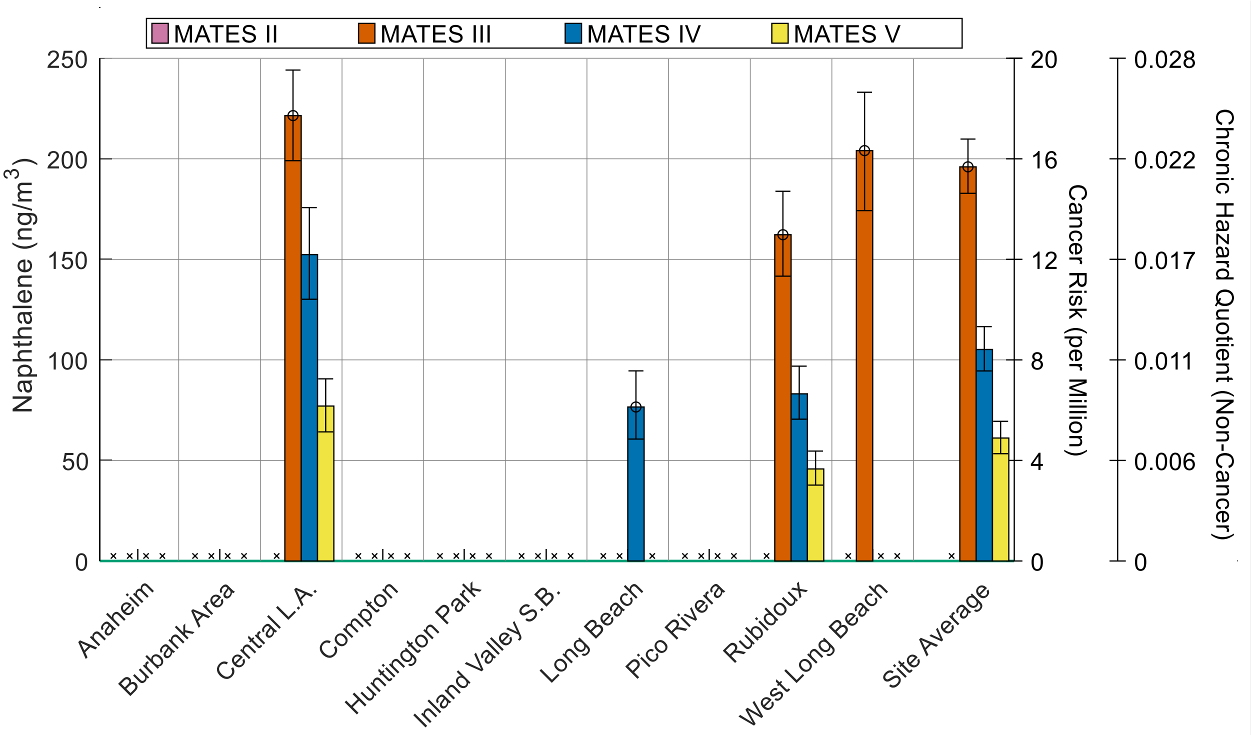

Figure 2-39 Average Annual Concentrations of Naphthalene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of Benzo(a)pyrene are shown in Figure 2-40. Concentrations of Benzo(a)pyrene are significantly lower at Central L.A. in MATES V compared to MATES II.

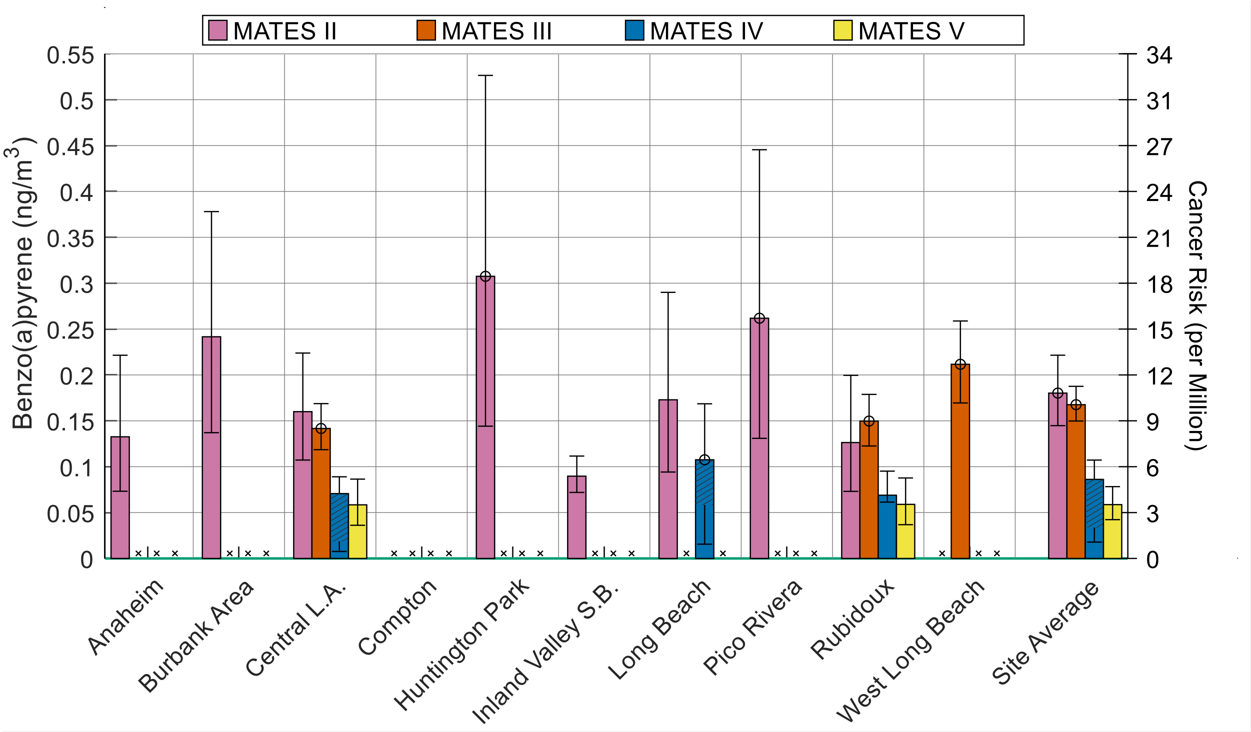

Figure 2-40 Average Concentrations of Benzo(a)pyrene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of Benzo(b)fluoranthene are shown in Figure 2-41. Concentrations of Benzo(b)fluoranthene do not show significant trends over time (i.e., the error bars representing the 95% confidence interval overlap).

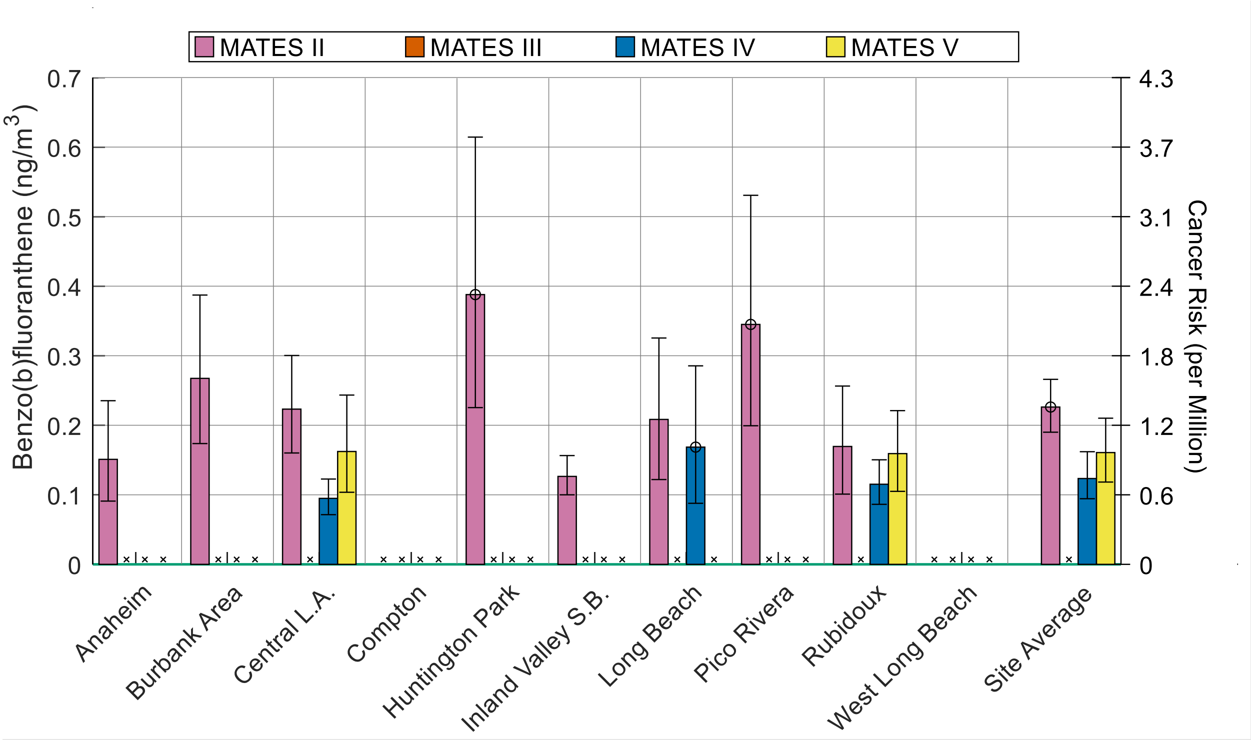

Figure 2-41 Average Concentrations of Benzo(b)fluoranthene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

Concentrations of Benzo(k)fluoranthene are shown in Figure 2-42. Concentrations of Benzo(a)pyrene are significantly lower at Central L.A. in MATES V compared to MATES II. Concentrations do not show significant trends over time in Rubidoux as the error bars representing the 95% confidence interval overlap. "x" indicates that data is unavailable for a given station/MATES iteration.

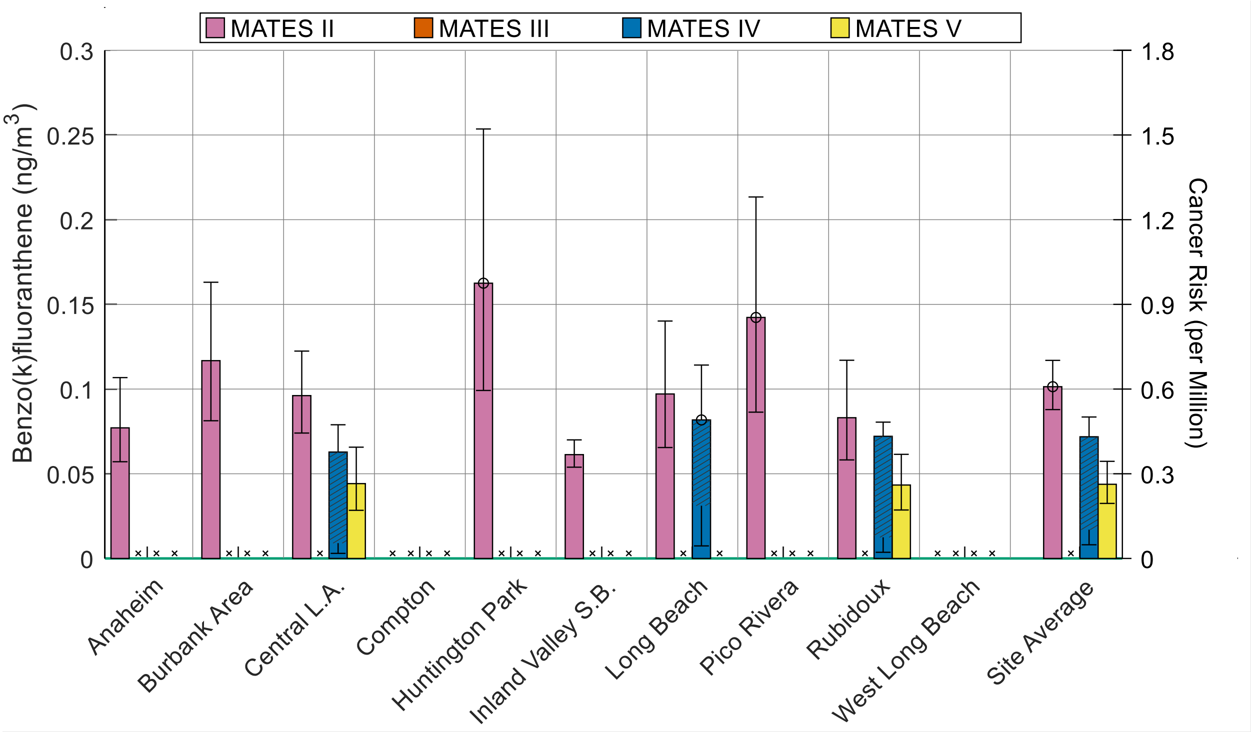

Figure 2-42 Average Concentrations of Benzo(k)fluoranthene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of Dibenz(a,h)anthracene are shown in Figure 2-43. The shading on a bar indicates that 80% of the data were below their MDL. This means that the height of the bars over time are primarily reflective of MDLs, and trends in concentrations over time cannot be determined from these data. The shaded bars do provide lower and upper bound estimates of average annual concentrations. Dibenz(a,h)anthracene concentrations decreased at Rubidoux from MATES III to V.

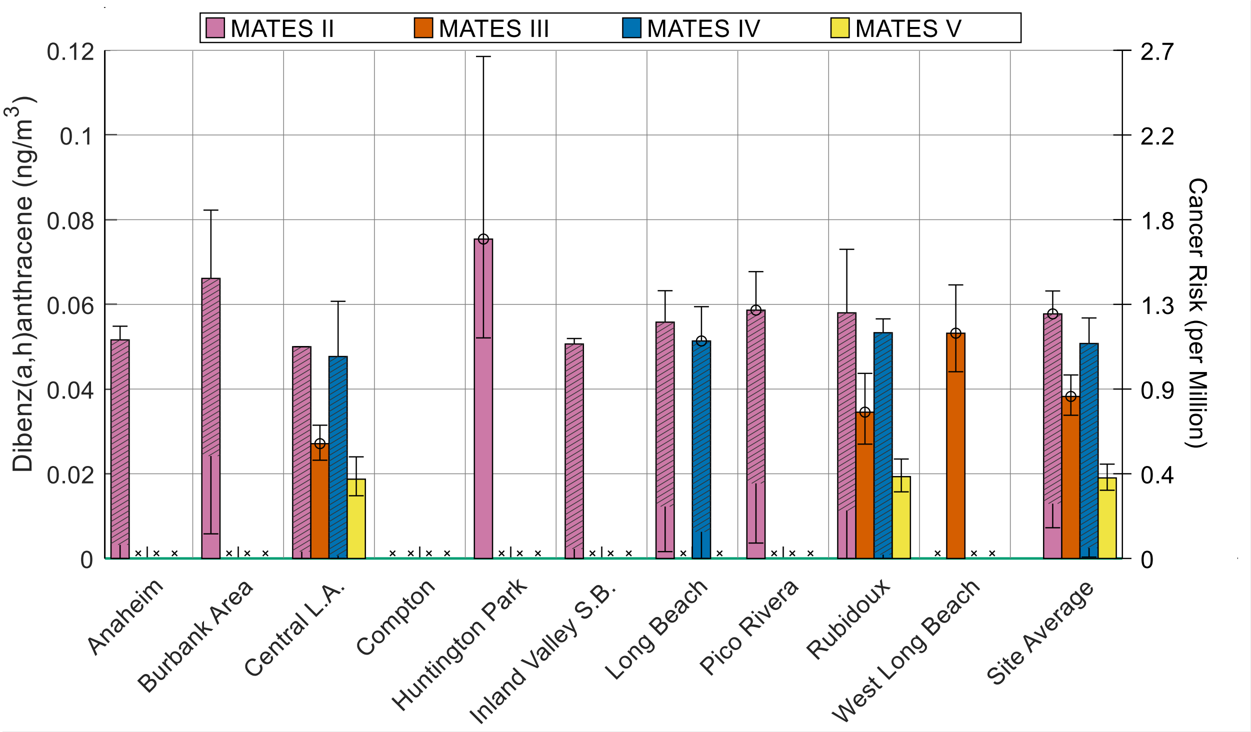

Figure 2-43 Average Concentrations of Dibenz(a,h)anthracene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. The upper edge of the shading shows the mean with the MDL substituted for all measurements below the MDL. All other averages are calculated using the KM mean. “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of indeno(1,2,3-c,d)pyrene are shown in Figure 2-44. Concentrations of indeno(1,2,3-c,d)pyrene are significantly lower during MATES IV and MATES V compared to MATES II at Central L.A. and Rubidoux, with insignificant changes between MATES IV and MATES V.

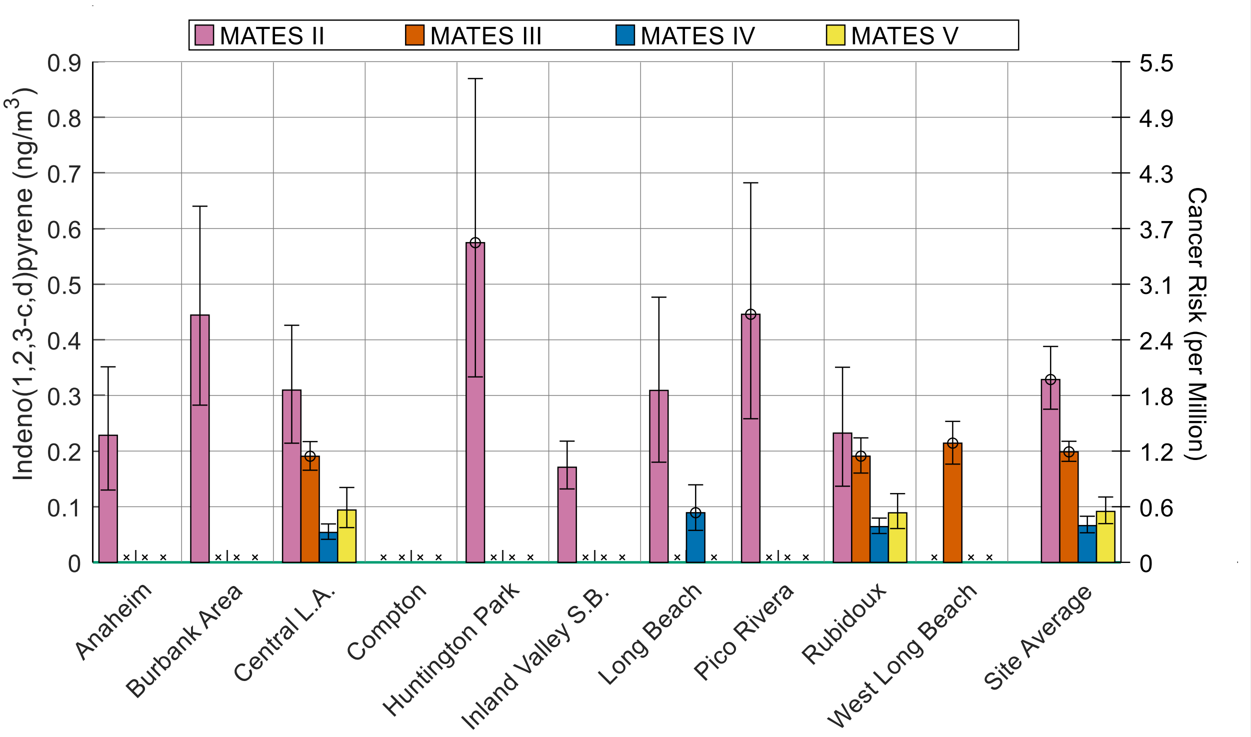

Figure 2-44 Average Concentrations of Indeno(1,2,3-c,d)pyrene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of benzo(a)anthracene are shown in Figure 2- 45. Concentrations of benzo(a)anthracene show a decrease in concentrations from MATES III to V, with insignificant changes from IV to V.

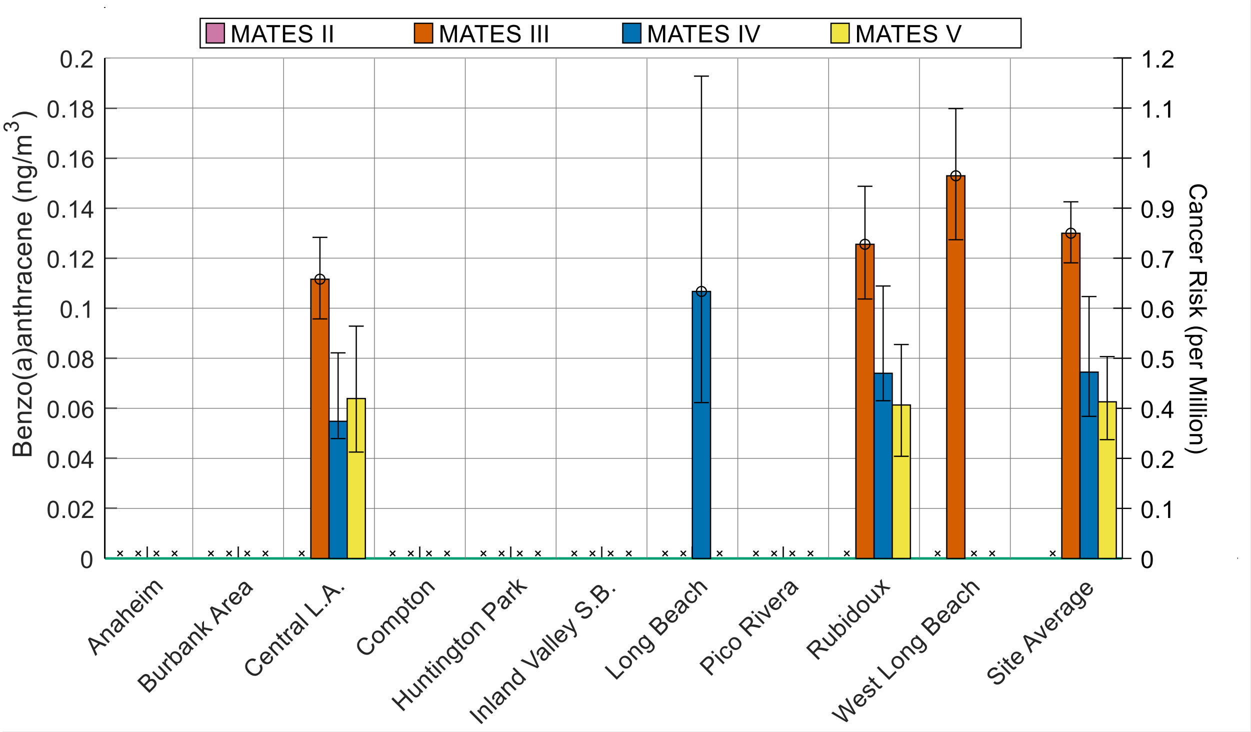

Figure 2- 45 Average Concentrations of Benzo(a)anthracene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

Concentrations of chrysene are shown in Figure 2-46. Concentrations of chrysene show a decrease in concentrations from MATES III to V, with insignificant changes from IV to V.

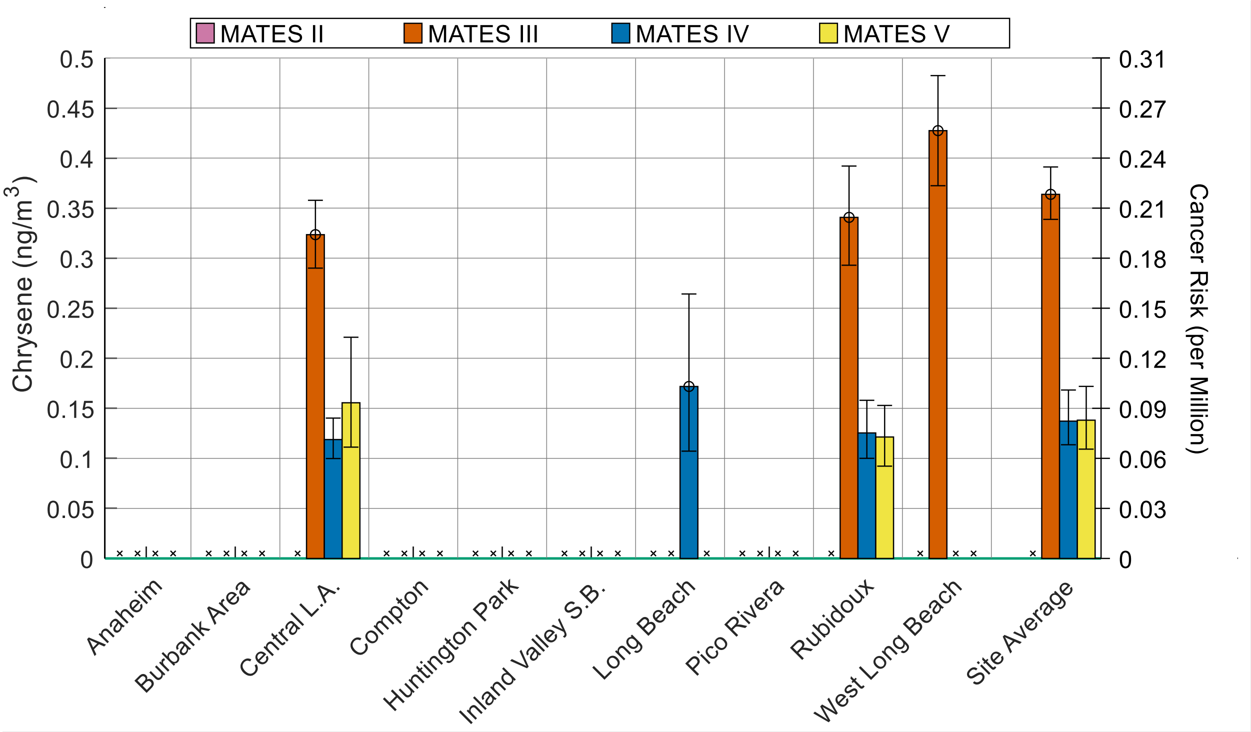

Figure 2-46 Average Concentrations of Chrysene. “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters. Error bars denote the 95% confidence interval.

MATES V Estimates of Cancer Risk based on Monitoring Data

Figure 2-47 shows the estimated cancer risks for the toxics measured at each site for the MATES V Study. Since cumulative risks would be artificially low if any analytes were not measured, substitutions were imputed (mostly using the basin average). Several data substitution methods were explored—all of which resulted in similar conclusions. Further descriptions of the data substitution method and a comparison to other methods can be found in Appendix IV. Bar segments that have larger uncertainty, either because the data were substituted or because more than 80% of the measurements were below detection limit, are marked with dots. See Appendix XI for statistical methods. Figure 2-48 shows the same data as Figure 2-47, with analytes grouped together. The same grouping is used for the pie chart in Figure 2-49 showing the fraction of cancer risk due to each pollutant category, based on basin-wide average concentrations.

As discussed in this chapter, most of the measurements at Anaheim for VOC and Carbonyl species were invalidated. The basin-wide average concentration was used to fill in the missing Anaheim data. This additional uncertainty for the Anaheim data is represented in the aggregate risk plots by the shading with dots. In MATES V, diesel PM is the largest contributor to the cancer risk for all stations, contributing approximately 50% of the cancer risk. Based on other South Coast AQMD analyses of projected diesel PM emissions in future years,[12,13] significant decreases in diesel PM health impacts are expected within the next 5-10 years. These reductions reflect recent and continued efforts by the District, CARB and US EPA that reduce diesel PM emissions, especially from mobile sources. Benzene, 1,3- Butadiene, and Carbonyls make up approximately 25% of the cancer risk.

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[12] South Coast AQMD (2017). 2016 Air Quality Management Plan, Appendix III: Base and Future Year Emission Inventory. http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/final-2016-aqmp/appendix-iii.pdf.

[13] South Coast AQMD (2019). Methodology for Source Attribution Analyses for the first year AB 617 Communities in the South Coast Air Basin. https://www.aqmd.gov/docs/default-source/ab-617-ab-134/technical-advisory-group/source-attribution-methodology.pdf?sfvrsn=8.

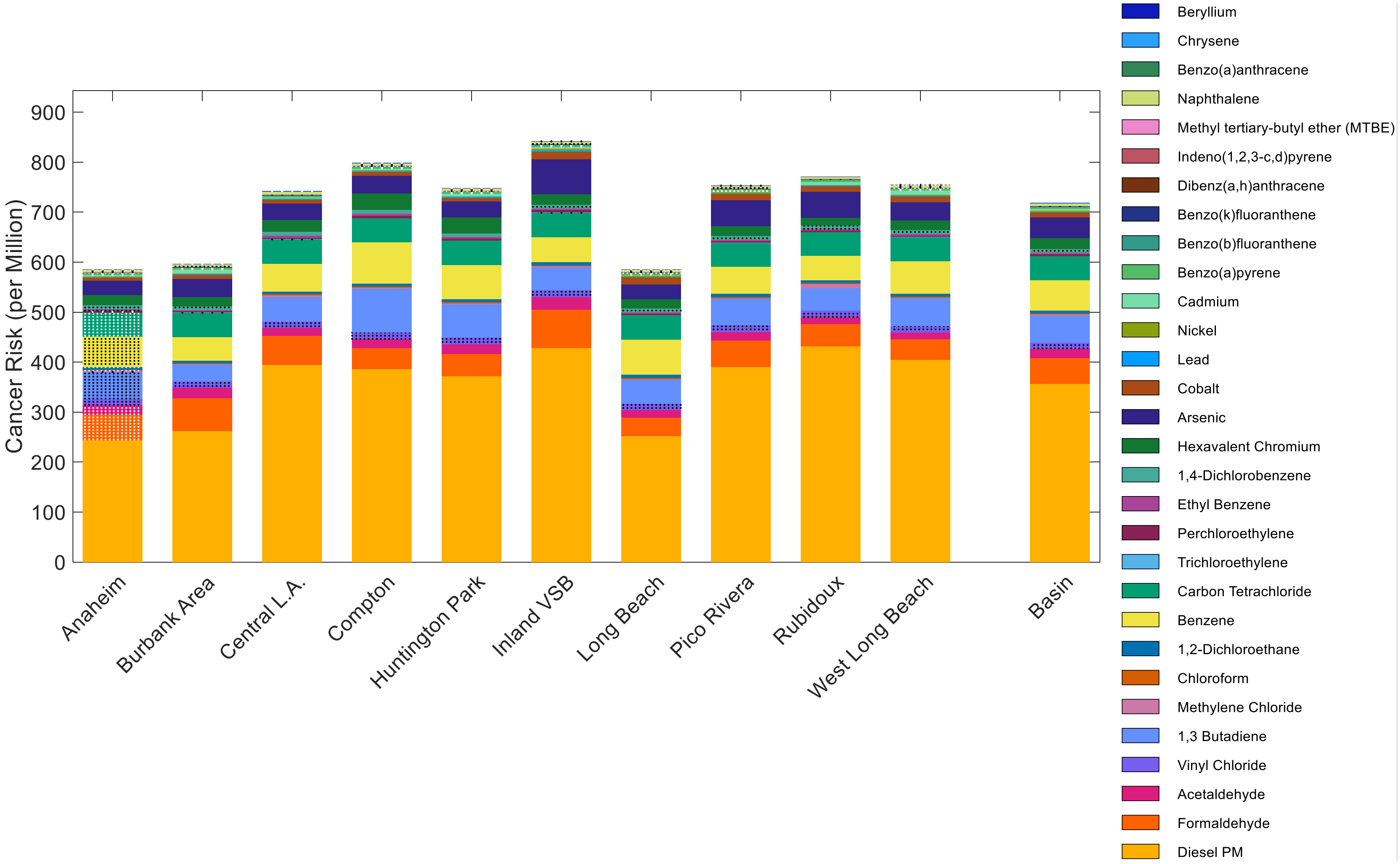

Figure 2-47 Bar charts of the cumulative cancer risks by station for MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit.

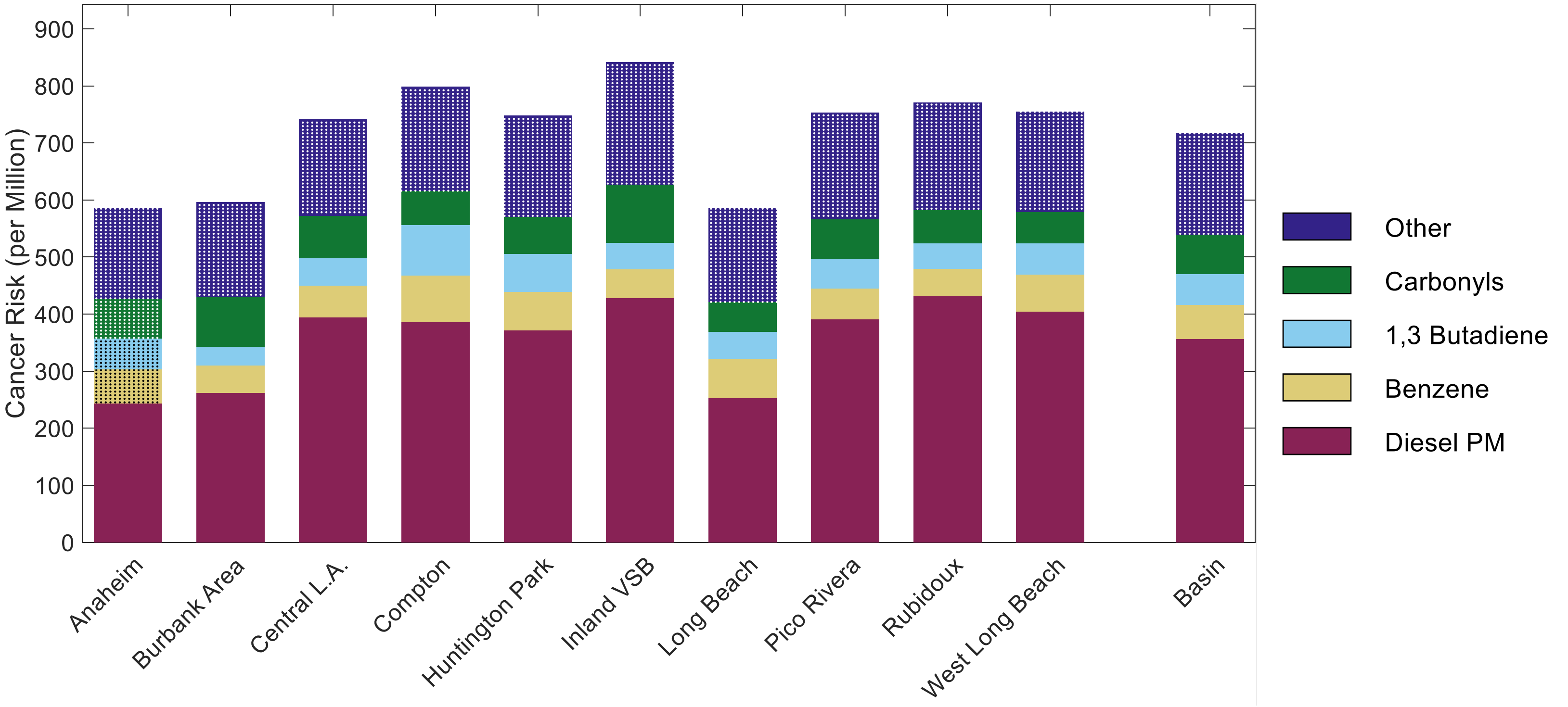

Figure 2-48 Bar charts of the cumulative cancer risks by station for MATES V with grouped analytes. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit.

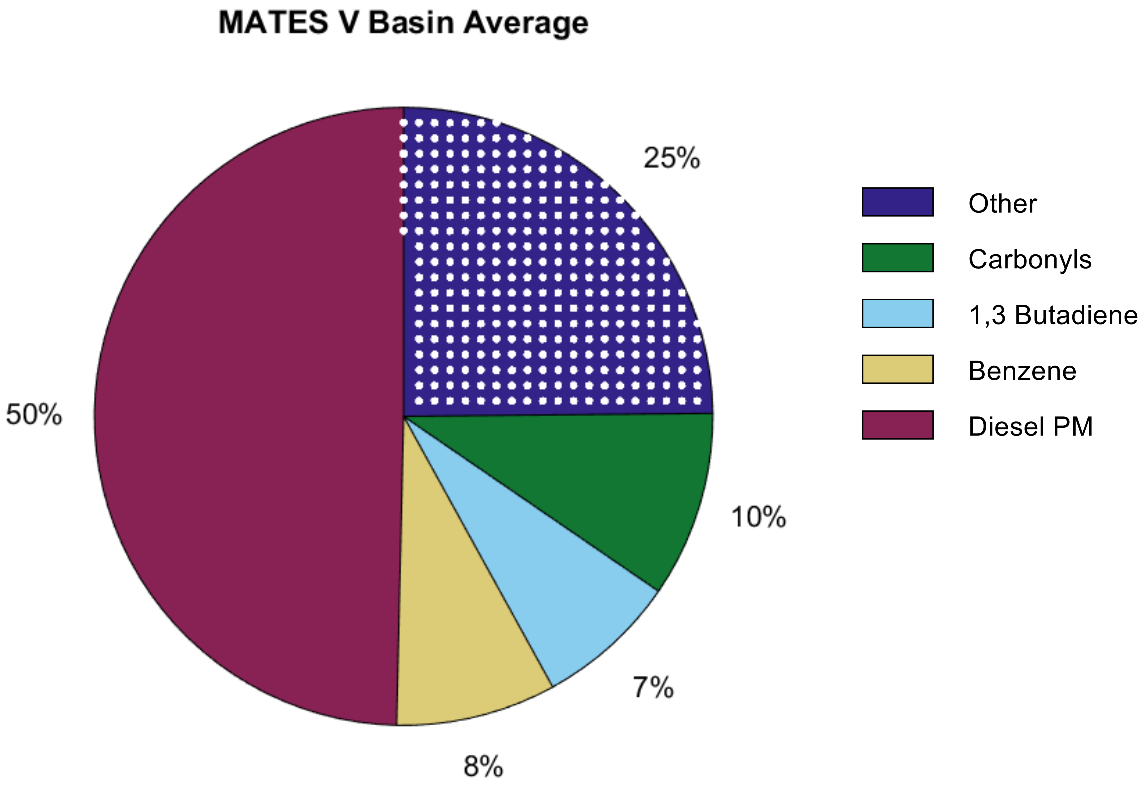

Figure 2-49 Pie charts of the basin-wide cumulative cancer risks for MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit. Numbers may not sum to 100 due to rounding.

Cancer Risk Trends based on Monitoring Data

Figure 2-50 shows the estimated cancer risk trends for the toxics measured at each site for MATES II through MATES V. Since cumulative risks would be artificially low if any analytes are missing, substitutions were imputed (mostly using the basin average). Several data substitution methods were explored—all of which resulted in similar conclusions. Further descriptions of the data substitution method and a comparison to other methods can be found in Appendix IV. Bar segments that have larger uncertainty, either because the data were substituted or because more than 80% of the measurements were below detection limit are marked with dots. See Appendix XI for statistical methods.

Figure 2-51 shows the same data as Figure 2-50, with analytes grouped together. The same grouping is used for the pie charts in Figure 2-52 showing the fraction of risk due to each pollutant category, based on basin-wide average concentrations for MATES II through MATES V.

Cancer risk declined substantially from MATES III to MATES IV, with continued, albeit smaller, progress from MATES IV to MATES V. As shown in Figure 2-51, cancer risk has declined due to decreased concentrations in all categories of pollutants. Cancer risk from diesel PM has declined more quickly than the other pollutant categories. Diesel PM was responsible for approximately 58-73% of the cancer risk for MATES II through MATES IV. In MATES V, however, diesel PM accounts for approximately 50% of the cancer risk, see Figure 2-52.

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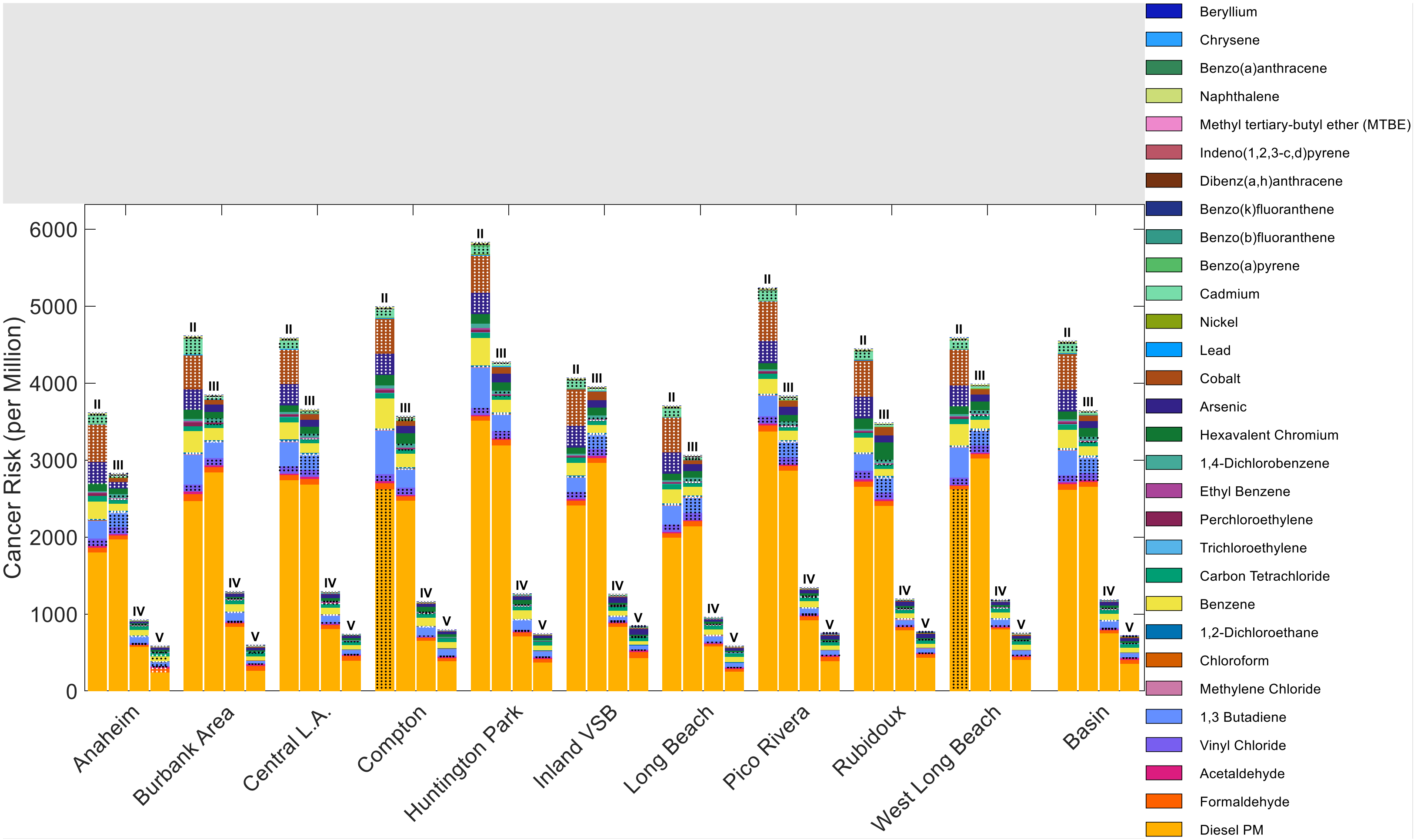

Figure 2-50 Cancer risk trends across MATES II through MATES V at all stations. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Bromomethane was also excluded because it was only measured in MATES V and trends cannot be inferred. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit.

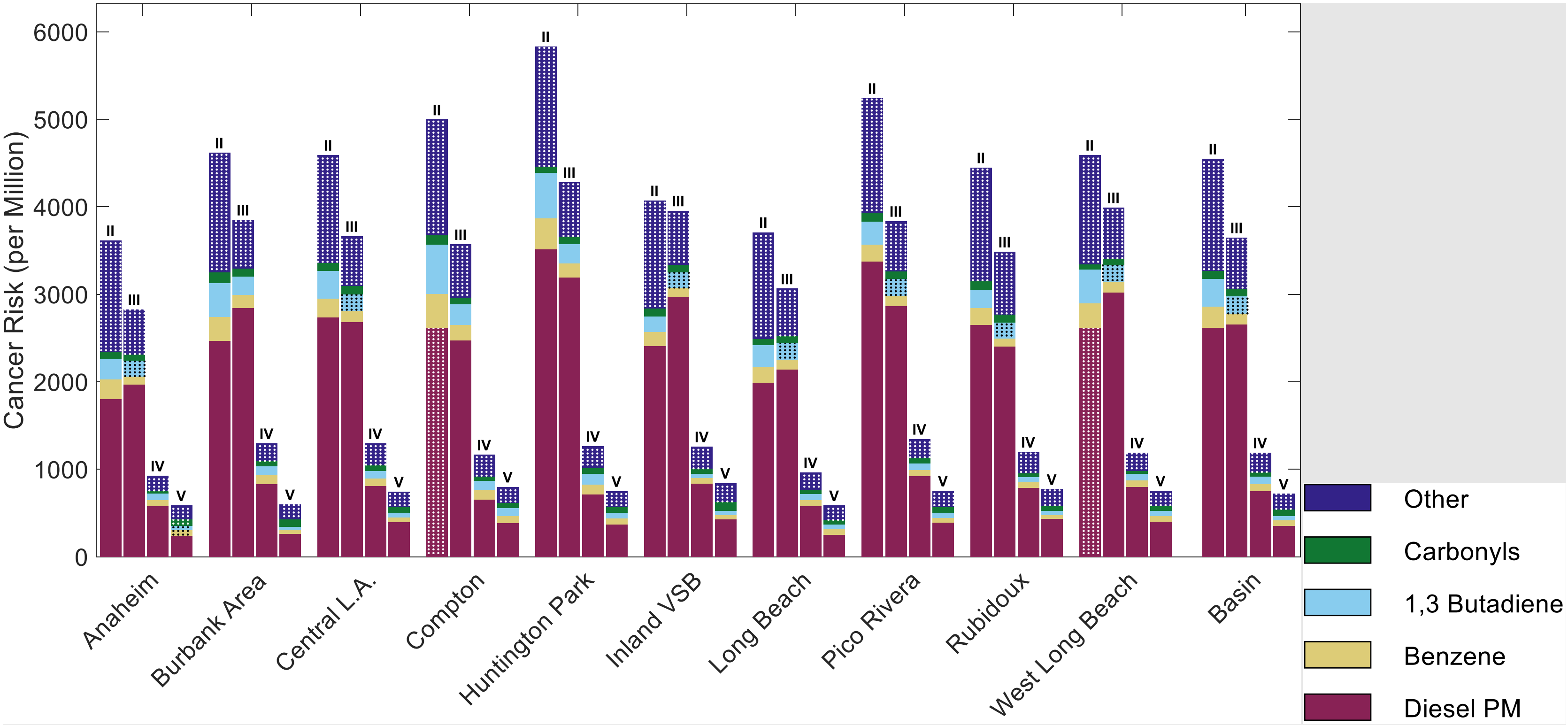

Figure 2-51 Cancer risk trends across MATES II through MATES V at all stations with analytes grouped. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit.

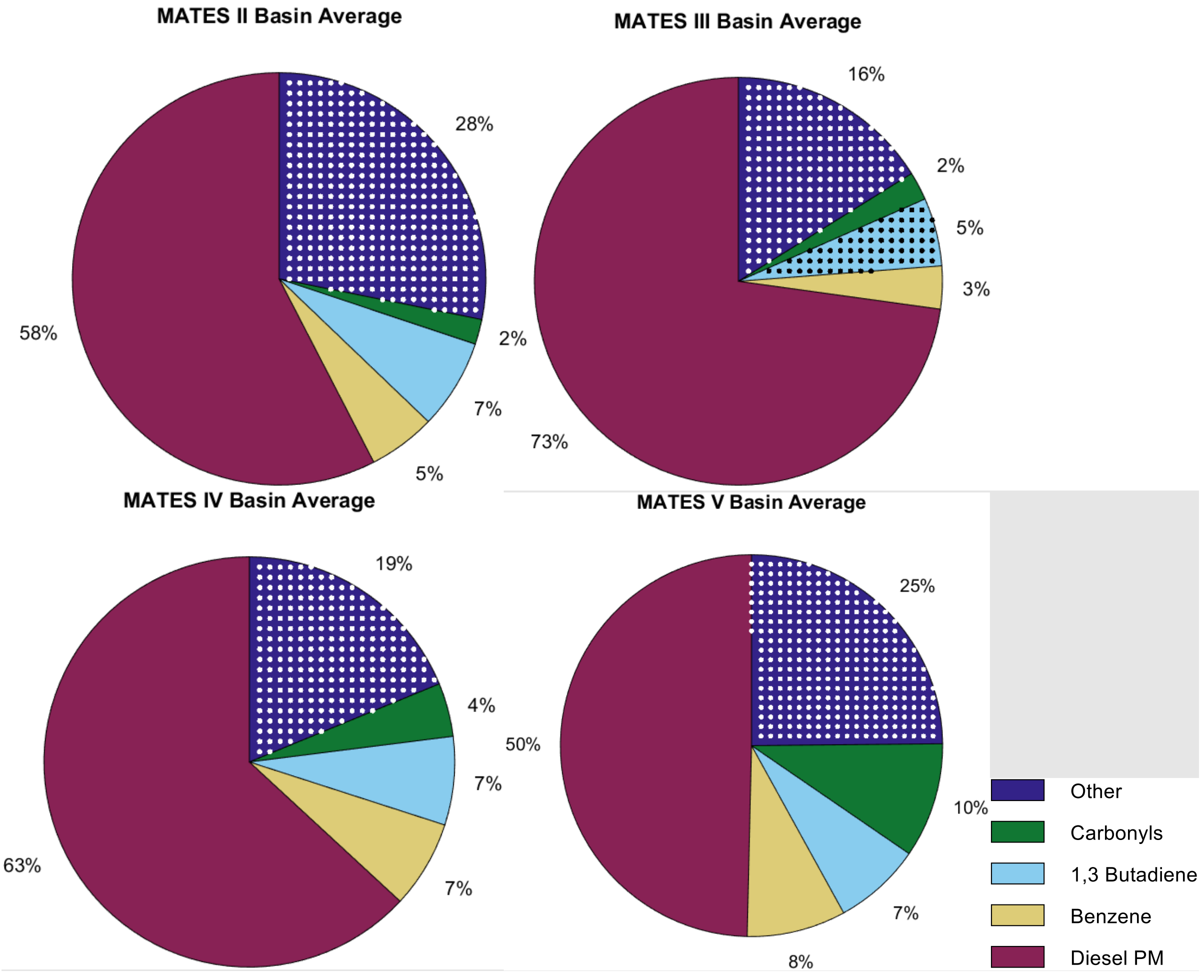

Figure 2-52 Pie charts of the basin-wide cumulative cancer risks for MATES II through MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit. Numbers may not sum to 100 due to rounding.

MATES V Estimates of Chronic Non-Cancer Health Impacts based on Monitoring Data

Figure 2-53 shows the estimated chronic non-cancer health impacts for the toxics measured at each site for MATES V. Since cumulative health impacts would be artificially low if any analytes are missing, substitutions were imputed (mostly using the basin average). Several data substitution methods were explored—all of which resulted in similar conclusions. Further descriptions of the data substitution method and a comparison to other methods can be found in Appendix IV. Bar segments that have larger uncertainty, either because the data were substituted or because more than 80% of the measurements were below detection limit are marked with dots. See Appendix XI for statistical methods.

Figure 2-54 shows the same data as Figure 2-53, with analytes grouped together. The same grouping is used for the pie chart in Figure 2-55 showing the fraction of chronic non-cancer health impacts due to each pollutant category, based on basin-wide average concentrations.

Chronic non-cancer health impacts are primarily driven by arsenic, which accounts for approximately 49% of the overall chronic HI. The chronic HI from arsenic is driven equally by the following target organ systems: cardiovascular system, nervous system, reproductive/developmental, respiratory, and skin. Based on the monitoring data, acrolein (2-Propenol) accounts for approximately 23% of the chronic HI, driven by the impacts on the respiratory system, although there is substantial uncertainty associated with the measurement method, and no alternative method has been published.[14] Formaldehyde and benzene account for approximately 7% and 5% of the chronic HI, respectively. The HQ for formaldehyde is driven by the impacts on the respiratory system, while the HQ for benzene is driven by the hematologic system impacts. Other species are responsible for the remainder of the chronic HI.

The TSP arsenic concentrations from MATES V are consistent with or lower than those measured at most of the 79 sites in 13 states around the U.S. in the Ambient Monitoring Archive (AMA) for 2017 (https://www3.epa.gov/ttn/amtic/toxdat.html#data). South Coast AQMD staff analyzed the 2017 AMA data using the same methods used for the MATES data (see Appendix XI). One site in Pennsylvania has a 95% confidence interval entirely lower than the 95% confidence intervals observed for the SoCAB for MATES V. Several sites around the nation have 95% confidence intervals that are entirely above the 95% confidence intervals seen in MATES V. All other sites in the AMA data have 95% confidence intervals that overlap with those of MATES V (see Appendix IV).

A chronic non-cancer HI that is less than one indicates that the air toxics levels are not expected to cause such health effects. An HI greater than one does not mean that such health effects are expected, but rather that the likelihood of experiencing adverse health effects increases. Although the likelihood of experiencing an adverse non-cancer health effect may not scale

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[14] https://ww2.arb.ca.gov/acrolein-test-method-advisory-and-data

linearly with the HI, a larger HI would generally indicate a greater likelihood of experiencing those health effects in the exposed population.

Based on the MATES V monitoring data, the estimated chronic non-cancer hazard indices range from about 5 to 9. Five stations (Burbank Area, Central LA, Compton, Huntington Park, and Long Beach) had chronic hazard indices between 5 and 6. West Long Beach had a chronic hazard index of approximately 6.5. The estimated chronic hazard indices for Pico Rivera and Rubidoux stations were approximately 7. The Inland Valley San Bernardino station had the highest chronic hazard index of 9. There was substantial missing data at the Anaheim station, but the best estimate of the chronic hazard index in this location is approximately 5. Given the uncertainty in the measurement accuracy of acrolein, however, these estimates should not be interpreted as precise health impact numbers, but rather provide a measure of comparative impacts across the different locations.

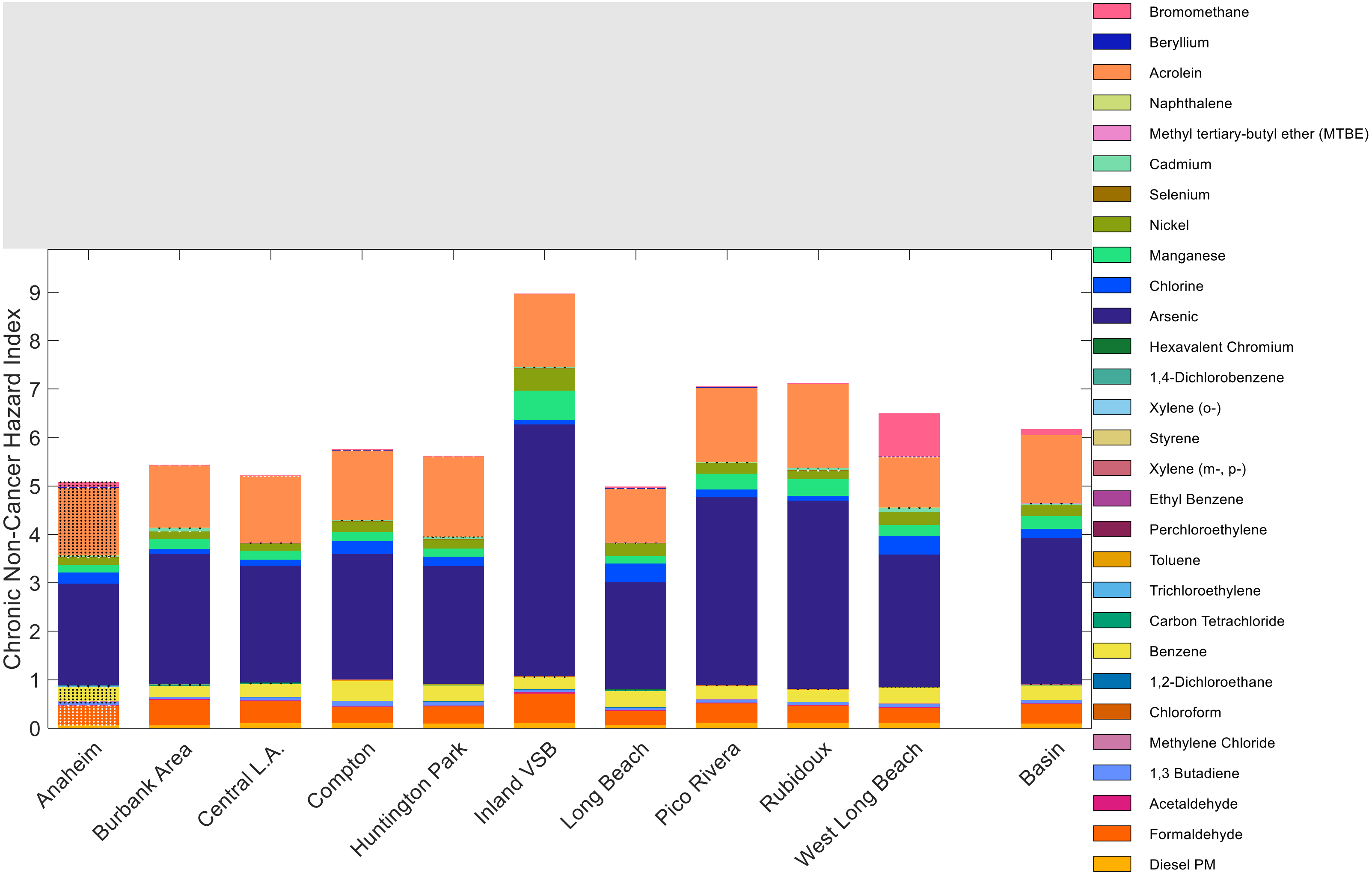

Figure 2-53 Bar charts of the cumulative chronic non-cancer hazard indices by station for MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit.

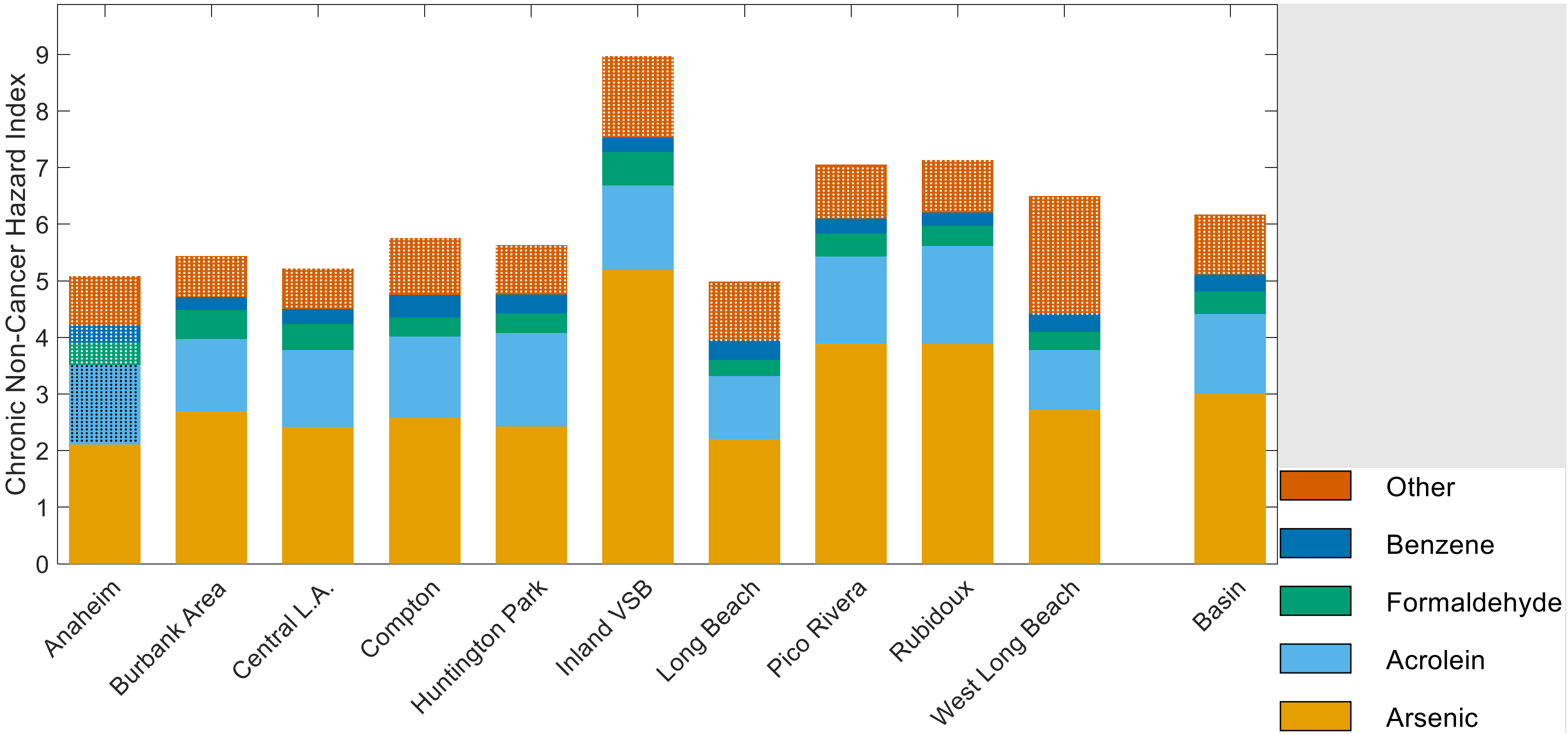

Figure 2-54 Bar charts of the cumulative chronic non-cancer hazard indices by station for MATES V with grouped analytes. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit.

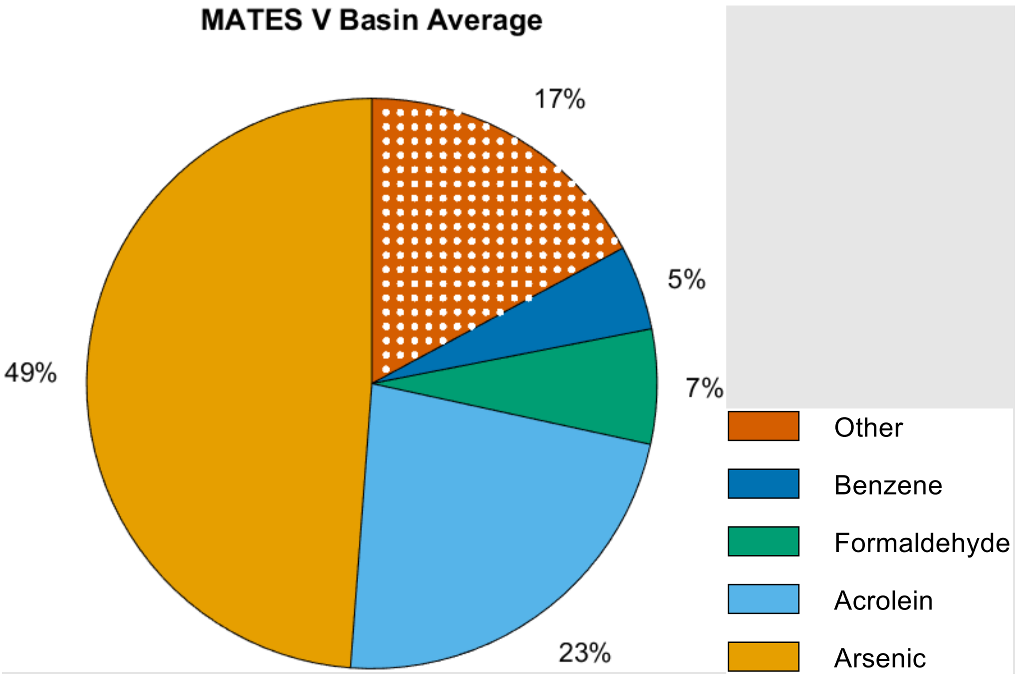

Figure 2-55 Relative contributions to the basin-wide chronic HI at the MATES V monitoring sites. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit. Note that this figure is slightly different from the MATES V pie chart shown in Figure 2-58 since Bromomethane is excluded from Figure 2-58. Numbers may not sum to 100 due to rounding.

Trends in Chronic Non-Cancer Health Impacts based on Monitoring Data

Figure 2-56 shows the estimated chronic non-cancer health impacts for the toxics measured at each site for MATES III through MATES V. Since the hazard indices would be artificially low if any analytes are missing, substitutions were imputed (mostly using the basin average). Several data substitution methods were explored—all of which resulted in similar conclusions. Further descriptions of the data substitution method and a comparison to other methods can be found in Appendix IV. Bar segments that have larger uncertainty, either because the data were substituted or because more than 80% of the measurements were below detection limit are marked with dots. See Appendix XI for statistical methods.

Figure 2-57 shows the same data as Figure 2-56, with analytes grouped together. The same grouping is used for the pie charts in Figure 2-58 showing the fraction of the chronic non-cancer hazard index due to each pollutant category, based on basin-wide average concentrations for MATES III through MATES V.

Given that there is more uncertainty in the MATES II data for the pollutants that appear to drive the chronic HI, it is difficult to draw conclusions about trends in this type of health impact since MATES II. However, the data do support that chronic HI's declined substantially from MATES III to MATES IV. Chronic HI's remained similar from MATES IV to MATES V, with some stations increasing slightly and some stations decreasing slightly. The fraction of the chronic HI due to arsenic declined from MATES III through MATES IV, decreasing from approximately 55% in MATES III to approximately 50% in MATES IV.

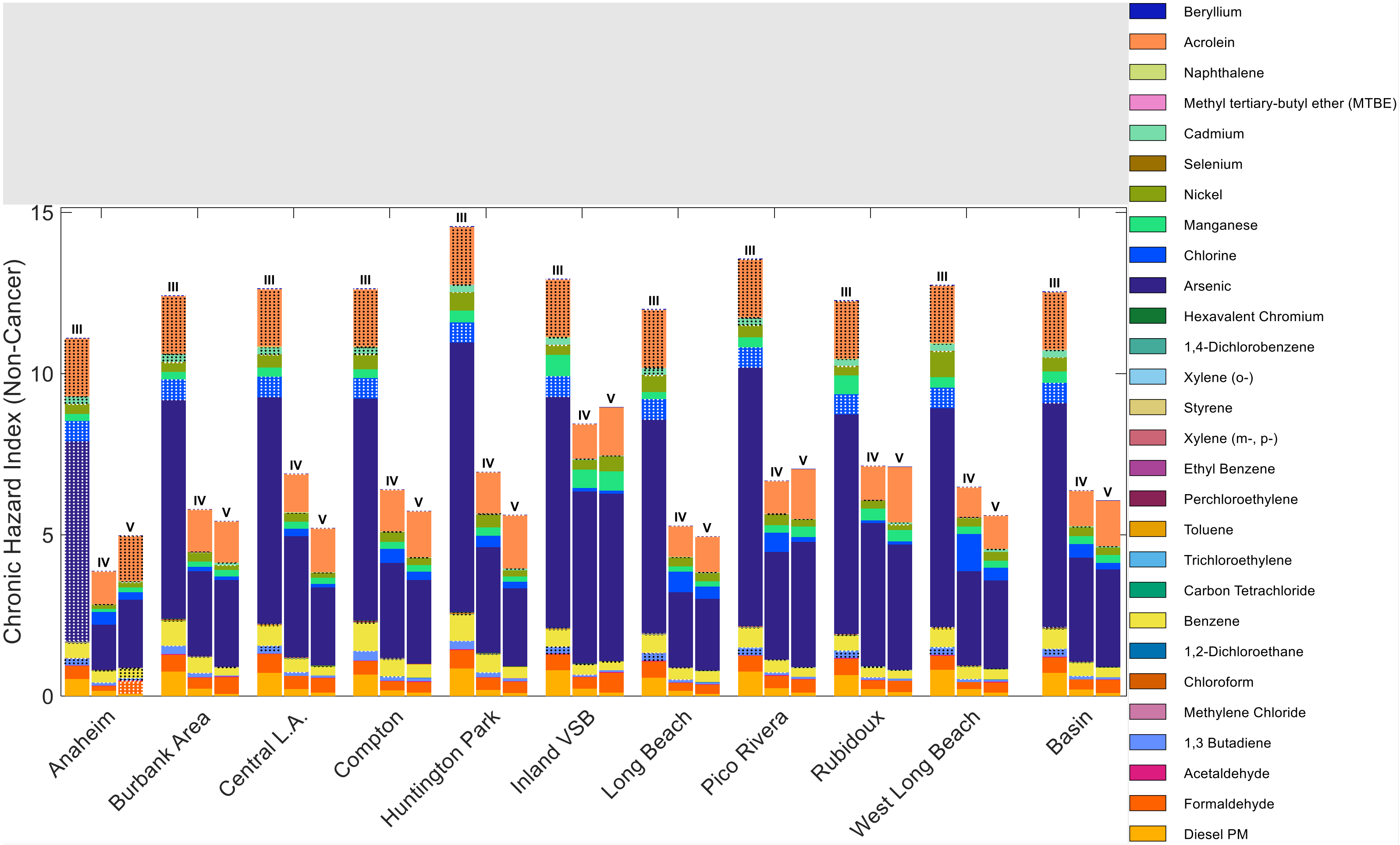

Figure 2-56 Chronic HI trends across MATES III through MATES V at all stations. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Bromomethane was also excluded because it was only measured in MATES V and trends cannot be inferred. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit.

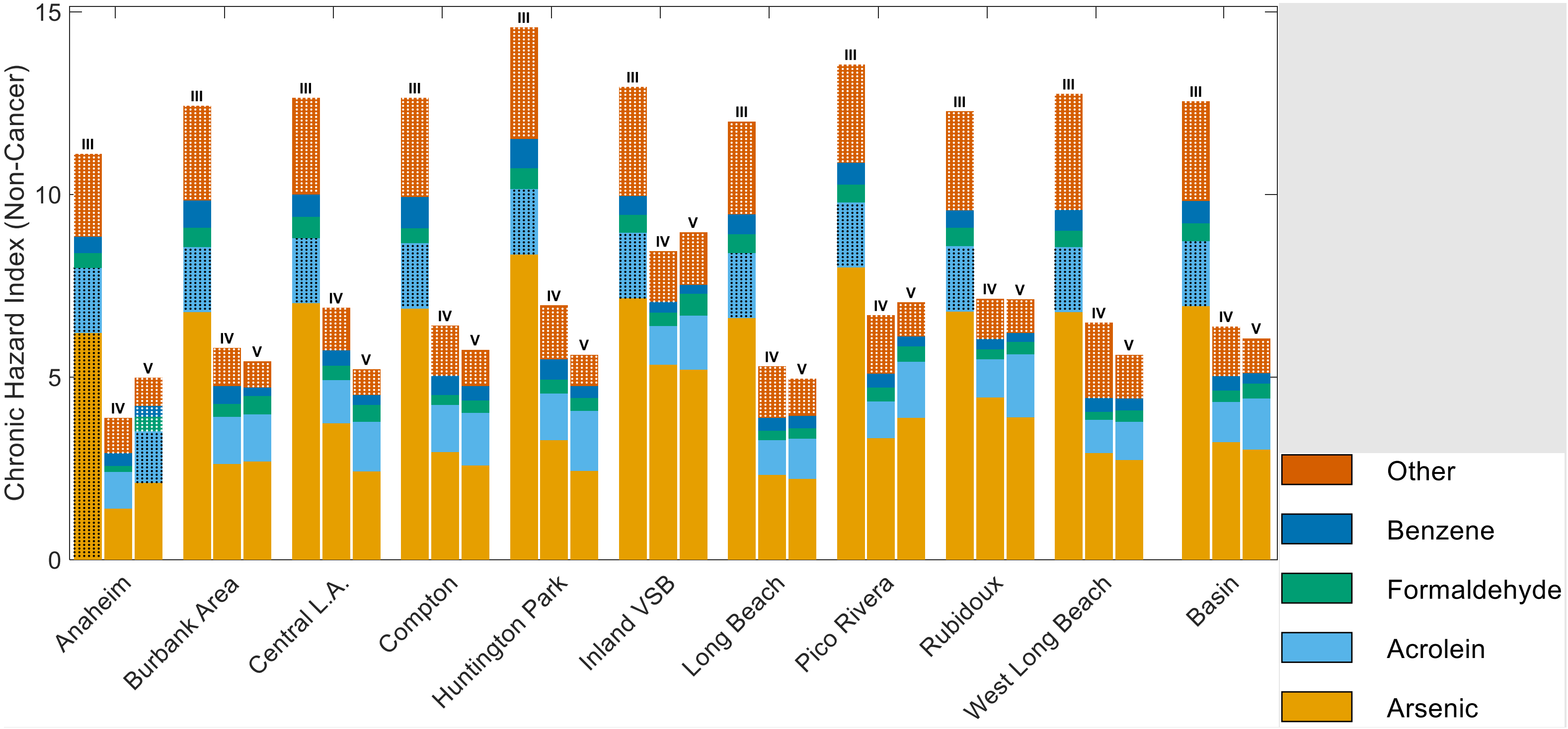

Figure 2-57 Chronic HI trends across MATES III through MATES V at all stations with analytes grouped. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Bromomethane was also excluded because it was only measured in MATES V and trends cannot be inferred. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit.

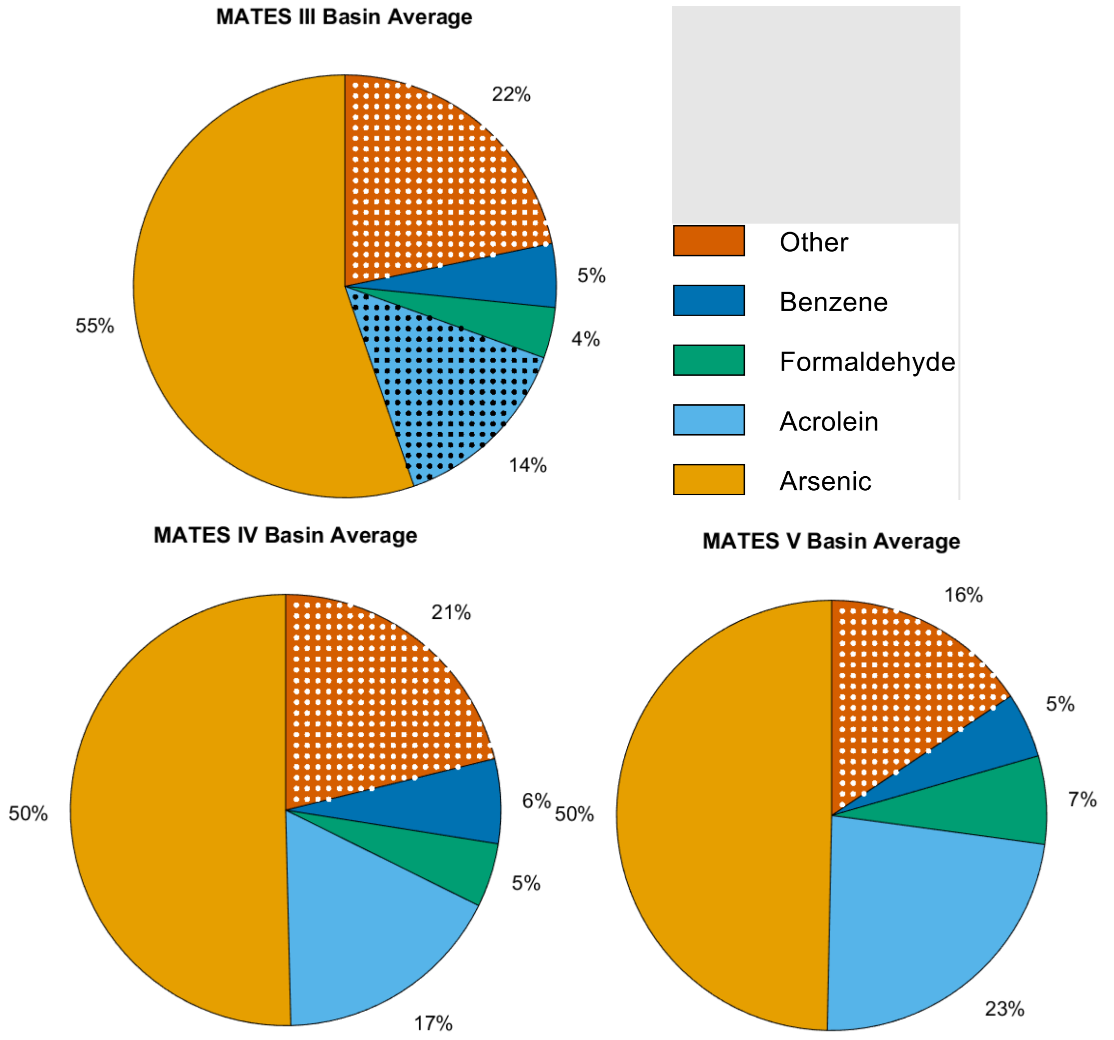

Figure 2-58 Pie charts of the basin-wide cumulative chronic non-cancer health impacts for MATES III through MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Bromomethane was also excluded because it was only measured in MATES V and trends cannot be inferred. Note that the MATES V pie chart in this figure is slightly different from the pie chart shown in Figure 2-55 due to the exclusion of Bromomethane from this figure. Dots are used to mark bar segments that are more uncertain due to either substitution for data that were unavailable or data for which more than 80% of measurements were below detection limit. Numbers may not sum to 100 due to rounding.

CHAPTER 3

DEVELOPMENT OF THE AIR TOXICS EMISSIONS INVENTORY

Chapter 3. Development of the Air Toxics Emissions Inventory

3.1 Introduction

An emissions inventory of air pollutants and their sources is essential to identify the major contributors of toxic air contaminants and to develop strategies to improve air quality. We obtain the information necessary to develop a detailed emissions inventory for the Basin from South Coast AQMD data sources as well as from other government agencies including California Air Resources Board (CARB), California Department of Transportation (Caltrans), and Southern California Association of Governments (SCAG).

Each of these agencies is responsible for collecting or generating data (e.g., industry growth factors, socio-economic projections, travel activity levels, emission factors, emission speciation profiles) and developing methodologies (e.g., models, demographic forecasts) that are used to develop a comprehensive emissions inventory. South Coast AQMD is solely responsible for developing the point source inventory while the area source inventory is developed jointly by South Coast AQMD and CARB. CARB is the primary agency responsible for developing the emissions inventory for all mobile sources and provides on-road and off-road mobile source inventories from their on-road emission factor model (EMFAC), and off-road inventory tools, respectively. SCAG is the primary agency for projecting population and economic activity growth in the Basin. Caltrans provides SCAG with highway network, traffic counts, and road capacity data. SCAG incorporates these data into their Travel Demand Model for estimating and projecting vehicle miles traveled (VMT) and vehicle speed. CARB’s on-road mobile source inventory also relies on SCAG’s VMT estimates.

3.2 Overview

The air toxic emissions inventory for MATES V consists of four components: (1) point sources; (2) area sources; (3) on-road mobile sources; and (4) off-road (or other) mobile sources. Point source emissions are emissions from facilities having one or more pieces of equipment permitted with the South Coast AQMD with total facility-wide emissions above certain threshold levels. Area sources represent numerous small sources of emissions that can collectively have significant emissions (e.g., dry cleaners, retail gasoline stations, auto body shops, residential heating). On-road mobile sources include cars, trucks, buses, and motorcycles. All mobile sources not included in the on-road mobile source inventory are considered “off-road” mobile sources including aircraft, ships, commercial boats, trains, recreational vehicles, construction and industrial equipment.

The 2016 Air Quality Management Plan (AQMP)[1] is the basis for the criteria and air toxics emissions inventory developed for MATES V with additional updates discussed in this chapter. A “top-down” approach is used to develop the toxics inventory; that is, toxic emissions are

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[1] Final 2016 Air Quality Management Plan: https://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/final-2016-aqmp.

calculated by applying the latest CARB speciation profiles[2] to the total organic gas (TOG) and particulate matter (PM) emissions. Speciation profiles provide estimates of the emission's chemical composition. CARB maintains and updates the chemical composition and size fractions of PM and the chemical composition and reactive fractions of TOG for a variety of emission source categories. The source type (e.g., equipment and fuel) is used to identify the appropriate speciation profile.

A top-down approach is preferable for a regional modeling risk analysis, for the following reasons:

- Speciating the VOC and PM inventory affords consistency with the 2016 AQMP;
- The photochemistry algorithms in the MATES V modeling system require the complete speciation of VOC emissions to ensure their correct application;
- Consistent approach used in the past MATES reports enables comparisons of emission changes over time.

3.3 Point Sources

The point source emissions included in MATES V are emissions reported to South Coast AQMD through the Annual Emissions Reporting (AER) program, which applies to facilities emitting four tons or more of VOC, NOx, SOx, or PM or emitting 100 tons or more of CO per year.

Facilities subject to the AER Program calculate and report their emissions primarily based on their throughput data (e.g., fuel usage, material usage), appropriate emissions factors from best available information (such as Continuous Emissions Monitoring, sources tests, permit limits and US EPA AP-42) and control efficiency, if applicable. Under the 2018 AER Program, approximately 1,800 facilities reported their annual emissions to the South Coast AQMD. Emissions from facilities not subject to the AER Program are included as part of the area source inventory (see Section 3.4).

To prepare the point source inventory, emissions from each facility is categorized based on the

U.S. EPA's Source Classification Codes (SCCs) for each emission source category. The AER facilities report their annual emissions at the device level (i.e., by SCC). For modeling purposes, the facility location specified in latitude/longitude coordinates is translated into the modeling coordinate system. The business operation activity profile is also recorded so that the annual emissions can be distributed temporally throughout the day, week, and month.

Toxic emissions are calculated by applying the latest CARB speciation profiles to the TOG and particulate matter emissions. The SCC is used to identify the appropriate speciation profile for the source.

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[2] CARB speciation profiles can be viewed or downloaded from the following CARB link: http://www.arb.ca.gov/ei/speciate/speciate.htm

3.4 Area Sources

The area source emissions developed for the 2016 AQMP projected from 2012 to the year of interest (2018) are used for MATES V. The South Coast AQMD and CARB shared the responsibility for developing the 2012 area source emissions inventory for approximately 500 area source categories. For each area source category, a specific methodology is used for estimating emissions. Emissions are spatially allocated to 2 km by 2 km grids using spatial surrogates. Some commonly used spatial surrogates are listed in Table 3-1. For some permitted minor point sources (not reported in the AER program) such as dry cleaners, gasoline dispensing facilities and autobody shops, emissions are allocated to permit locations according to permitted emissions. As with the point source inventory, toxic emissions are calculated by applying the latest CARB speciation profiles to the TOG and particulate matter emissions.

Table 3-1. Commonly Used Spatial Surrogates for Spatial Distributions of Area and Off-Road Sources

Population	Total employment
VMT	Industrial employment
Length of rail per grid cell	Retail employment
Locations of unpaved rural roads	Single dwelling units
Total housing	Rural land cover – forest
Agricultural land cover	Rural land cover – range land
National forest > 5000 ft	

Source: http://eos.arb.ca.gov/eos/projects/surrogates/

3.5 On-Road Mobile Sources

On-road emissions are estimated by combining emission factors with vehicular activity data. For the 2016 AQMP, CARB's EMFAC2014 emission factors were used along with link-based traffic volumes and speeds obtained from the SCAG's regional transportation modeling. Since the 2016 AQMP, EMFAC2017 was released and replaced EMFAC2014, reflecting more recent available vehicle emission factors and regulations.[3] Therefore, emission factors from EMFAC2017 were applied to vehicle activity data used in the 2016 AQMP (based on 2016 RTP) to develop the 2018 on-road emissions for MATES V. The Direct Travel Impact Model (DTIM) was used to link emission factors and the SCAG's transportation modeling results to generate hourly gridded emissions of criteria pollutants (i.e., TOG, NOx, PM, CO, and SOx). The DTIM emissions were adjusted based on the EMFAC2017 values. Environmental variables that affect emission rates (e.g., ambient temperature and humidity) were derived from meteorological modeling. The SCAG's transportation modeling results were for an average weekday. To obtain day-specific

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[3] EMFAC model and documentation: http://www.arb.ca.gov/msei/modeling.htm

on-road emissions, the CalTrans Performance Monitoring System (PeMS) and weigh-in-motion (WIM) data were utilized. Toxic emissions are calculated by applying the latest CARB speciation profiles for mobile sources to the TOG and PM emissions. A flow chart illustrating this process is provided in . Some of the key steps in the process are discussed in more detail below.

EMFAC, in its current form, is a suite of computer models that estimates the on-road emissions of hydrocarbons (TOG and HC), CO, NOx, PM, lead (Pb), SO_2, and CO_2 for calendar years 2000 to 2050. EMFAC considers 1965 and newer model year vehicles powered by gasoline, diesel, or electricity and reports for 13 broad vehicle classes as shown in Table 3-2. Over 100 different technology groups are accounted for within each class (e.g., catalyst, non-catalyst, three-way catalyst, carbureted, multiport fuel injection, LEV, TLEV, SULEV).

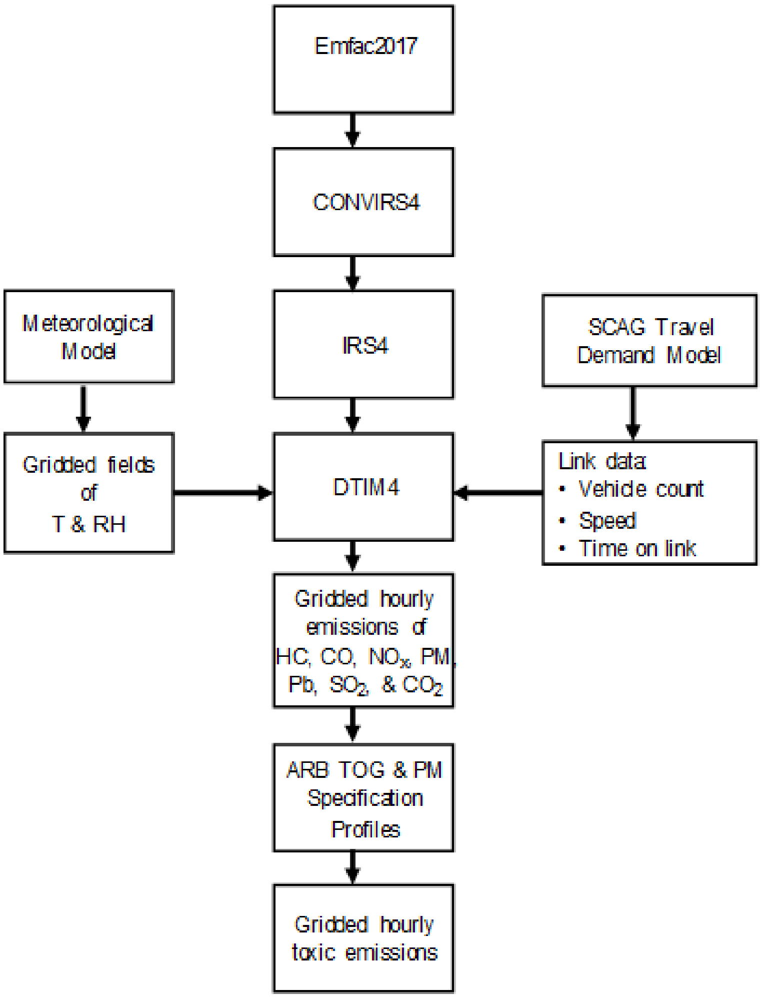

Figure 3-1. Flow Diagram for On-Road Emissions Processing.

Table 3-2. Broad Vehicle Classes Considered by EMFAC.

Vehicle Class	Weight (lbs)
Passenger cars	All
Light Truck I	0 – 3,750
Light Truck II	3,751 – 5,750
Medium-Duty Truck	5,751 – 8,500
Light-Heavy-Duty Truck I	8,501 – 10,000
Light-Heavy-Duty Truck II	10,001 – 14,000
Medium-Heavy-Duty Truck	14,001 – 33,000
Heavy-Heavy-Duty Truck	33,001 – 60,000
Motorcycle	All
Urban Diesel Bus	All
School Bus	All
Other bus	All
Motor Homes	All

Source: Adopted from the User's Guide for EMFAC2017.

EMFAC currently considers the following county-specific information when calculating emissions:

- Ambient air temperature (denoted by T in Figure 3-1);
- Relative humidity (denoted by RH in Figure 3-1);
- Vehicle population;
- Fleet composition;
- Fleet growth rates;
- Mileage accrual rates;
- Vehicle age distribution;
- Distribution of VMT by speed;
- Smog check regulations;
- Fuel properties; and
- Altitude.

Selected on-road activity information for the four counties in the Basin is summarized in Table 3-3. Four of the top seven counties in California in terms of vehicle population, VMT, and vehicle trips are within the South Coast AQMD jurisdiction.

Table 3-3. Vehicle Activity Information for the Counties in the Basin.

County	Vehicle Population	VMT/day	Trips/day	Miles per Vehicle-Day
Los Angeles	5,678,851	223,446,000	27,863,372	39.3
Orange	2,077,140	81,369,000	10,167,130	39.2
Riverside	1,186,800	49,847,000	5,997,085	42.0
San Bernardino	1,021,318	43,021,000	5,150,475	42.1

Source: EMFAC2017 and SCAG 2016 RTP

One of the EMFAC outputs summarizes TOG, CO, NOx, PM, lead, SO_2, and CO_2 emission rates for a given calendar year for each vehicle class and for each county/air basin specified. The DTIM modeling system is used in conjunction with EMFAC emission rates to prepare gridded hourly on-road emissions for photochemical grid modeling. EMFAC provides emissions rates by vehicle category, fuel type and fleet average vehicle model year.

The DTIM processing system consists of three Fortran program modules: CONVIRS4, IRS4, and DTIM4. The main function of CONVIRS4 is to re-format the emission rate file output from EMFAC into a form compatible with IRS4. IRS4 creates fleet average emission rates by ambient air temperature, relative humidity, and vehicle speed.

The DTIM4 module prepares gridded, hourly on-road emissions of TOG, CO, NO_X, PM, SO_2, and CO_2 link by link in the transportation network. SCAG's Travel Demand Model provides the following for each link in the transportation network: the number of vehicles, their average speed, and time on the link. Separate files containing hourly gridded temperature (T in Figure 3-1) and relative humidity (RH in Figure 3-1) are provided as input to DTIM4. Knowing the air temperature and relative humidity representative of the link and the average vehicle speed on the link, DTIM4 looks up the fleet average emission rate in the file prepared by IRS4 and multiplies these by the number of vehicles and the average time on the link.

Finally, CARB speciation profiles[4] are used to speciate the on-road TOG and PM emissions into its toxic components.

3.6 Off-Road Mobile Sources

The 2016 AQMP off-road emissions projected for 2018 were used for MATES V. CARB developed and updated the methods to estimate emissions from each off-road source category[5] except for aircraft, which South Coast AQMD developed. For the 2016 AQMP, CARB's off-road emissions tools were used to estimate emissions for all off-road categories (100+ source categories). These emissions tools incorporate various aspects of off-road elements, such as the

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[4] CARB speciation profiles can be viewed or downloaded from the following CARB link: http://www.arb.ca.gov/ei/speciate/speciate.htm

[5] The OFF-ROAD Model tools and its documentation can be obtained at the following CARB link: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-road-documentation-0

effects of various adopted regulations, technology types, and seasonal conditions on emissions.

The tools combine population, activity, horsepower, load factors, and emission factors to yield the annual equipment emissions by county, air basin, or state. Spatial and temporal features are incorporated to estimate seasonal emissions. Emissions for ocean-going vessels (OGV) and commercial harbor craft (CHC) were developed by CARB for the 2016 AQMP. Subsequent to the 2016 AQMP, CARB updated the OGV inventory and submitted it to the US EPA as part of its SIP updates.[6] This version of the OGV inventory was used in MATES V. The rest of the off-road mobile emissions are from the 2016 AQMP emissions inventory. Countywide off-road emissions are spatially allocated to 2 km by 2 km grids using spatial surrogates while aircraft emissions are allocated to the respective airports. Toxic emissions are calculated by applying the latest CARB speciation profiles for off-road mobile sources to the hydrocarbon and particulate matter emissions.

3.7 Summary of Air Toxic Emissions

Table 3-4 presents the emissions of selected compounds apportioned by the on-road, off-road, point, and area source categories. Chemicals that are considered potential or known human carcinogens are denoted with a check mark. Toxic emissions by major source categories are provided in Appendix VIII.

Table 3-4. 2018 Annual Average Day Toxic Emissions for the South Coast Air Basin.

	Pollutant	**Emissions (lbs/day)**				
		On-road	**Off-road**	**Point**	**Area**	**Total**
	VOC Species					
√	Acetaldehyde*	2,575.1	2,449.2	91.4	1,653.1	6,768.8
	Acetone**	2,268.2	1,695.8	400.3	25,900.9	30,265.1
√	Benzene	4,662.6	4,156.2	634.2	1,392.3	10,845.3
√	1,3-Butadiene	546.9	986.1	142.9	42.0	1,717.8
√	Carbon tetrachloride	0.0	0.0	10.4	0.1	10.6
√	Chloroform	0.0	0.0	54.3	0.9	55.2
√	1,1 Dichloroethane	0.0	0.0	2.3	68.1	70.4
√	1,4 Dioxane	0.0	0.0	0.2	0.0	0.2
√	Ethylene dibromide	0.0	0.0	0.2	0.0	0.2
√	Ethylene dichloride	0.0	0.0	84.2	11.9	96.1
√	Ethylene oxide	0.0	0.0	3.7	0.0	3.7
√	Formaldehyde*	5,249.2	6,222.9	1,597.4	4,320.3	17,389.8
	Methyl ethyl ketone*	445.6	296.9	366.8	5,676.5	6,785.7
√	Methylene chloride	0.0	0.0	1,016.0	11,687.0	12,703.0
√	MTBE	206.1	0.8	0.0	0.0	206.9

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[6] CARB 2018 SIP Update can be viewed or download from the following CARB link: https://ww2.arb.ca.gov/resources/documents/2018-updates-california-state-implementation-plan-2018-sip-update

√	Naphthalene	206.8	185.4	30.4	118.8	541.5
√	p-Dichlorobenzene	0.0	0.0	114.9	2,185.3	2,300.2
√	Perchloroethylene	0.0	0.0	1,079.2	2,145.1	3,224.3
√	Propylene oxide	0.0	0.0	0.5	0.3	0.8
	Styrene	242.0	165.5	801.8	3,853.7	5,063.0
	Toluene	10,970.5	8,078.3	3,238.8	19,671.2	41,958.8
√	Trichloroethylene	0.0	0.0	656.7	498.1	1,154.8
√	Vinyl chloride	0.0	0.0	178.7	1,103.4	1,282.1
	PM Species					
√	Arsenic	0.4	1.8	5.3	6.5	14.0
√	Cadmium	0.1	0.3	4.3	7.7	12.5
	Chromium	46.7	5.0	15.3	30.9	97.9
√	Diesel particulate	4,210.6	5,213.0	218.9	66.7	9,709.2
	Elemental carbon***	4,003.9	4,019.1	946.6	6,739.7	15,709.3
√	Hexavalent chromium	0.5	0.3	0.1	0.0	0.8
√	Lead	4.0	9.6	5.9	98.9	118.4
√	Nickel	24.6	8.2	27.6	19.5	79.9
	Organic carbon	9,479.2	6,030.4	4,462.7	45,715.6	65,687.9
	Selenium	0.9	0.2	0.6	2.4	4.1
	Silicon**	2,535.3	121.3	2,665.6	101,422.4	106,744.5

√ Denotes potential or known human carcinogen.
* Primarily emitted emissions. These materials are also formed in the atmosphere from photochemical reactions.
** Acetone and silicon are not toxic compounds. Their emissions are included here because they were measured in the sampling program.
*** Includes elemental carbon from all sources (including diesel particulate).

Species and source apportionment data are shown in Table 3-5 and Figure 3-2, respectively. In those illustrations, the emissions of the carcinogenic pollutants in Table 3-4 are weighted by the ratio of their inhalation cancer potency to the cancer potency of diesel PM. Thus, emissions from species less potent than diesel PM (e.g, benzene, perchloroethylene) are weighted less, while emissions from species more potent than diesel PM (e.g., hexavalent chromium, arsenic) are weighed more. diesel PM has a weighting factor of one. These weighted emissions will be referred to as diesel PM equivalent emissions.

Table 3-5. Cancer Potency Weighted Species Apportionment for 2018 Emissions

Toxic	Contribution (%)	Toxic	Contribution (%)
Diesel particulate	72.52	Methylene chloride	0.30
Benzene	7.36	Trichloroethylene	0.05
1,3-butadiene	7.00	Lead	0.03
Hexavalent chromium	2.92	Ethylene dichloride	0.04
Formaldehyde	2.48	Ethylene oxide	<0.01
Vinyl chloride	2.35	Carbon tetrachloride	<0.01
Cadmium	1.21	1,1-Dichloroethane	<0.01
Arsenic	1.14	MTBE	<0.01
p-dichlorobenzene	0.62	Ethylene dibromide	<0.001
Nickel	0.49	Chloroform	<0.01
Acetaldehyde	0.46	Propylene oxide	<0.0001
Perchloroethylene	0.46	1,4-Dioxane	<0.0001
Naphthalene	0.44		

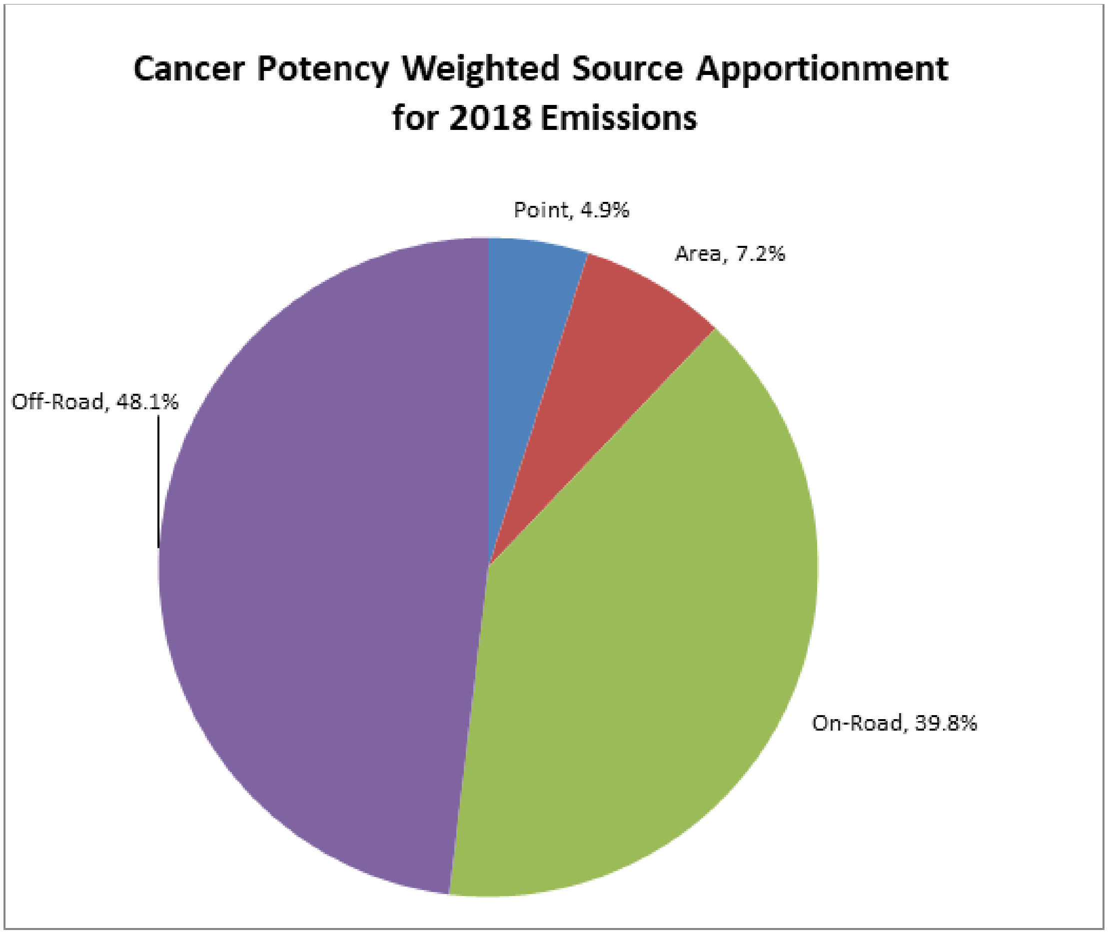

Figure 3-2. Cancer Potency Weighted Source Apportionment for 2018 Emissions.

Taking cancer potency into consideration, diesel PM account for about 72% of the overall carcinogenic air toxics emissions (Table 3-5). Model predicted cancer risks are discussed in Chapter 4. Based on other South Coast AQMD analyses of projected diesel PM emissions in future years,[7,8] significant decreases in diesel PM health impacts are expected within the 5-10 years. These reductions reflect recent and continued efforts by the District, CARB and US EPA that reduce diesel PM emissions, especially from mobile sources.

The other significant compounds (i.e., contributions >1%) are 1,3-butadiene, benzene, hexavalent chromium, formaldehyde, vinyl chloride, arsenic and cadmium. On-road and off-road mobile sources account for nearly 88% of the total weighted carcinogenic air toxics emissions

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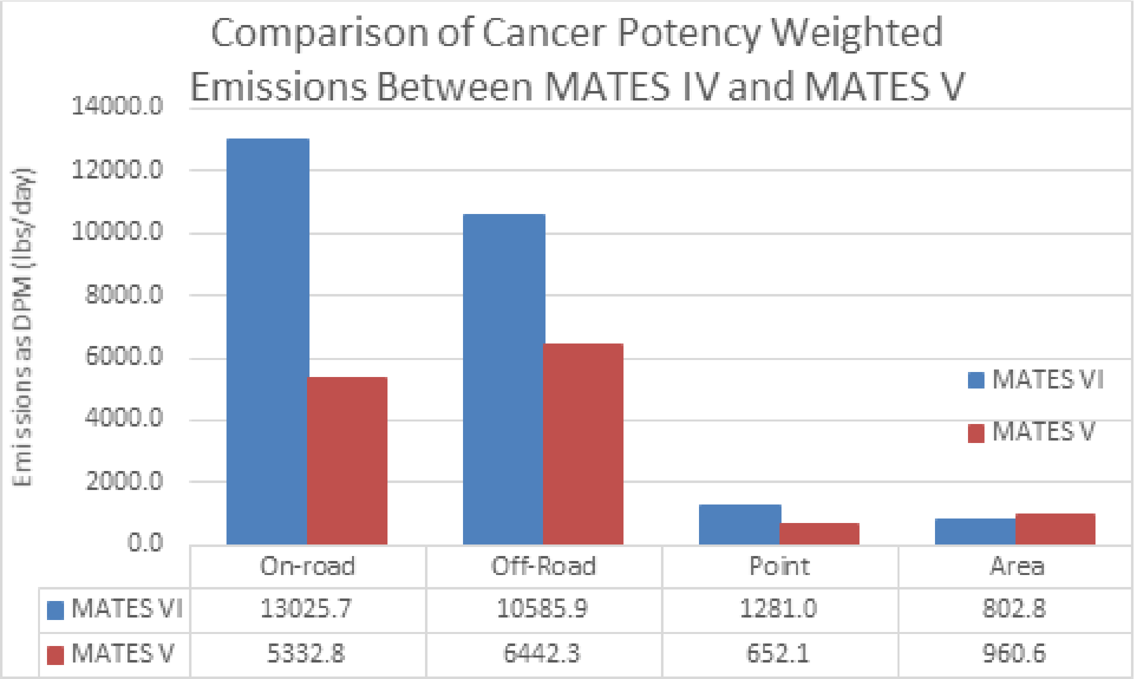
[7] South Coast AQMD (2017). 2016 Air Quality Management Plan, Appendix III: Base and Future Year Emission Inventory. http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/final-2016-aqmp/appendix-iii.pdf.

[8] South Coast AQMD (2019). Methodology for Source Attribution Analyses for the first year AB 617 Communities in the South Coast Air Basin. https://www.aqmd.gov/docs/default-source/ab-617-ab-134/technical-advisory-group/source-attribution-methodology.pdf?sfvrsn=8.

and stationary (i.e., point and area) sources contribute about 12% (Figure 3-2). Compared to the past MATES reports where the on-road category was the biggest contributor the carcinogenic air toxics emissions in the air toxics inventory (e.g., 50.7% in MATES IV), MATES V shows that the off-road category is now the highest contributor at 48.1% with the on-road category at 39.8%.

Carcinogenic emissions have been continuously decreasing over the last several decades due to existing regulations and control programs and adoption of cleaner technologies. Compared to MATES IV, emissions of carcinogenic pollutants have decreased by 48% in MATES V. As shown in Figure 3-3, carcinogenic emissions from on-road mobile, off-road mobile and point source categories decreased by 59%, 39%, and 49%, respectively. These reductions primarily are attributable to programs and regulations by South Coast AQMD and CARB. Carcinogenic emissions from area source category increased by 20%. This increase in toxics emissions in area sources is due to changes in assignment of speciation profiles in two area source categories ‘plastics and plastic product manufacturing’ and ‘coatings and related processes’. The former, which did not have any gaseous toxics emissions in the MATES IV modeling platform, used an industry specific profile that yielded 235 lbs/day diesel PM equivalent toxics emissions from vinyl chloride in the MATES V modeling. Similarly, the latter category, which did not have particle phase toxics emissions during the MATES IV modeling, yielded 53 lbs/day diesel PM equivalent toxics emissions from cadmium due to changes in speciation profiles. Without these updates in speciation profile assignments, toxics emissions from the area source category would have decreased by 16% from MATES IV to MATES V. Methylene chloride emissions increased from 9,900 lbs/day (31.5 lbs/day diesel PM equivalent) in MATES IV to 12,703 lbs/day (40.4 lbs/day diesel PM equivalent) in MATES V. This increase was due to: 1) increase in area sources TOG emissions from MATES IV to MATES V, for example, a category of area source degreasing (sealant and caulking) TOG emissions increased from 2.77 tons/day to 3.39 tons/day, resulting in 1,241 lbs/day increase in methylene chloride emissions: 2) a change in speciation profile used for consumer products/paint remover (methylene chloride content increased from 51% to 66%) resulted in 1,008 lbs/day more and 3) there were 989 lbs/day more from MATES V point sources due to changing in assignments of SCC codes to emissions.



	On-road	Off-Road	Point	Area
■ MATES VI	13025.7	10585.9	1281.0	802.8
■ MATES V	5332.8	6442.3	652.1	960.6

Figure 3-3. Comparison of Cancer Potency Weighted Emissions between MATES IV and MATESV.

3.8 Emissions and Air Quality Changes for Select Air Toxics Since MATES IV

Table 3-6 compares the emissions and the measured air quality changes since MATES IV for selected air toxics. The air quality change was quantified as the difference of measured annual average ambient concentrations from the MATES IV to the MATES V periods. For gaseous species, measurements from the following stations were evaluated: Burbank Area, Compton, Huntington Park, Inland Valley San Bernardino, Long Beach, Pico Rivera and West Long Beach. For toxic metals and EC, data from all ten monitoring sites were used. As shown in the table, emissions of elemental carbon have decreased by 56%, and measured concentrations have reduced by 45% since MATES IV. Comparisons of some other species are more complicated due to atmospheric chemistry and transport.

Several caveats are important to consider when comparing the changes in emissions inventory and ambient measurements. For example, weather and dispersion of pollutants can influence the relationship between emissions and ambient concentrations. Also, the inventory is a regional estimate of total emissions throughout the Basin, whereas ambient measurements are from the ten fixed monitoring locations where there may be influences from local sources. Another difference is that secondary formation and degradation of substances in the atmosphere are not accounted for in the emissions comparisons but are captured in the ambient measurements. In particular, current MATES V modeling results showed that formaldehyde and acetaldehyde came from secondary formation rather than direct emissions during the MATES V period.

Table 3-6. Emissions and Air Quality Changes for Select Air Toxics Since MATES IV.

Pollutant	Change in Emissions	Change in Monitored Concentration
Gases		
Acetaldehyde	+2%	+62%
Benzene	-10%	-27%
1,3-butadiene	-33%	-36%
Formaldehyde	-8%	+31%
Methylene chloride	+28%	-46%
Perchloroethylene	-52%	-46%
Trichloroethylene	-29%	-70%
Particulates		
Arsenic	-42%	-1%
Cadmium	+45%	+114%
EC ($PM_{2.5}$)	-56%	-45%
Hexavalent chromium	-73%	-29%
Lead	+1%	-21%
Nickel	-15%	-17%

Therefore, emissions trends are not necessarily consistent with the ambient concentration trends. As shown in Table 3-6, for inert species, e.g., EC, perchloroethylene, trichloroethylene, and some metals, the emissions trends and the ambient concentration trends are consistent. For some chemically active species, comparing the emissions and concentration trends are more nuanced.

Nonetheless, comparing emissions estimates with air quality measurements can provide information on whether expected emissions changes are reflected in actual ambient measurements, can be used to help calibrate emissions estimates, and may suggest where emissions inventory methods can be improved.

CHAPTER 4
REGIONAL MODELING AND EVALUATION

Chapter 4. Regional Modeling and Evaluation

4.1 Background

Regional air quality modeling is used to estimate community exposure to air toxics as a function of both time and geography due to known toxic emissions sources. The model-simulated concentrations of toxic compounds are translated into a spatial pattern of air toxics health risk based on the cancer potency and risk factors for each compound. The regional modeling method provides a mechanism to predict the transport of emissions from a variety of source categories as well as individual sources to estimate risk throughout the modeling domain. This analysis complements and is compared to the techniques used to assess concentrations and risks from the data acquired at the fixed monitoring sites.

For over the last 20 years the South Coast AQMD has used regional air quality models in air toxics risk analyses. In the MATES II analysis, the Urban Airshed Model with TOX (UAMTOX) chemistry was used to simulate the transport and accumulation of toxic compounds throughout the Basin. In this chapter, South Coast Air Basin is referred as SCAB or the Basin. UAMTOX was simulated for a protracted 2 km by 2 km grid domain that overlaid the Basin.

Subsequent to MATES II, the South Coast AQMD transitioned to more technologically advanced tools that use updated chemistry modules, improved dispersion algorithms, and mass consistent meteorological data. In the 2007 Air Quality Management Plan (AQMP) and the subsequent MATES III analysis, the dispersion platform moved from UAM to the Comprehensive Air Quality Model with Extensions (CAMx), enhanced with a reactive tracer modeling capability (RTRAC),[1] and the diagnostic wind meteorological model was replaced by the Mesoscale Model version 5[2] prognostic model. CAMx, coupled with the MM5 input, using the "one atmosphere" gaseous and particulate chemistry, was used to simulate both episodic ozone and annual concentrations of $PM_{2.5}$ and air toxic pollutants. The modeling was performed based on the UTM coordinate systems.

In the 2012 AQMP, the South Coast AQMD transitioned from MM5 to a new mesoscale meteorological model, Weather Research Forecast[3] and adopted a statewide Lambert Conformal coordinate system. Both CAMx and Community Multiscale Air Quality (CMAQ) models were used for air quality simulations. Within the South Coast Air Basin (SCAB), both models performed similarly. For MATES IV, the CAMx RTRAC with WRF was used to model air toxic concentrations of both particulate matter and gaseous species. MATES V used the MATES IV

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[1] Ramboll Environment and Health, 2018. CAMx User's Guide Version 6.50. Novato, CA 94998

[2] Grell, G.A., Dudhia, J., Stauffer, D.R., 1994, A Description of the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5), NCAR/TN-398+STR, NCAR Technical Note

[3] Skamarock, WC, Klemp, JB, Duchia, J, Gill, D.O., Barker, D.M., Duda, M.G., Huang, X.-Y., Want, W, Powers, J.G., 2008, A Description of the Advanced Research WRF Version 3, NCAR/TN–475+STR http://www2.mmm.ucar.edu/wrf/users/docs/arw_v3.pdf

modeling setup with the latest versions of CAMx and WRF.

The MATES V modeling was conducted over a domain that encompassed the Basin, portions of Coachella Valley (CV) and the coastal shipping lanes located off the shore of Los Angeles, Orange, and Ventura counties using a grid size of 2 km by 2 km. Figure 4-1 depicts the MATES V modeling domain. Compared to MATES IV, the MATES V modeling domain was extended further east by 40 km to include populated portions of the Coachella Valley. An emissions inventory for 2018 was developed based on the 2016 AQMP emissions inventory with updates using the 2018 reported point source emissions, the latest CARB on-road emission model (EMFAC2017),[4] and speciation profiles. Although the actual measurements and modeling for MATES V spanned the period from May 1, 2018 through April 30, 2019, for simplicity, the MATES V modeling used the 2018 emissions inventory, with day-of-week information reflected in the modeling emissions. Anthropogenic emissions change depending on the day-of-week, for example, heavy-duty truck traffic reduces significantly on weekends. Grid-based, hourly meteorological fields generated from WRF provided the wind, temperature, humidity patterns and other atmospheric parameters for the model simulations. Using the 2018 annual inventory to represent the MATES V period is not expected to significantly impact modeling results.

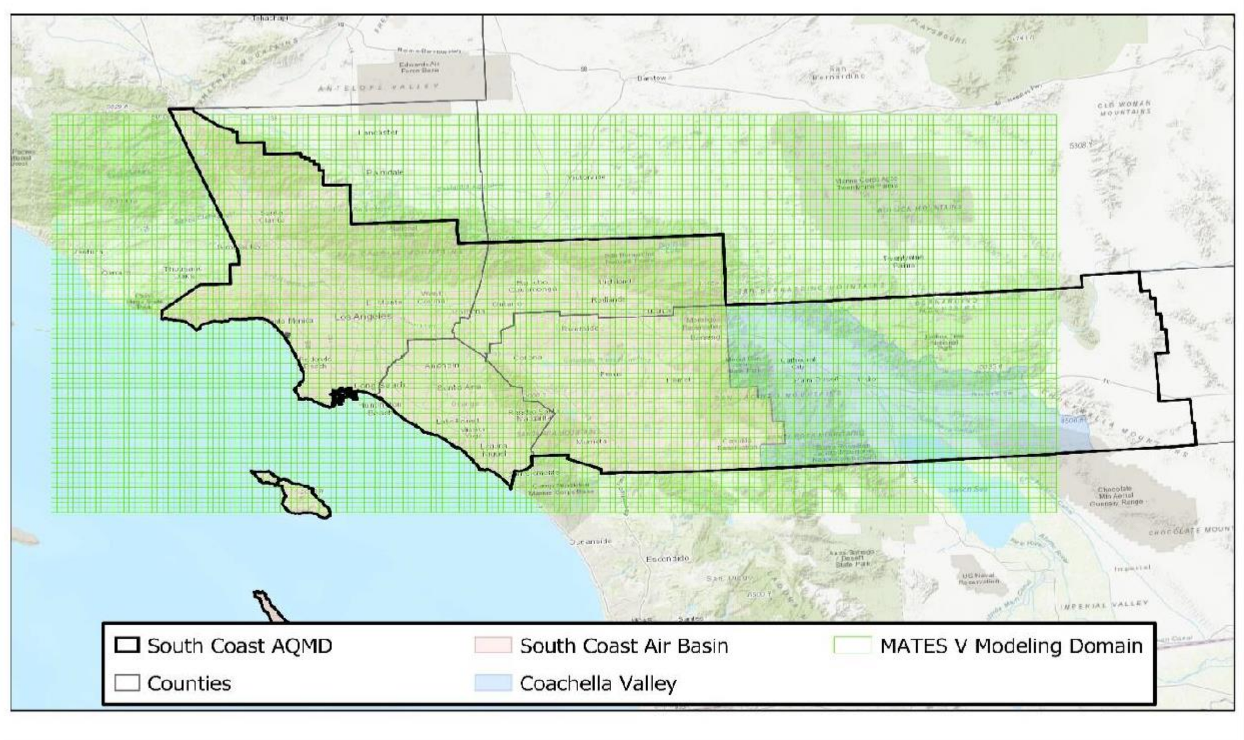

Figure 4-1.
MATES V Modeling Domain

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[4] CARB, 2017, EMFAC2017 model and its documentation can be obtained at the following CARB link: http://www.arb.ca.gov/msei/modeling.htm

4.2 Modeling Setups

The MATES V regional modeling analyses relied on the CAMx RTRAC model to simulate annual impacts of both gaseous and aerosol toxic compounds. The accuracy of the modeling analyses depends on the accuracy of region-wide emissions of air toxic compounds, temporal and spatial resolutions of these emissions, accurate representation of meteorological conditions and quality of modeling tools used. The South Coast AQMD staff has been striving to use the best information and modeling tools available at the time for its MATES modeling analyses. The MATES V appendices provides the technical details about the emissions and modeling.

As in MATES IV, MATES V used the CAMx-WRF coupled system. WRF is a state-of-the-science meteorological modeling tool offering a variety of user options to cover atmospheric boundary layer parameterizations, turbulent diffusion, cumulus parameterizations, land surface-atmosphere interactions, which can be customized to model-specific geographical and climatological situations. The South Coast AQMD staff performed extensive sensitivity tests to improve WRF model performance for the South Coast Air Basin and surrounding areas, where the geographical and climatological characteristics impose great challenges in predicting the complex meteorological structures associated with air quality episodes. CAMx with RTRAC algorithms was employed as a chemical transport platform, given the importance of tracking chemically active toxic elements individually to assess the contribution of each source category. The RTRAC algorithm provides a flexible approach for tracking the emissions, dispersion, chemistry, and deposition of multiple gases and particles that are not otherwise included in the model's chemistry mechanisms. MATES V used the latest available version of models, compared model performances with Community Multiscale Air Quality (CMAQ) model, a model used in AQMP/State Implementation Plan modeling attainment demonstration, and available databases.

The MATES V modeling used the latest available emissions data. For major point sources, reported annual emissions were used. For area and off-road mobile sources, although annual emissions were based on projection in 2016 AQMP, the latest updated spatial surrogates were used to allocate county total emissions to a specific grid in the modeling domain. The EMFAC2017 emission factors along with SCAG's transportation modeling results for 2018, which provided a link-based midweek traffic volumes and speeds by vehicle types, CalTrans Performance Measurement System (PeMS) and Weigh-in-Motion (WIM) data, and ambient conditions from WRF modeling were used to generate spatially and temporally resolved on-road modeling emissions. The annual emissions from ocean-going vessels (OGV) from the CARB 2018 Updates to the California State Implementation Plan[5] were used. Emissions from OGV and commercial harbor craft (CHC) were spatially and temporally resolved using Automatic Identification System (AIS) data. All OGVs have emissions released through stacks, which result in the emissions penetrated to the computational layer 2 and higher, while CHC emissions were assumed to be released at the sea level due to the lower profile of a typical harbor craft. The

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[5] CARB, 2018, the 2018 Updates to the California State Implementation Plan, Available at https://ww3.arb.ca.gov/planning/sip/2018sipupdate/2018update.pdf

latest biogenic emission model, Model of Emissions of Gases and Aerosols from Nature 3 (MEGAN3), together with WRF outputs were used to generate day-specific biogenic emissions.

Table 4-1 summarizes the major components in the air toxics modeling and provides a comparison between the MATES V and MATES IV analyses.

Table 4-1
Summary and Comparison of Key Modeling Considerations Between
MATES IV and MATES V

Parameter	MATES IV	MATES V
Meteorological Modeling	July 2012 - June 2013	May 2018 - April 2019
Model Platform / Chemistry	CAMx RTRAC (5.30)	CAMx RTRAC (6.50)
Meteorology Model /Vertical Layers	WRF with 30 layers/ CAMx: 16 layers	WRF with 30 layers/ CAMx: 16 layers
On-Road Mobile Emissions	EMFAC2011/2012 RTP SCAG Traffic Activity Fixed day of week and hourly distributions by Caltrans District	EMFAC2017/2016 RTP SCAG Traffic Activity Day-specific spatial and temporal distributions based on CalTrans PeMS/WIM data
OGV and CHC Emissions	2012 AQMP for 2012 OGV; Emissions spread through mostly layers 1 and 2; uniform spatial and temporal distributions	2018 SIP Update for OGV; Emissions spread through mostly layers 1 and 2; day-specific temporal and spatial distributions
Point Source Emissions	2012 Projection from 2008 (2012 AQMP)	2018 Annual Emissions Reports
Area Source Emissions	2012 Projection from 2008 (2012 AQMP)	2018 Projection from 2012 (2016 AQMP)
Off-Road Emissions other than OGV and CHC	2012 Projection from 2008 (2012 AQMP)	2018 Projection from 2012

4.3 Modeling Results

CAMx RTRAC regional modeling was conducted to estimate annual average concentrations of 19 key compounds measured as part of the MATES V monitoring program from May 1, 2018 to April 30, 2019. Simulated annual average concentration plots for the four toxic compounds that contributed most to the air toxics cancer risk throughout the domain (diesel particulate, benzene, 1,3-butadiene and formaldehyde) are depicted in Figures 4-2 through 4-5.

Figure 4-2 depicts the projected annual average concentration of diesel PM in the model domain. The highest concentration (1.13 μg/m^3) was simulated to occur around the Ports of Los Angeles and Long Beach. In general, the distribution of diesel particulates is aligned with the transportation corridors including freeways, major arterials and rail rights-of-way. The peak diesel concentration is much lower than the previous MATES studies, due in a large part to emission reductions from regulations and programs impacting in various categories of on-road and other mobile sources. Based on other South Coast AQMD analyses of projected diesel PM emissions in future years,[6,7] significant decreases in diesel PM health impacts are expected within the 5-10 years. Figures 4-3 and 4-4 provide the distributions of benzene and 1,3-butadiene respectively whereby the toxic compounds are almost uniformly distributed throughout the Basin, reflecting light-duty vehicle traffic pattern since benzene and 1,3-butadiene emissions are mostly from gasoline combustion. Benzene emissions are primarily from on- and off-road mobile sources, with portions emitted from refineries located near the coast.

The modeled benzene concentrations mostly reflect patterns of the mobile sources with marginal enhancement near the coastal area. The 7 monitoring stations, Burbank Area, Compton, Huntington Park, Inland Valley San Bernardino, Long Beach, Pico Rivera and West Long Beach - showed the measured annual concentrations for benzene ranging from 0.22 ppb, the lowest at Burbank Area to 0.38 ppb, the highest at Compton with a 7-station average to be 0.29 ppb. Model prediction at those stations ranges from 0.21 to 0.28 ppb with a 7-station average to be 0.25 ppb, which are in reasonable agreement with the measurements.

The ambient concentrations of formaldehyde in the Basin are attributed to direct emissions, combustion sources, and secondary formation in the atmosphere. The formaldehyde concentrations shown in Figure 4-5 depict a spatial distribution indicative of its sources, with measurable concentrations in the heavily-traveled western and central Basin, with additional elevated levels in the downwind areas of the Basin that are impacted by higher levels of photochemistry and ozone formation. While the emissions from primary combustion sources decreased by approximately 8% since MATES IV, the MATES V measurements indicated the ambient formaldehyde concentrations increased compared to MATES IV. This increase means that the formaldehyde concentrations are being driven by secondary formation instead of direct emissions, indicating a complex chemistry involved in formaldehyde formation and depletion and possibly uncertainties in emissions inventory method. The modeled concentrations from the 7 monitoring stations averaged at 1.61 ppb, lower than the measured values averaged at 2.95 ppb.

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[6] South Coast AQMD (2017). 2016 Air Quality Management Plan, Appendix III: Base and Future Year Emission Inventory. http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/final-2016-aqmp/appendix-iii.pdf

[7] South Coast AQMD (2019). Methodology for Source Attribution Analyses for the first year AB 617 Communities in the South Coast Air Basin. https://www.aqmd.gov/docs/default-source/ab-617-ab-134/technical-advisory-group/source-attribution-methodology.pdf?sfvrsn=8

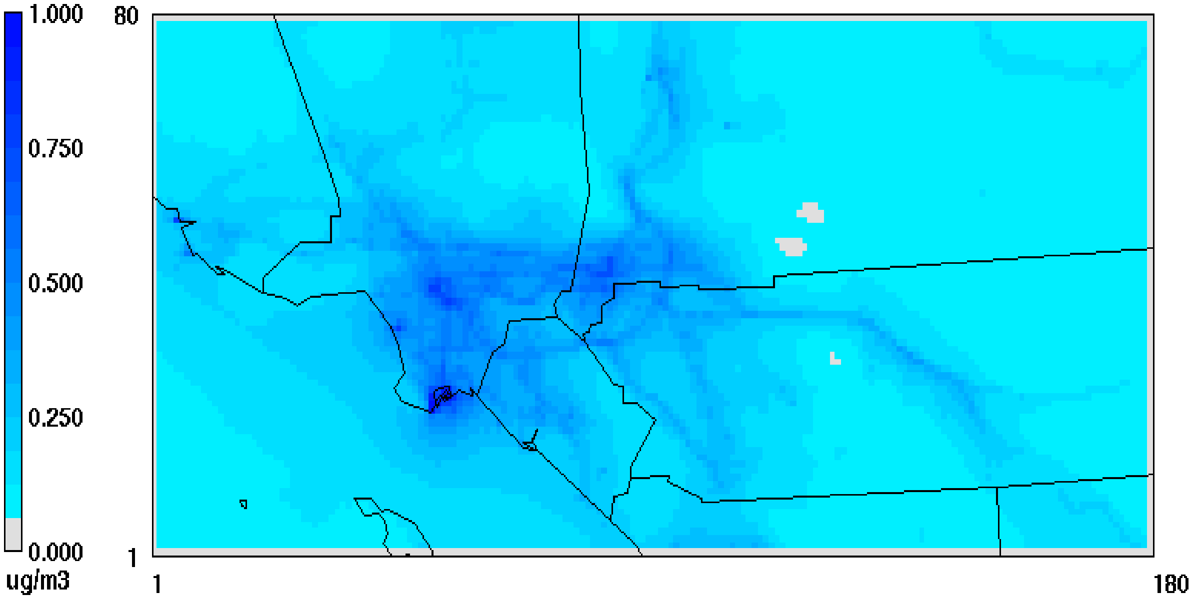

Figure 4-2
Annual Average Concentration Pattern for Diesel PM

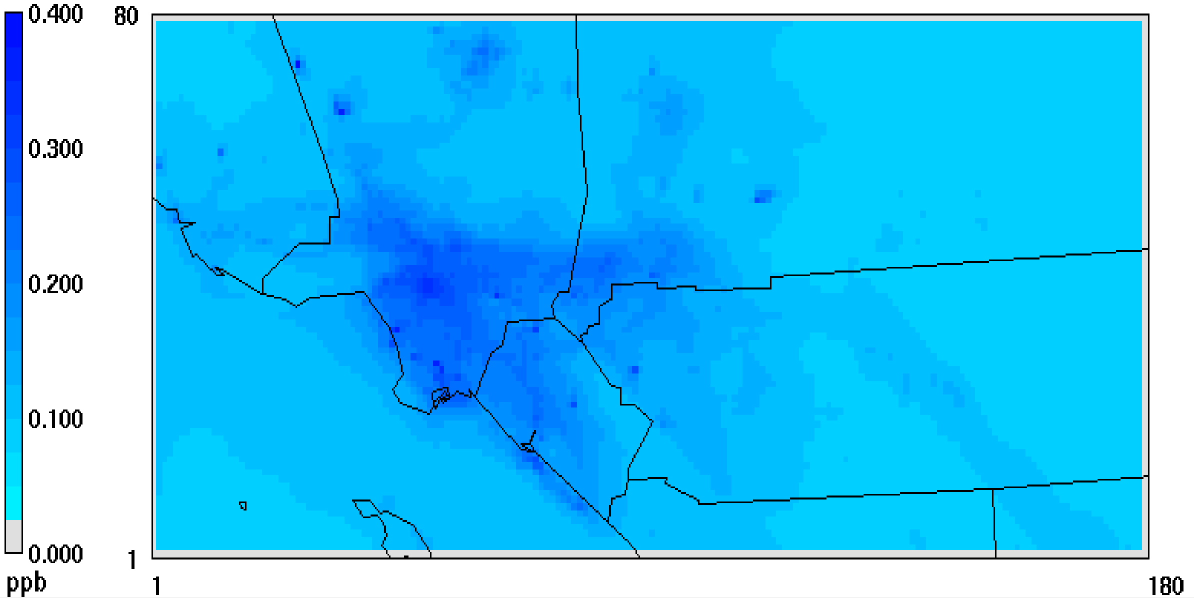

Figure 4-3
Annual Average Concentration Pattern for Benzene

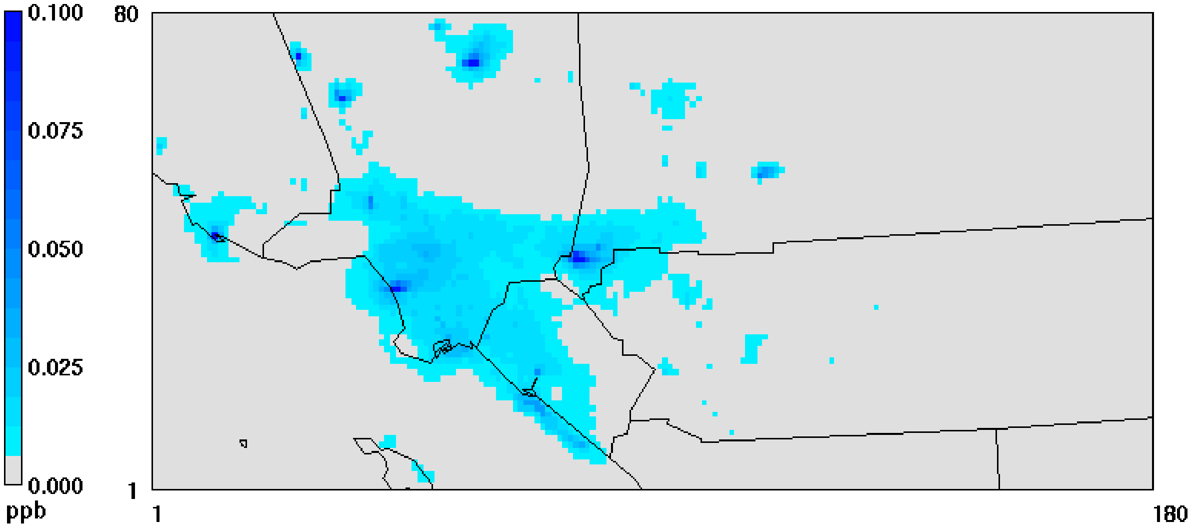

Figure 4-4
Annual Average Concentration Pattern for 1,3-Butadiene

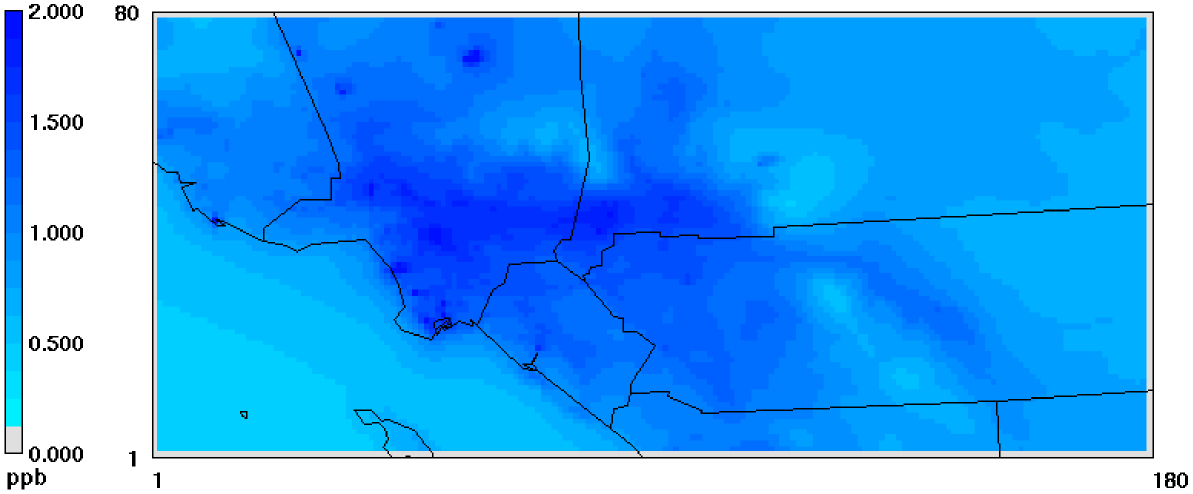

Figure 4-5
Annual Average Concentration Pattern for Total Formaldehyde

Table 4-2 provides a summary of the model performance relative to the actual measured annual average concentrations. For this comparison, the monitored data from seven stations (Burbank Area, Compton, Huntington Park, Inland Valley San Bernardino, Long Beach, Pico Rivera and West Long Beach) are combined to provide an estimate of average Basin-wide conditions for the MATES V sampling period for the gaseous species while 3 additional stations Anaheim, Los Angeles and Rubidoux are used as well for metals and EC. The CAMx RTRAC estimated concentrations at the monitoring sites were derived using the inverse distance-square weighted surrounding nine-cell average. Since direct measurements of diesel PM are not possible, no direct comparisons can be made with simulated annual average concentrations. However, using the methodology for converting measured EC into diesel PM as described in Chapter 2, the 10-site average diesel PM concentration is estimated to be 0.48 μg/m^3. The modeled average concentration corresponding to the average across the same 10 sites is 0.51 μg/m^3. Naphthalene was measured only at the Central Los Angeles and Rubidoux stations. For the rest of the species, each of the four counties within the South Coast AQMD jurisdiction is represented by at least one station.

Table 4-2

Measured and Modeled Annual Average Concentrations During MATES V

Compound	Units	2018-2019 MATES V	
		Measured Annual Average*	Modeled Annual Average
$EC_{2.5}$	μg/m^3	0.66	0.63
Cr 6 (TSP)	ng/m^3	0.040	0.032
As (TSP)	ng/m^3	0.52	0.51
Cd (TSP)	ng/m^3	0.32	0.64
Ni (TSP)	ng/m^3	3.14	4.15
Pb (TSP)	ng/m^3	4.80	3.51
Benzene	ppb	0.29	0.25
Perchloroethylene	ppb	0.03	0.02
p-Dichlorobenzene	ppb	0.03	0.03
Methylene Chloride	ppb	0.17	0.18
Trichloroethylene	ppb	0.02	0.01
1,3-Butadiene	ppb	0.06	0.02
Formaldehyde	ppb	2.95	1.59
Acetaldehyde	ppb	1.55	0.60
Naphthalene*	ng/m^3	62	26

* The table shows the average across all 10 stations for each of the particulate matter pollutants, the average across 7 stations for VOC pollutants except for naphthalene, which is the average across two stations.

The modeled concentrations of particulate matter species, such as $EC_{2.5}$ and TSP metals compared well with measured concentrations. The model performances for gaseous species are more mixed. Ambient concentrations of perchloroethylene, p-dichlorobenzene, and trichloroethylene have become so low such that the typical ambient concentrations are often below the measurement's method detection limits (MDLs). Thus, greater uncertainties exist in evaluating model performance against measurements for these species. However, the measured and modeled concentrations are in the same general ranges, as shown in Table 4-2. Given the low ambient concentrations of these three gaseous air toxics, their contribution to the overall air toxic cancer risk is less than one percent for each pollutant. For 1,3-butadiene, due to its highly reactive nature, large uncertainties exist in speciation profiles, and decay parameters used in the modeling as well as measurements. As a result, good model performance for 1,3-butadiene is not typically expected. Accurate information on speciation profiles for naphthalene is limited.

Naphthalene concentrations measured in MATES III, MATES IV and MATES V showed very low ambient concentrations and therefore very low air toxic cancer risk contributions. Benzene, which past MATES modeling showed remarkably good agreement between modeling and measurement results, was predicted reasonably well. Meanwhile, carbonyls, formaldehyde and acetaldehyde, were underpredicted. While carbonyl emissions continue to decrease, the measured carbonyl concentrations increased compared to MATES IV, which indicates potential uncertainties in multiple areas such as chemical mechanism, transport modeling, emissions inventory, and measurement. Further analysis and research are warranted to improve the understanding. Modeled and observed concentrations of methylene chloride compared well.

Modeled annual average concentrations of $EC_{2.5}$ were used to assess the overall model performance, especially diesel PM for the MATES V period. Tables 4-3 summarizes the MATES V $EC_{2.5}$ model performance.

The U.S. EPA's guidance[8] recommends evaluating particulate matter modeling performance using prediction bias and error. Prediction Accuracy (PA), calculated as the percentage difference between the mean annual observed and simulated $EC_{2.5}$ concentrations, is another tool used in the performance evaluation. PA goals of ±20% for ozone and ±30% for individual components of $PM_{2.5}$ or PM_{10} have been used to assess simulation performance in modeling attainment demonstrations in previous Air Quality Management Plans. PA indicated that $EC_{2.5}$ prediction meets the EPA performance criteria at eight out of 10 stations, with EC concentrations at Burbank Area overpredicted and Rubidoux underpredicted. A detailed discussion of the model performance is presented in Appendix IX.

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[8] U.S. EPA, 2006," Guidance on Use of Modeled and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze NAAQS," U.S. EPA, Office of Air Quality Planning and Standards, Emissions, Monitoring, and Analysis Division, Air Quality Modeling Group, Research Triangle Park, North Carolina.

Table 4-3
MATES V $EC_{2.5}$ Model Performance

Location	**Observed ($\mu g/m^3$)**	***Modeled ($\mu g/m^3$)**	**Prediction Accuracy**	**Mean Bias ($\mu g/m^3$)**	**Mean Error ($\mu g/m^3$)**	**Normalized Mean Bias**	**Normalized Mean Error**
Anaheim	0.47	0.55	16	0.08	0.21	0.78	0.89
Burbank Area	0.50	0.67	33	0.17	0.33	1.06	1.22
Compton	0.80	0.66	-17	-0.14	0.42	0.59	0.86
Inland Valley San Bernardino	0.78	0.63	-20	-0.15	0.33	0.05	0.48
Huntington Park	0.68	0.66	-2	-0.02	0.32	0.74	0.97
Long Beach	0.52	0.62	19	0.10	0.28	1.53	1.67
Central L.A.	0.71	0.78	9	0.07	0.27	0.63	0.76
Pico Rivera	0.74	0.61	-17	-0.13	0.25	0.11	0.41
Rubidoux	0.69	0.42	-40	-0.27	0.35	0.06	0.60
West Long Beach	0.72	0.71	-2	-0.01	0.38	0.89	1.16
All Stations	0.66	0.63	-5	-0.03	0.31	0.64	0.90

* Included only the days that measurements are available. The sample frequency is one in every 6th day.

4.4 Inhalation-Only Cancer Risk

Previous MATES studies have focused on calculating air toxics cancer risk for the inhalation exposure pathway only. Since diesel PM was the dominant risk driver, and since this risk is driven by the inhalation exposure pathway, this approach accounted for the vast majority of the air toxics cancer risk in the region. Although diesel PM continues to be the major risk driver in the region, it is important to evaluate other air toxics that contribute to risk, which includes other exposure pathways such as oral or dermal exposures. First, we describe the results from the evaluation of inhalation-only cancer risk, consistent with previous MATES studies. In Section 4.5 below, we describe the evaluation of multiple pathway risk, which includes inhalation as well as other exposure pathways.

Figure 4-6 depicts the MATES V distribution of inhalation cancer risk estimated from the predicted annual average concentrations of the key toxic compounds. Risk is calculated for each grid cell as follows:

$$\text{Risk}_{i,j} = \Sigma\ \text{Concentration}_{i,j,k} \text{ X Risk Factor}_k$$

Where i,j is the grid cell (easting, northing) and k is the toxic compound. The risk factor for a given compound is derived from its inhalation slope factor following OEHHA's 2015[9] risk assessment guidelines, as shown in Appendix I. In addition to the inhalation exposure, which was the method to estimate cancer risk in the previous MATES studies, the cancer risk calculations in MATES V expanded to include risk factors accounting for multiple exposure pathways. The multiple pathway exposure includes additional air toxics cancer risk from oral exposures of toxic metals and additional exposure pathways, as discussed later in Section 4.5.

The grid cell having the maximum simulated cancer risk of 990 in a million was located near the Ports of Los Angeles and Long Beach. High risk value of 963 in a million was modeled in the grid where the Los Angeles International Airport is located at. In addition to the clusters of cells around the seaports and the airport with high risk, a third cluster of high-risk area is centered around a railyard southeast of downtown Los Angeles. In general, as in the past studies, the higher-risk areas tend to be along transportation and goods movement corridors.

Figure 4-7 provides the CAMx RTRAC simulated inhalation air toxics risk for the MATES IV period, and Figure 4-8 depicts the changes in risk from MATES IV (2012-2013) to MATES V (2018-2019). The greatest percentage decrease in risk occurred in the ports area, reflecting the emission reductions from OGVs, Commercial Harbor Craft (CHC) and other port operations including cargo handling equipment, port trucks and locomotives. The air toxics cancer risk in the ports areas decreased by approximately 57% between MATES IV and MATES V (Table 4-4). Overall, air toxics risk improved significantly, consistent with air toxic emissions reductions that occurred over the time period.

The MATES V period Basin-average population-weighted risk summed for all the toxic components yielded an air toxic cancer risk of 424 in a million for the inhalation pathway only. The average risk included all populated land cells within the South Coast Air Basin portion of the modeling domain. In comparison, the MATES IV Basin average risk was 897 per million. Between the MATES IV and MATES V periods, the modeled risk decreased by 53%. The risk reduction can be attributed to several factors, most notably, changes in diesel emissions between 2012 and 2018. As shown in Chapter 3, the overall toxic emissions reduced between the two MATES periods by 48%. The corresponding reductions from on-road and off-road mobile sources are 59% and 39%, respectively. To distinguish the impact of emission reductions from year-to-year meteorological variations, a numerical experiment using MATES V meteorology and MATES IV emissions was conducted. The result showed 49% risk reduction, indicating majority of risk reduction was due to emission reductions, while a minor portion of the improved risk was contributed by meteorology leading to better air quality.

Non-diesel sources pose risk as well (Figure 4-9). The non-diesel related risk is uniformly distributed throughout the Basin with most of grids showing values approximately 100-200 in a

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[9] CalEPA, 2015, Office of Environmental Health Hazard Assessment, Air Toxics Hot Spots Program Risk Assessment Guidelines. The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments, http://www.oehha.ca.gov/air/hot_spots/hotspots2015.html

million.

Figure 4-10 provides a close-up plot of the cancer risk in the ports area. Table 4-4 provides a summary of the cancer risk estimated for the Basin, the ports area, and the rest of the Basin excluding the ports area. For this assessment, the ports area is defined as the populated cells roughly bounded by the Interstate 405 to the north, San Pedro to the west, Balboa Harbor to the east, and Pt. Fermin to the south, as shown in Figure 4-10. The MATES V average population-weighted air toxics risk is 504 in a million in the ports area. The Basin average population-weighted air toxics risk, excluding the grid cells in the ports area, is 418 in a million. The downwind impacts resulting from port area activities are still reflected in the toxics risk estimates for the grid cells categorized as "Basin minus Ports". Similarly, the MATES IV simulations indicated that the ports area air toxics risk was 1,177 in a million; and the Basin minus the ports area was 879 in a million. Overall, between the MATES IV and MATES V time periods, the ports area experienced an approximate 57% decrease in risk, while the average population-weighted risk in other areas of the Basin decreased by about 52%.

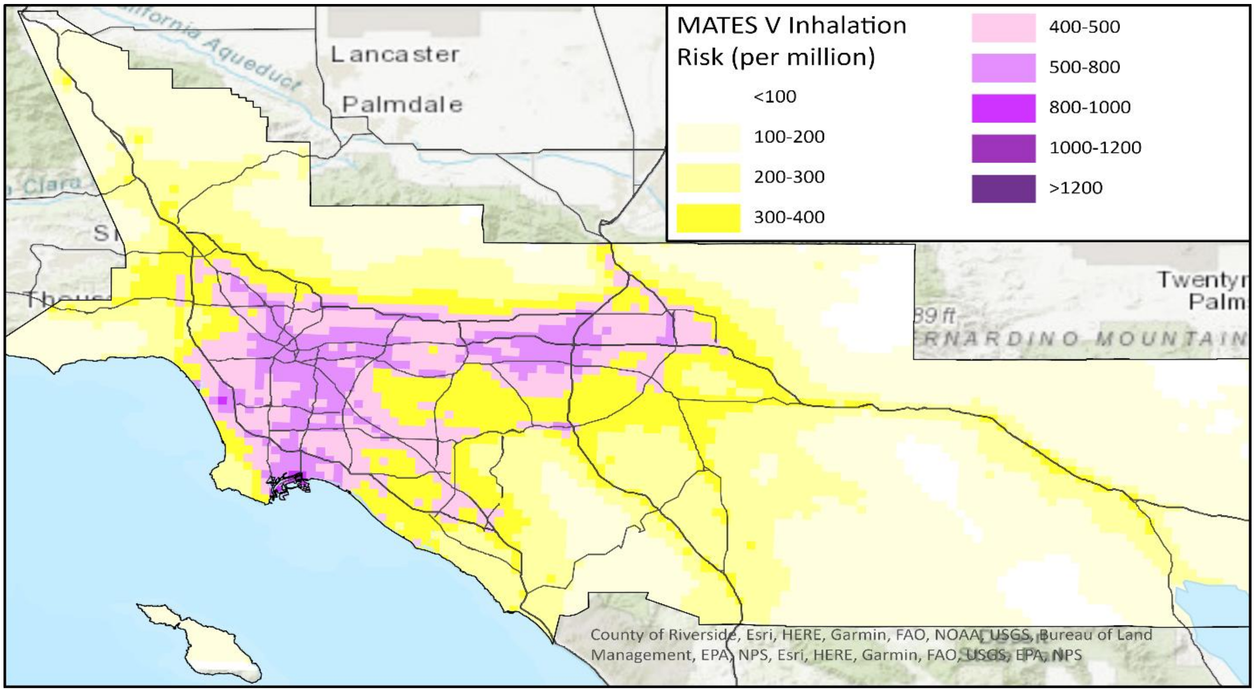

Figure 4-6

MATES V CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk

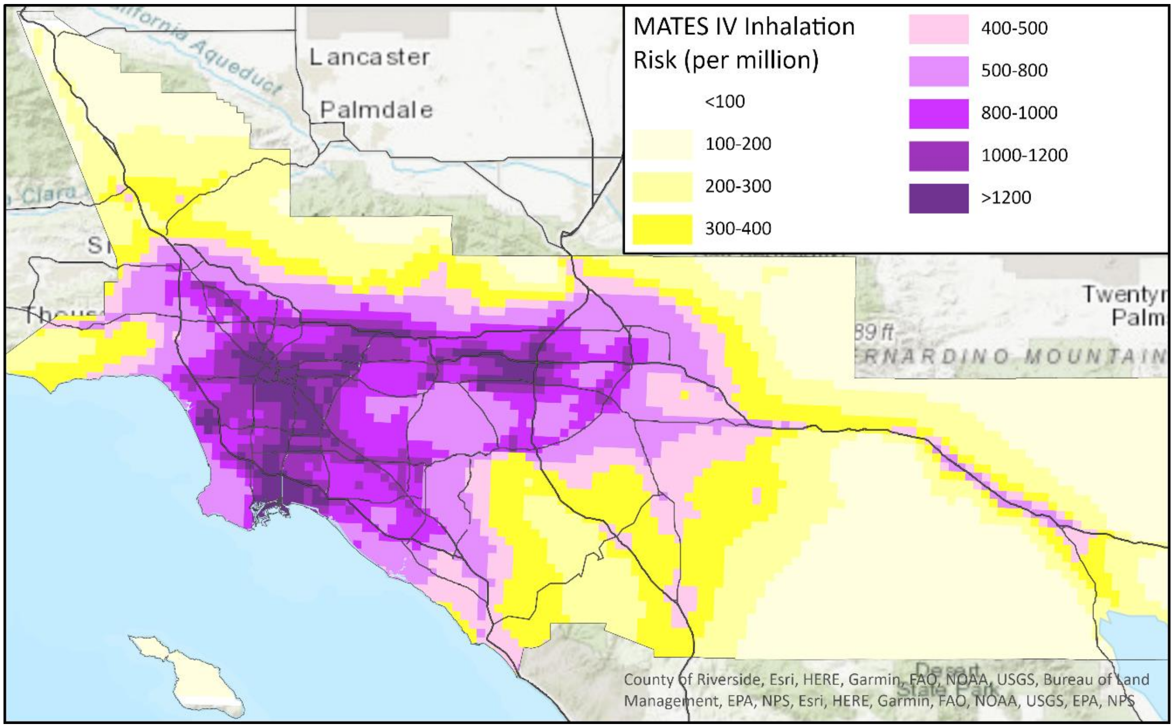

Figure 4-7
MATES IV CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk

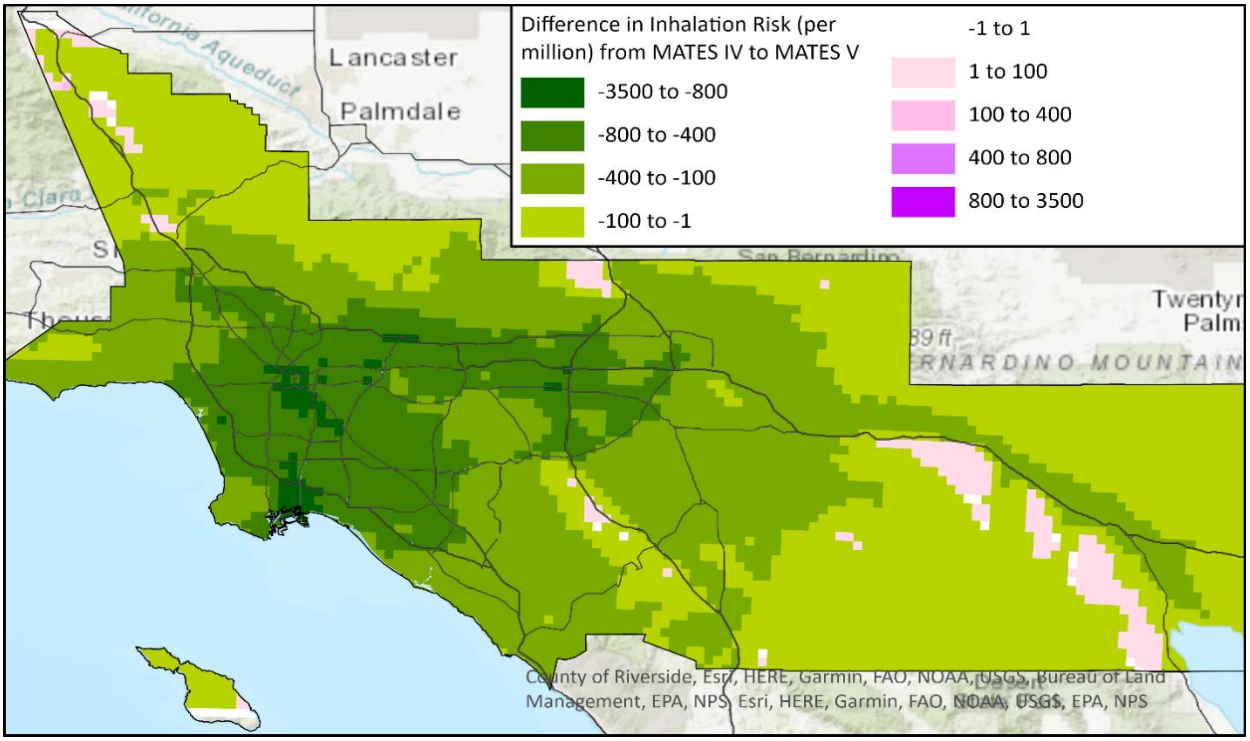

Figure 4-8
Changes in CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk (per million) from MATES IV to MATES V Period

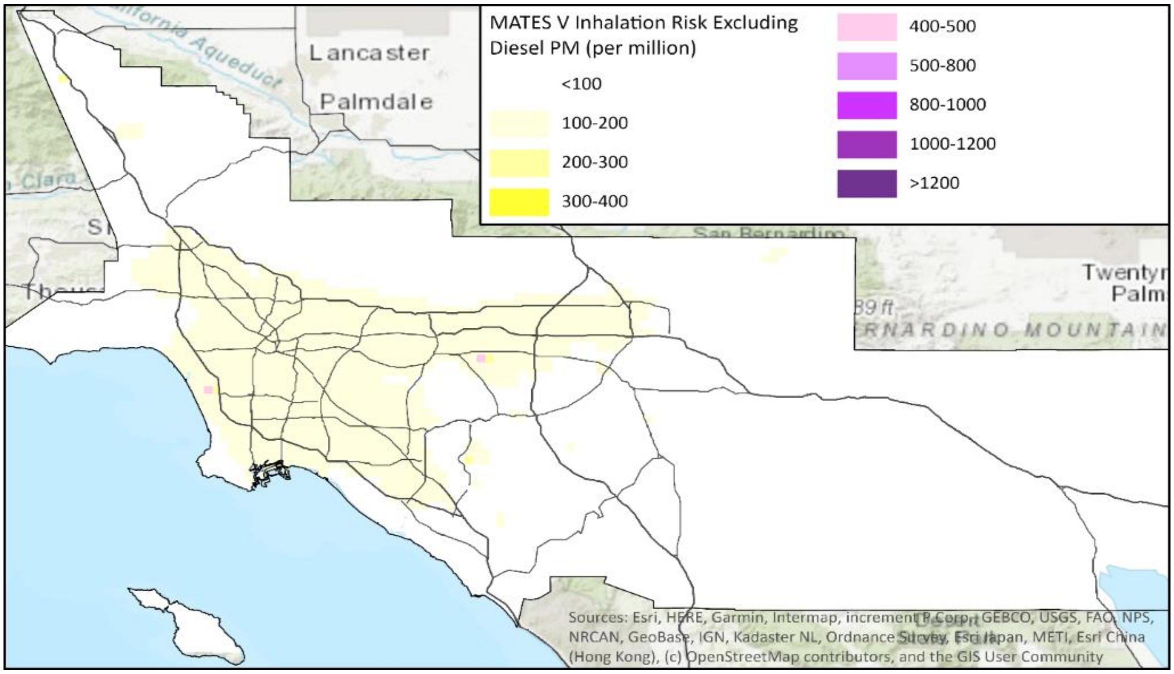

Figure 4-9
MATES V Simulated Inhalation Air Toxics Cancer Risk excluding Diesel PM

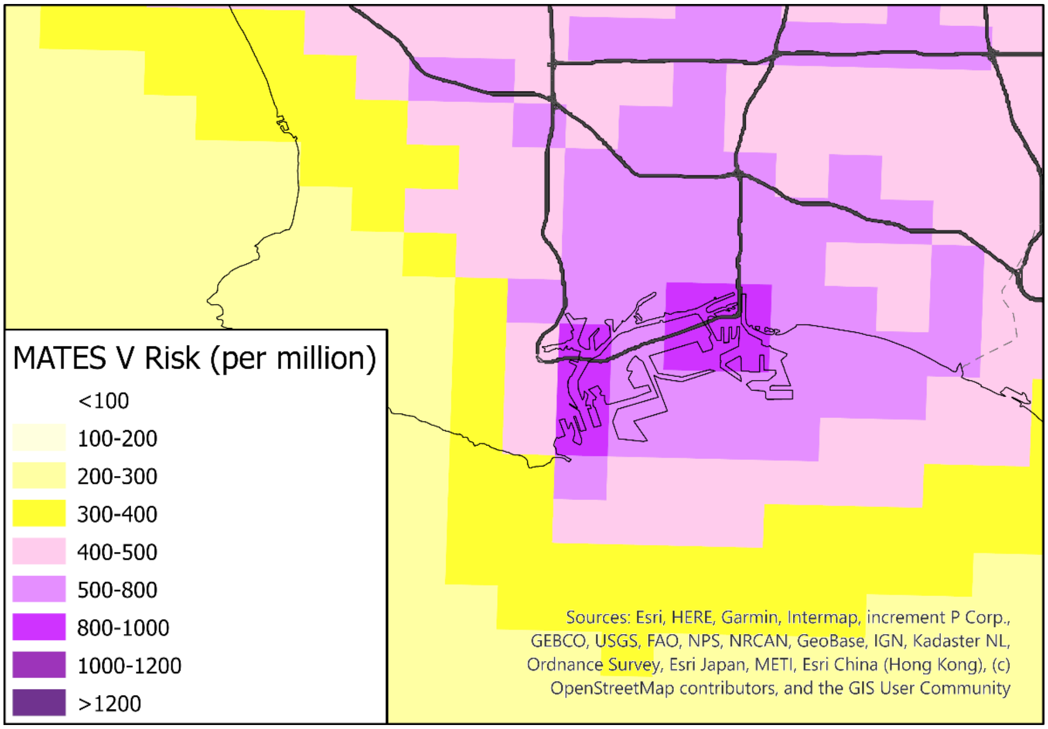

Figure 4-10
Ports Area MATES V Simulated Inhalation Air Toxics Cancer Risk

Table 4-4
Basin and Port Area Population-Weighted Cancer Risk (Inhalation Only)

Region	**MATES IV**		**MATES V**		**Average Percentage Change in Risk**
	2012 Population	Average Risk (Per Million)	2018 Population	Average Risk (Per Million)	
Basin	15,991,150	897	16,599,786	424	-53
Ports Area	998,745	1,177	1,004,938	504	-57
Basin Excluding Ports Area	14,992,806	879	15,994,848	418	-52

Table 4-5 provides the county-by-county air toxics risk to the affected population. Evident from the spatial distribution map (Figure 4-6), the Basin portion of Los Angeles County bears the greatest average cancer risk of 462 per one million. The Basin portion of San Bernardino County has the second highest projected risk at 439 per one million. The estimated risk for Orange County is 365 per million, and the Basin portion of Riverside County was estimated to have the lowest population-weighted risk at 313 per million. As expected, the Coachella Valley portion of Riverside County, which does not have high density industrial activity or population, has the lowest toxic risk at 239 per million. It should be noted that these are county-wide averages, and individual communities could have higher risks than the average if they are near emissions sources, such as railyards or intermodal facilities.

Comparing county-wide population-weighted risk, Los Angeles County shows the greatest reduction among the four counties. Still, the rate of population-weighted reductions is similar in all the four counties. Reductions in emissions from mobile sources including benzene, 1,3-butadiene, and diesel PM, as presented in Chapter 3, are the primary contributors to the improved county-wide risk.

Table 4-5

County-Wide Population-Weighted Cancer Risk (Inhalation Only)

Region	**MATES IV**		**MATES V**		**Average Percentage Change in Risk**
	2012 Population	Average Risk (Per Million)	2018 Population	Average Risk (Per Million)	
Los Angeles*	9,578,586	1015	9,846,922	462	-54
Orange	3,067,909	770	3,223,763	365	-53
Riverside*	1,784,872	543	1,912,855	313	-42
San Bernardino*	1,560,183	827	1,616,247	439	-47
South Coast Air Basin	15,991,550	897	16,599,786	424	-53
Coachella Valley	465,064	339	479,055	239	-30

* Data for these counties reflects the South Coast Air Basin portion only. Please note that all of Orange County is within the South Coast Air Basin.

Table 4-6 provides the Basin-wide average risk associated with each of the key air toxics modeled in the analysis. Average risks for the Coachella Valley area were not included in this table; those estimated risks are lower than the air toxics risks for the Basin. Diesel PM has the largest contribution to cancer risk from air toxics. The next three highest contributors are benzene, formaldehyde and 1,3-butadiene.

Table 4-6
MATES V Inhalation Cancer Risk from Simulated Individual Toxic Air Contaminants

Toxic Compound	Risk Factor (µg/m^3)$^{-1}$	Max Annual Average Concentration	Population Weighted Annual Average Concentration	Units	Risk (per million)	% Contribution
Diesel PM	7.40E-04	1.13	0.41	µg/m^3	306.30	72.3
Benzene	6.80E-05	0.42	0.14	ppb	46.87	11.1
Formaldehyde	1.40E-05	3.60	1.49	ppb	25.78	6.1
1,3- Butadiene	4.10E-04	0.44	0.03	ppb	12.90	3.0
Hexavalent Chromium	3.50E-01	0.00025	2.01E-05	µg/m^3	7.13	1.7
Acetaldehyde	6.80E-06	1.02	0.55	ppb	6.82	1.6
Cadmium	1.00E-02	0.019	4.69E-04	µg/m^3	4.08	1.0
p-Dichlorobenzene	2.70E-05	0.07	2.37E-02	ppb	3.86	0.9
Arsenic	8.10E-03	0.029	5.89E-04	µg/m^3	3.00	0.7
Perchloroethylene	1.40E-05	0.10	2.06E-02	ppb	1.97	0.5
Nickel	6.20E-04	0.18	2.82E-03	µg/m^3	1.78	0.4
Naphthalene	8.10E-05	0.025	3.46E-03	ppb	1.48	0.3
Methylene Chloride	2.40E-06	0.77	0.15	ppb	1.29	0.3
Trichloroethylene	4.70E-06	0.08	8.34E-03	ppb	0.21	<0.1
Lead	2.80E-05	0.038	3.21E-03	µg/m^3	0.08	<0.1

Table 4-7 provides the simulated air toxics risk at each of the 10 stations for the top three toxic compounds and the remaining aggregate contributing to the overall risk. Risk is calculated using each toxic component concentrations predicted for the specific monitoring station location. The model prediction comparison used the nine-cell average at the grid corresponding to a monitoring station and its surrounding 8 grid cells using an inverse distance squared weighting factor. The summary also provides the comparison between simulated average risk for the 10 stations and the average risk calculated using the annual toxic compound measurements. Since diesel PM cannot be measured, measurement-based risk is calculated using an EC$_{2.5}$ to diesel PM conversion as described in Chapter 2 to estimate the diesel PM contributions. The comparison to measured risk was conducted with the 7 stations which are listed in the previous section.[10]

Table 4-7

Modeled Inhalation Cancer Risk at monitoring locations and Monitoring-Based Risk

Location	MATES V CAMX RTRAC Simulation				
	Benzene	1,3-Butadiene	Diesel	Others	Total
Anaheim	49	14	307	56	426
Burbank Area	58	16	381	72	526
Central Los Angeles	65	21	499	82	667
Compton	53	15	381	70	519
Inland Valley San Bernardino	46	12	362	86	506
Huntington Park	57	20	408	75	559
Long Beach	52	16	359	65	492
Pico Rivera	50	11	368	63	492
Rubidoux	39	9	295	48	390
West Long Beach	60	20	455	80	615
10-Station Average Modeled	53	15	382	70	519
7-station+ Averaged Modeled	54	16	387	73	530
7-Station+ MATES V Average Measured*	62	56	362	114	593

*Includes modeled species only. Risk from some measured species, such as carbon tetrachloride, chloroform and PAHs are excluded. Measured EC2.5 was converted into diesel PM as described in Chapter 2

Among the monitored locations, the highest risk was simulated in Central Los Angeles followed by West Long Beach and Huntington Park. The lowest modeled risk was simulated at Rubidoux. With continued diesel PM reductions in port operations, the West Long Beach is no longer the highest risk site as it was in the previous MATES. Additionally, the modeled risk at the Long Beach station is below the overall average risk across all stations, although the location of the Long Beach station was relocated from an area near the I-710 to a mostly residential location southeast of the previous location. The MATES V monitoring with the highest air toxics cancer risk was Inland Valley San Bernardino. This inland location is located in an area near major goods movement land uses.

Based on modeled concentrations, the cancer risk averaged over the 7 stations is 530 in a million,

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[10] Burbank Area, Compton, Huntington Park, Inland Valley San Bernardino, Long Beach, Pico Rivera and West Long Beach

which is approximately 11% lower than the measurement-based risk as shown in Figure 4-11.

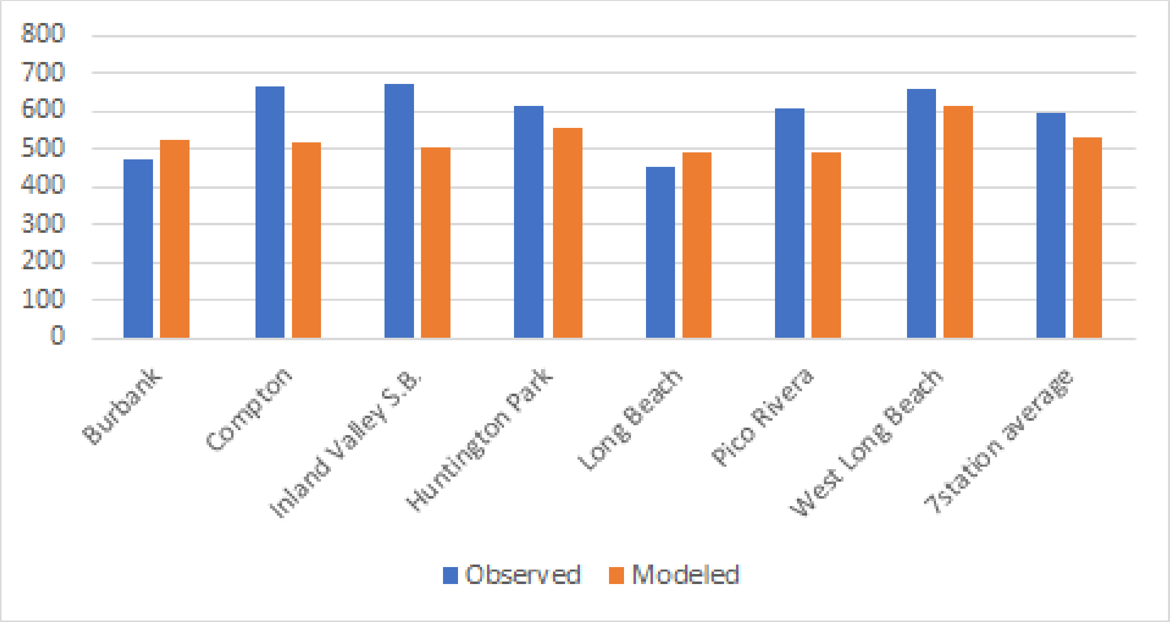

Figure 4-11

MATES V Modeled vs. Measured Inhalation Air Toxics Cancer Risk (Per Million)

The portion of the simulated cancer risk attributed to air toxics other than diesel PM can be directly compared to risk calculated from the toxic compound measurements. Figure 4-12 presents a comparison of the model simulated and measurement-based non-diesel risk at each monitoring site, as well as the 7-station average. The modeled non-diesel risk at each station is 27 to 50% lower than the risk calculated based on measurement data, with the modeled 7-station average cancer risk being 39% lower than the measurement-based risk. This difference in non-diesel risk is primarily due to underprediction of concentrations of formaldehyde, acetaldehyde and 1,3-butadiene and, to a lesser extent, benzene.

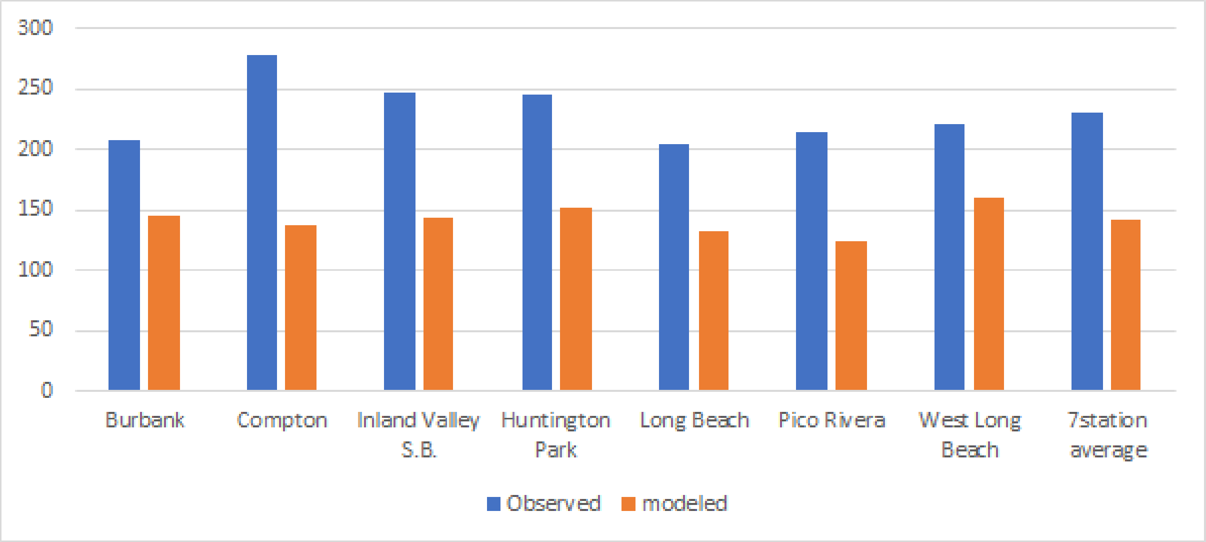

Figure 4-12
MATES V Simulated vs. Measured Non-Diesel Inhalation Air Toxics Cancer Risk (Per Million)

4.5 Multiple-Pathway Cancer Risk

The cancer risk discussed in the previous section was based on inhalation exposure only, which was the practice used in previous MATES studies. Among the toxic species included in the modeling, arsenic, hexavalent chromium and lead have associated cancer risks from non-inhalation exposures. This additional cancer risk can be assessed by a multiple-pathway factor. For arsenic, hexavalent chromium and lead, the multiple-pathway factors are 9.71, 1.6 and 11.41, respectively. These factors account for oral and dermal exposures for these toxic metals. The overall multiple-pathway risk due to the inclusion of the three metals was estimated to be 455 per million, which is approximately 7.3% higher than the inhalation-only risk. Table 4-8 lists average risks for individual county and Coachella Valley. Figure 4-13 depicts the MATES V distribution of multiple-pathway cancer risk estimated from the predicted annual average concentrations of the modeled toxic compounds. Compared to Figure 4-6, where only inhalation toxic risk is depicted, additional risk from oral exposure of arsenic, hexavalent chromium and lead elevated the overall risk in some areas. County-wide and air basin level population weighted cancer risks are compared to MATES IV modeling results in Table 4-9. The reduction in the multiple-pathway risk is similar to the inhalation-only risk trends as shown in Table 4-5.

Table 4-8
County-Wide Population-Weighted Air Toxics Cancer Risk for Inhalation-Only and for Multiple-Pathway Factors

Region	**2018 Population**	**Inhalation-Only**	**Multiple-Pathway**
		Average Risk (Per Million)	Average Risk (Per Million)
Los Angeles*	9,846,922	462	497
Orange	3,223,763	365	390
Riverside*	1,912,855	313	332
San Bernardino*	1,616,247	439	471
South Coast Air Basin	16,599,786	424	455
Coachella Valley	479,055	239	250

* Data for these counties reflects the South Coast Air Basin portion only. Please note that all of Orange County is within the South Coast Air Basin.

Table 4-9
County-Wide Population-Weighted Multiple-Pathway Cancer Risk

Region	**MATES IV**		**MATES V**		**Average Percentage Change in Risk**
	2012 Population	Average Risk (Per Million)	2018 Population	Average Risk (Per Million)	
Los Angeles*	9,578,586	1143	9,846,922	497	-57%
Orange	3,067,909	829	3,223,763	390	-53%
Riverside*	1,784,872	586	1,912,855	332	-43%
San Bernardino*	1,560,183	905	1,616,247	471	-48%
South Coast Air Basin	15,991,550	997	16,599,786	455	-54%
Coachella Valley	465,064	357	479,055	250	-30%

* Data for these counties reflects the South Coast Air Basin portion only. Please note that all of Orange County is within the South Coast Air Basin.

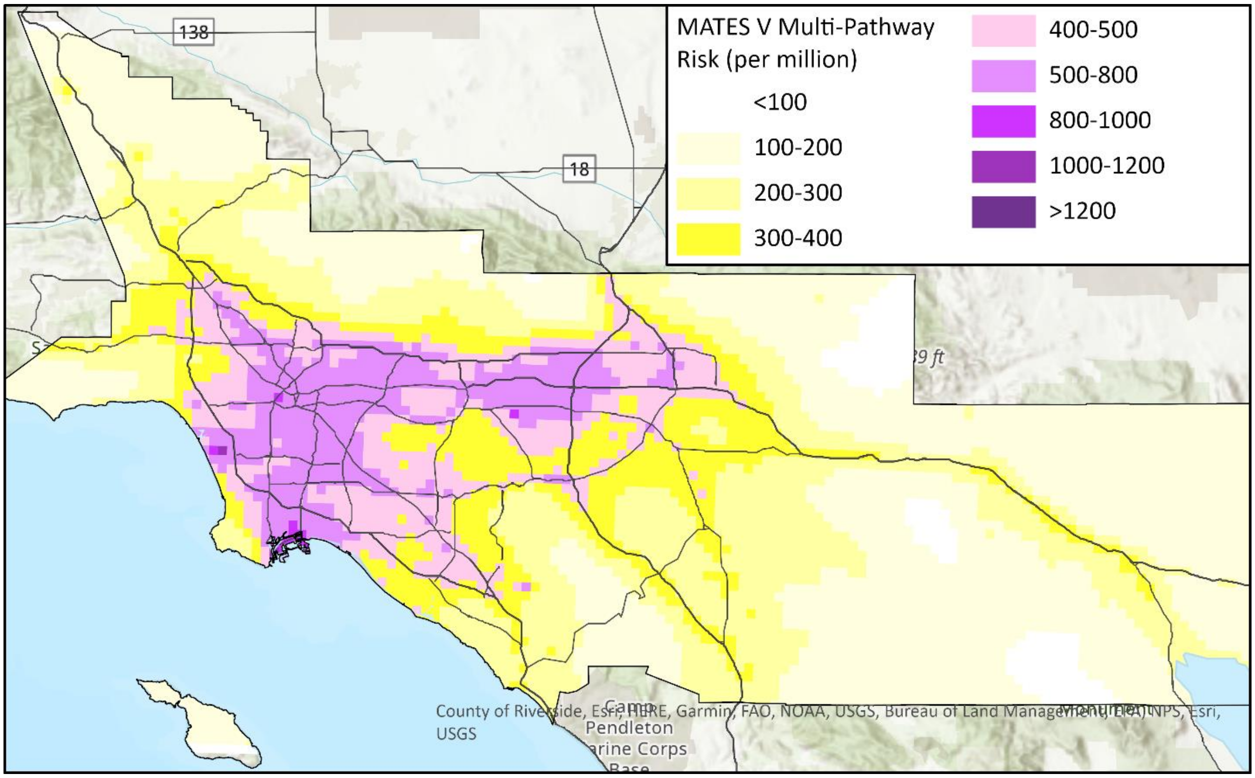

Figure 4-13
MATES V CAMx RTRAC Simulated Multiple-Pathway Air Toxics Cancer Risk

4.6 Chronic Non-Cancer Health Impacts from Exposure to Air Toxics

Previous MATES studies focused only on air toxics cancer risk. However, some chemical components captured in measurements have exclusively cancer, exclusively non-cancer, or both impacts on human health. To evaluate chronic non-cancer health impacts related to air toxics, Chapter 2 presents an exploratory analysis of chronic non-cancer health impacts based on measurement data. Given the exploratory nature of the chronic non-cancer health impacts analysis, and the complexities involved in estimating the spatial distribution of the measured compounds that appear to contribute most to the chronic hazard index based on the monitoring data, this analysis cannot be repeated with the modeled air toxics data without substantial uncertainty. Some species that appear to contribute most to the chronic hazard index based on the monitoring data were not estimated in the modeling. However, future iterations of MATES may consider this detailed analysis of chronic non-cancer health impacts, using the exploratory analysis to help inform which species may need to be included in the modeling efforts.

4.7 Analysis of Air Toxics Risks in Environmental Justice Communities

Environmental justice (EJ) communities are communities experiencing environmental injustices and are disproportionately impacted by various types of pollution and experience health, social, and economic inequities that also can make residents more sensitive or more vulnerable to the effects of environmental pollution. To evaluate the impacts and trends of toxic air contaminants in EJ communities, the MATES V study includes an analysis of the air toxics health risks in EJ communities as compared to the average risks throughout the jurisdiction.

While there is no universal definition for what constitutes an EJ community, one commonly used definition is the Senate Bill (SB) 535 definition of disadvantaged communities in California. SB 535 disadvantaged communities are defined as the "25% highest scoring census tracts in CalEnviroScreen 3.0", along with "22 census tracts that score in the highest 5% of CalEnviroScreen's Pollution Burden, but do not have an overall CalEnviroScreen score because of unreliable socioeconomic or health data".[11] For this analysis, only the SB535 disadvantaged communities located inside the SCAB were evaluated. The SB535 communities are shown in Figure 4-15.

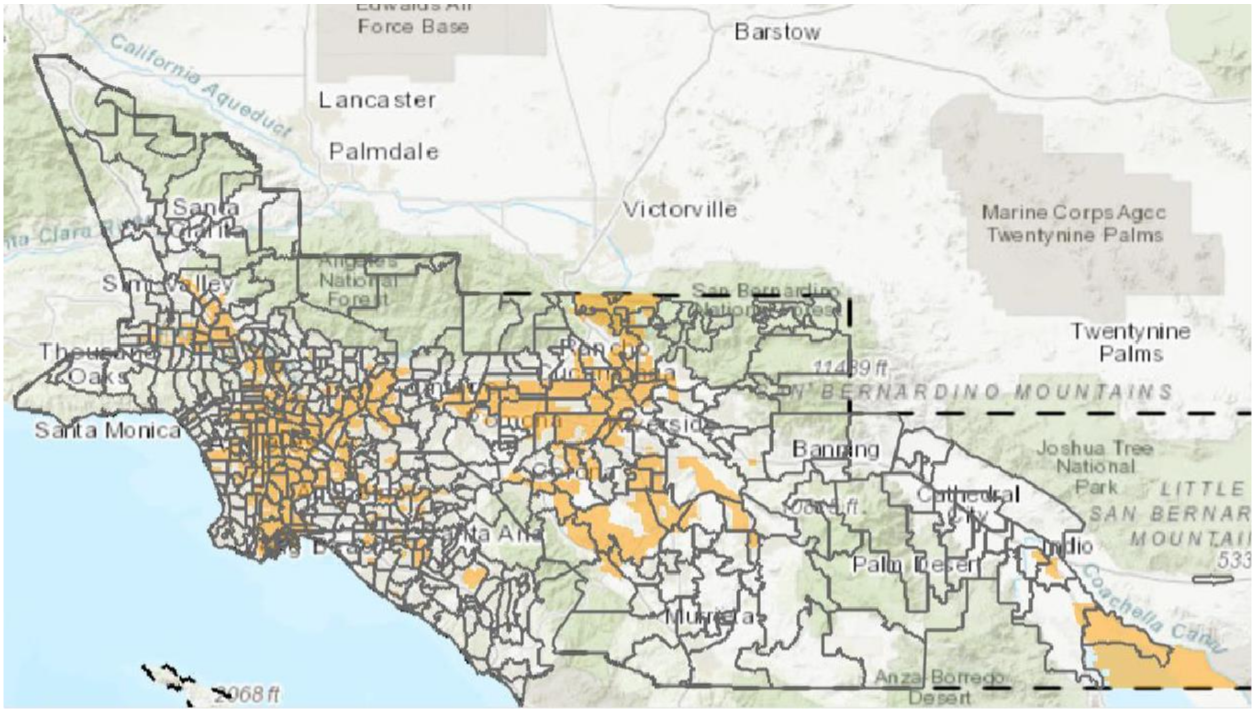

Figure 4-15: SB535 Communities

To conduct this analysis, staff first determined which of the model grid cells intersected each community boundary, and then calculated the population-weighted average residential air toxics cancer risk and population-weighted average chronic risk for those grid cells. This calculation was done using MATES IV and MATES V model data. Next, the difference in modeled risks from MATES IV to MATES V was calculated. While there are no set "thresholds" that these

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[11] https://oehha.ca.gov/calenviroscreen/sb535

overall health risk results should aim to meet, it may be helpful to illustrate the magnitude of the health risk by using the AB 2588 program's significant risk thresholds for cancer risk. The AB 2588 Air Toxics Hot Spots program and South Coast AQMD's Rule 1402 establishes the significant risk level as ≥100-in-a-million for cancer risk.[12] However, this threshold applies only to the risk based on emissions from a single facility, whereas MATES evaluates the combined emissions from all sources. In other words, it is not surprising that the MATES health risk levels are higher than the AB 2588 and Rule 1402 significant risk level.

Figure 4-16 shows the air toxics health risk trends in EJ communities in the SCAB (defined by SB 535) and non-EJ communities. Between MATES IV and MATES V, air toxics cancer risk decreased by 57% in EJ communities overall compared to a 52% reduction in non-EJ communities. Importantly, although air toxics cancer risks have decreased overall, and especially decreased substantially in EJ communities, people living in EJ communities in the SCAB continue to experience higher air toxics cancer risks compared to those in non-EJ communities.

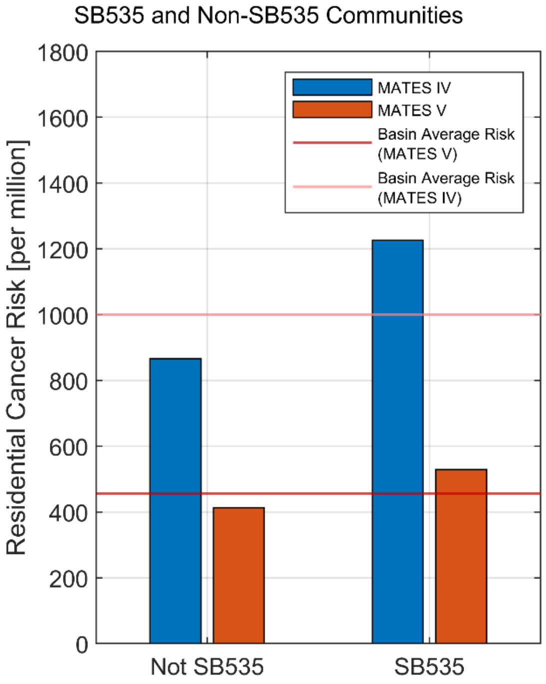

Figure 4-16: Population weighted average Residential Cancer Risk in SB535 and Non-SB535 Communities.

In 2017, Assembly Bill (AB) 617 was signed into law to address air quality disparities in EJ communities across the state. Among the many AB 617 program elements that aim to bring air quality benefits to EJ communities, one part of the program involves the designation of specific communities for the development of community plans. As of March 2021, there are six

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[12] https://www.aqmd.gov/home/rules-compliance/compliance/toxic-hot-spots-ab-2588/risk-reduction

communities in the South Coast AQMD that have been designated for the AB 617 program.[13] The community boundaries for the 6 communities that were designated in 2018,2019, and 2021 are shown in Figure 4-17.

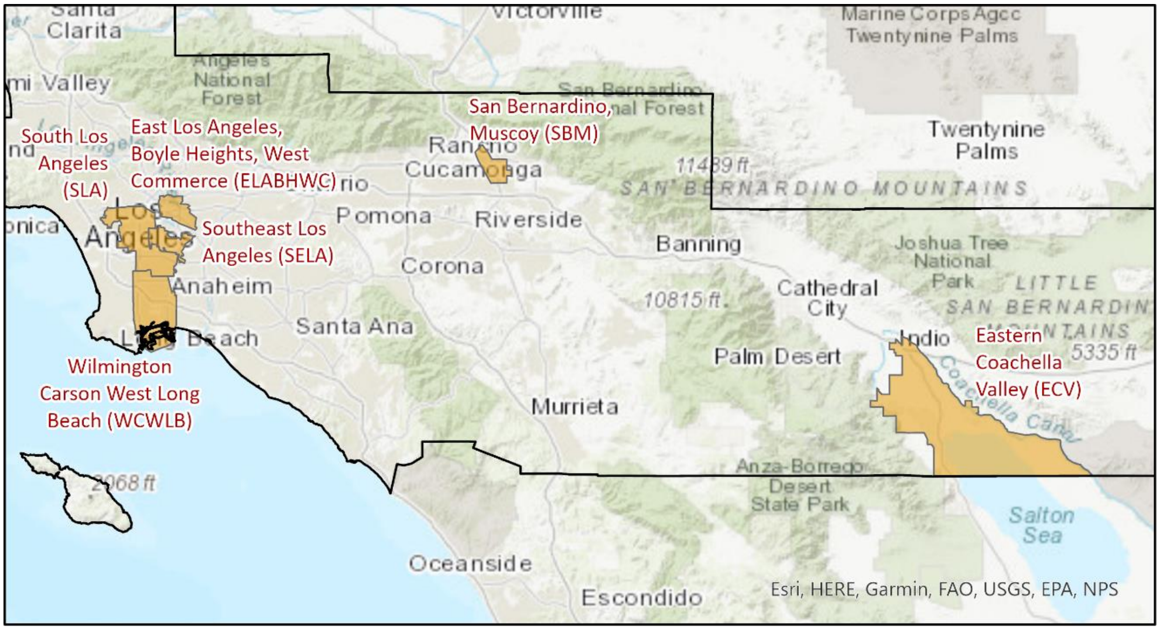

Figure 4-17: AB 617 Designated Communities in the South Coast AQMD

The air toxics cancer risks are shown for each of these six communities designated for the AB 617 program:

1. Wilmington, Carson, West Long Beach (WCWLB)
2. San Bernardino, Muscoy (SBM)
3. East Los Angeles, Boyle Heights, West Commerce (ELABHWC)
4. Southeast Los Angeles (SELA)
5. Eastern Coachella Valley (ECV)
6. South Los Angeles (SLA)

Through the AB 617 program, staff worked with each of these communities to develop a Community Emissions Reduction Program (CERP). The plans are designed to be implemented over the course of approximately five years, and these plans are in the relatively early stages of implementation. The MATES V modeling results reflect the conditions in the year 2018, which is prior to any of these CERPs being approved. Therefore, the MATES V data could be used as an estimate of the air toxics levels in these communities before the CERPs and other programs

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[13] www.aqmd.gov/ab617

(including regulatory programs) have taken effect.

Wilmington, Carson, West Long Beach

The community of Wilmington, Carson, West Long Beach (WCWLB) is located in the southern portion of Los Angeles County, and is home to more than 300,000 people. This community was designated for the AB 617 Community Air Program in 2018. More than half of the people living in this community are Hispanic or Latinx. About 17.6% of the residents in this community are Asian American and 16.6% are African American. The community's rates of asthma-related emergency department visits are more than 40% higher than the state average, and the community also experiences higher rates of linguistic isolation, poverty, unemployment, and other social and economic disadvantages, compared to state averages. The community includes about 72 square miles of land area. About 25% of this land area is used for residential living, 25% is zoned for industrial uses, and 23% is used for freeways, roadways, and land used for utilities and communications services. Within this community, there are 78 facilities in the U.S. EPA Title V program, 54 facilities in the AB 2588 Air Toxics Hot Spots program, 43 miles of freeways, 9 rail yards, and 2 major marine ports. Between MATES IV and MATES V, the air toxics cancer risk decreased by 57% in the WCWLB community (Figure 4-18). Based on MATES V data, air toxics cancer risk in this community (613-in-a-million) remains higher than the overall average in the SCAB.

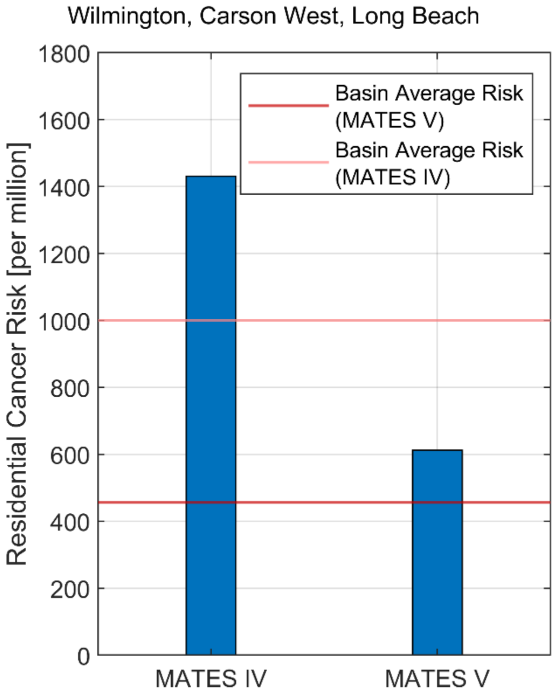

Figure 4-18: Population weighted average Residential Cancer Risk in Wilmington, Carson, West Long Beach.

San Bernardino, Muscoy

The community of San Bernardino, Muscoy (SBM) is located in central San Bernardino County, and is home to more than 90,000 people. This community was designated for the AB 617 Community Air Program in 2018. About 74% of the residents in this community are Hispanic or Latinx, 13.1% are African American, and 9.3% are White. The community's rates of asthma-related emergency department visits are more than double the state average, and the community also experiences substantially higher rates of poverty, unemployment, and other social and economic disadvantages, compared to state averages. Of the 17.3 square miles of land area in this community, 48% of this land is used for residential living, 19% is zoned for commercial use, and 7% is zoned for industrial uses, and 7% is used for freeways, roadways, and land used for utilities and communications services. Within this community, there are 22 miles of freeways and 5 railyards. Between MATES IV and MATES V, the air toxics cancer risk decreased by 43% in the SBM community (Figure 4-19). Based on MATES V data, air toxics cancer risk in this community (507-in-a-million) remains higher than the overall average in the SCAB.

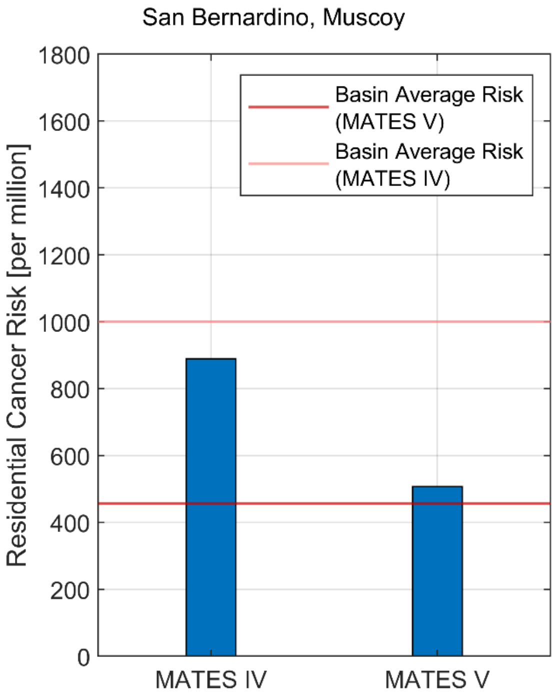

Figure 4-19: Population weighted average Residential Cancer Risk in San Bernardino, Muscoy.

East Los Angeles, Boyle Heights, West Commerce

The community of East Los Angeles, Boyle Heights, West Commerce (ELABHWC) is located in central Los Angeles County, and is home to more than 220,000 people. This community was designated for the AB 617 Community Air Program in 2018. More than 95% of the residents in this community are Hispanic or Latinx. This community has higher rates of asthma-related and cardiovascular disease-related emergency department visits are about 20% higher than the state averages, and the community experiences substantially higher rates of poverty, linguistic isolation, and other social and economic disadvantages, compared to state averages. Of the approximately 19 square miles of land area in this community, 41% of this land is used for residential living, 19% is zoned for commercial use, and 21% is zoned for industrial uses, and 10% is used for freeways, roadways, and land used for utilities and communications services.

Within this community, there are more than 30 miles of freeways and 5 railyards. Between MATES IV and MATES V, the air toxics cancer risk decreased by 60% in the ELABHWC community (Figure 4-20). Of the 5 designated AB 617 communities analyzed here, the ELABHWC community had the highest cancer risk during MATES IV, but also experienced the largest reduction in cancer risk (-1037 chances in a million), largely due to reductions in diesel particulate matter. Based on MATES V data, air toxics cancer risk in this community (653-in-a-million) remains higher than the overall average in the SCAB.

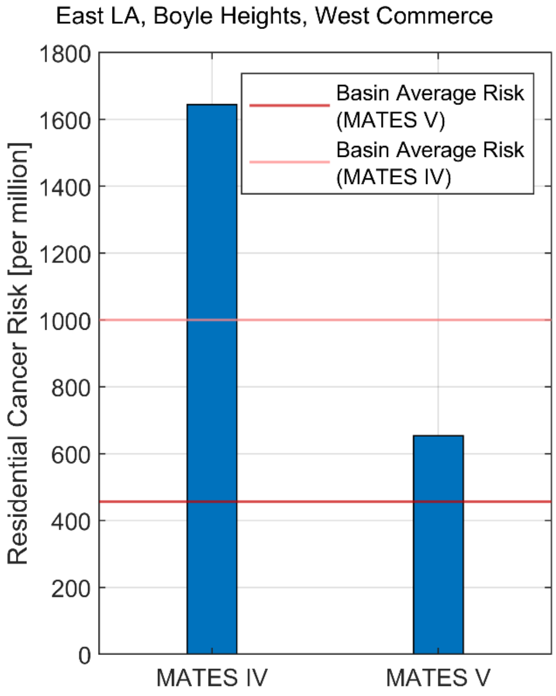

Figure 4-20: Population weighted average Residential Cancer Risk in East LA, Boyle Heights, West Commerce.

Southeast Los Angeles

The community of Southeast Los Angeles (SELA) is located in central Los Angeles County, and is home to more than 290,000 people. This community was designated for the AB 617

Community Air Program in 2019. About 95% of the residents in this community are Hispanic or Latinx. Of the approximately 18 square miles of land area in this community, 56% of this land area is used for residential living, 18% is zoned for commercial uses, 15% is zoned for industrial uses, and 5% is used for freeways, roadways, and utilities and communications services. Air pollution sources in this community include the I-710 freeway, locomotives and industrial facilities along the Alameda Corridor, and facilities in the adjacent industrial city of Vernon.

Between MATES IV and MATES V, the air toxics cancer risk decreased by 63% in the SELA community (Figure 4-21). Based on MATES V data, air toxics cancer risk in this community (567-in-a-million) remains higher than the overall average in the SCAB.

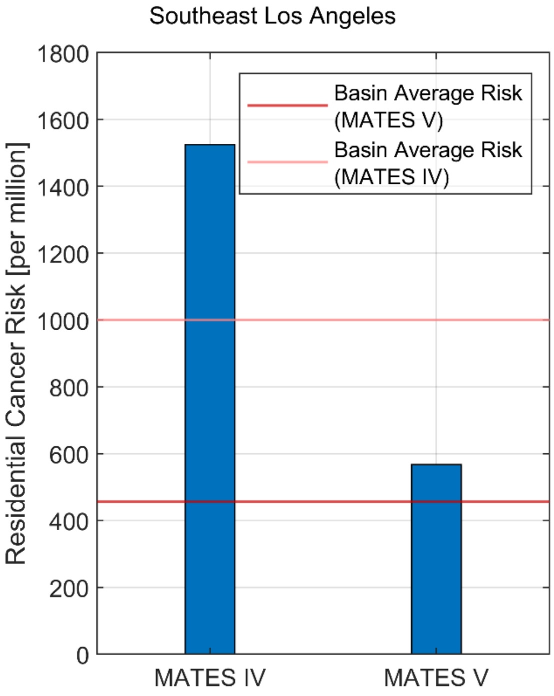

Figure 4-21: Population weighted average Residential Cancer Risk in Southeast Los Angeles.

Eastern Coachella Valley

The community of Eastern Coachella Valley (ECV) is located in Riverside County, and is home to more than 80,000 people. This community, which includes several cities and rural communities, was designated for the AB 617 Community Air Program in 2019. About 92% of the residents in this community are Hispanic or Latinx. ECV is home to four Tribal Reservations (Figure 3a-2). These include the Twenty-Nine Palms Band of Mission Indians Tribe, the Cabazon Band of Mission Indians Tribe, the Torres-Martinez Desert Cahuilla Indians Tribe, and the Augustine Band of Cahuilla Indians Tribe. Of the 288 square miles of land area in this community, about 2% of this land area is used for residential living, 1% is zoned for commercial uses, 1% is zoned for industrial uses, 3% is used for freeways, roadways, and utilities and communications services, 29% is used for agriculture which is land that is used primarily for the production of food, fiber, and livestock, 39% is used for vacant land which is land that had not been built-up with man-made structures, and 25% is water which includes open water bodies which are greater than 2.5 acres in size. There are multiple sources of pollution in the region that are associated with agricultural activities, goods movement, industrial facilities and hazardous waste facilities. The Salton Sea is also a major environmental concern in the community.

Between MATES IV and MATES V, the air toxics cancer risk decreased by 31% in the ECV community (Figure 4-22). Based on MATES V data, the air toxics cancer risk in this community (282-in-a-million) is lower than SCAB averages, but higher than the overall average in the Salton Sea Air Basin (SSAB). There are some important limitations that may impact the ability to capture the air toxics cancer risk in the ECV community. First, the MATES V is not able to account for potential pesticide exposures and associated health risks. Second, the emissions inventory is not able to account for illegal burning activities which occur in this community.

Therefore, while the results from the MATES V study would be helpful to compare to future data, these results should be interpreted with caution.

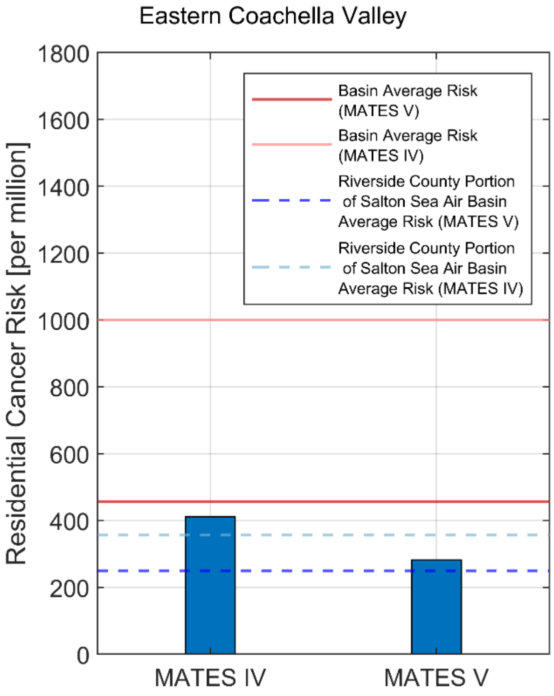

Figure 4-22: Population weighted average Residential Cancer Risk in Eastern Coachella Valley.

South Los Angeles

The community of South Los Angeles (SLA) is located in central Los Angeles County. This community was designated for the AB 617 Community Air Program in 2021.

Between MATES IV and MATES V, the air toxics cancer risk decreased by 59% in the SLA community (Figure 4-23). Based on MATES V data, air toxics cancer risk in this community (548-in-a-million) remains higher than the overall average in the SCAB.

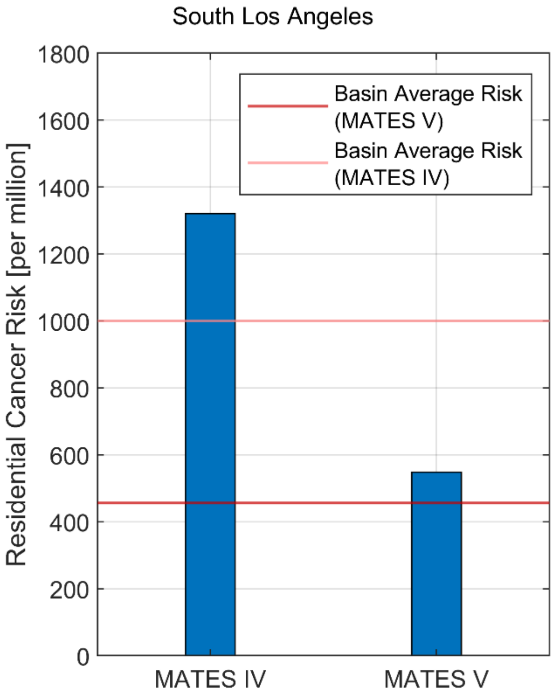

Figure 4-23: Population weighted average Residential Cancer Risk in South Los Angeles.

4.8 Summary and Conclusions

The MATES V study used CAMx with RTRAC algorithm, WRF, MEGAN and mobile source emissions modeling systems to model air toxics cancer risk for the MATES V study. The population-weighted average Basin air toxics cancer risk using multiple-pathway factors is 454 in a million, and the average inhalation-only risk is 423 in a million. The areas of the Basin that are exposed to the higher air toxics cancer risk continue to be along the goods movement corridors. The MATES V risk in the SCAB is estimated to be 55% lower than the corresponding risk during the MATES IV period (997 in-a-million for multiple pathway risk). Much of the air toxics cancer risk reduction was due to the 51% reduction of diesel particle emissions between 2012 and 2018. In particular, diesel PM from OGV/CHC in the ports area reduced by 60% between 2012 and 2018. Diesel PM continues to be the primary risk driver, contributing to more than 72% of the inhalation-only risk and 67% of the overall multiple pathway air toxics cancer risk. The air toxics cancer risk in the Coachella Valley is estimated to be 249 in-a-million, based on multiple exposure pathways. The changes of other toxic compounds emissions marginally contribute to the overall reduction in the MATES V simulated risk. Overall carcinogenic emissions during the MATES V period are lower than the MATES IV by 48%. The simulated risk showed a greater rate of reduction than the corresponding risk derived from measurements, which showed 31% reduction from MATES IV. Los Angeles County continues to have the highest among the four counties in air toxics cancer risk. Although the single highest grid cell is the one encompassing LAX, there are several grid cells in the ports area that are above 900-in-a-million for air toxics cancer risk.

CHAPTER 5

ULTRAFINE PARTICLES AND BLACK CARBON MEASUREMENTS

Chapter 5. Ultrafine Particles and Black Carbon Measurements

5.1. Ultrafine Particle Measurements at Fixed Sites

5.1.1. Background on UFP Measurements

There is increasing evidence in the public health community that exposure to ultrafine particles (UFPs) may be associated with certain health effects, including neurological, respiratory and cardiovascular health endpoints.[1] While substantial effort has been made to characterize the health risks associated with exposure to PM from vehicles[2], information about the health effects of UFPs is still emerging. These very small particles (< 0.1 μm in diameter) primarily consist of organic material, soot, secondary ions, and trace elements and typically have different chemical composition than larger PM size fractions, PM_{10} (particles with a diameter less than 10 µm) and $PM_{2.5}$ (diameter less than 2.5 µm).[3,4]

UFPs comprise a majority (~90%) of the number of airborne particles in the atmosphere.[5,6] For this reason, total particle number concentration (PNC; i.e., number of particles per cubic centimeter of sampled air) is typically used as a proxy for UFP concentration. UFPs are emitted from nearly all fuel combustion processes, including diesel, gasoline, and jet engines. UFP nucleation and growth mechanisms are not fully understood, but it is clear that vehicle exhaust is a major contributor to UFPs in urban areas.[7] Consequently, people living nearby highly trafficked roadways and other sources of combustion-related pollutants (e.g., airports, refineries, and railyards) may be exposed to high levels of UFPs and other air toxics. In addition to primary UFP emissions, secondary formation of UFPs resulting from photochemical reactions also contributes to total particle number concentrations. Secondary formation of UFPs depends strongly on the intensity of solar radiation and presence of precursor gases and thus is more important during the summer.

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[1] U.S. Environmental Protection Agency. (2019). U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019). Washington, DC: U.S. Environmental Protection Agency

[2] Health Effects Institute (2010) “Traffic-Related Air Pollution: A Critical Review of Literature on Emissions, Exposure, and Health Effects”, http://pubs.healtheffects.org/getfile.php?u=553.

[3] Daher, N., Hasheminassab, S., Shafer, M. M., Schauer, J. J., Sioutas, C. (2013). Seasonal and Spatial Variability in Chemical Composition and Mass Closure of Ambient Ultrafine Particles in the Megacity of Los Angeles. Environ.

[4] Shirmohammadi, F., Hasheminassab, S., Saffari, A., Schauer, J. J., Delfino, R. J., Sioutas, C. (2016) “Fine and Ultrafine Particulate Organic Carbon in the Los Angeles Basin: Trends in Sources and Composition”, Sci. Total Environ. 541, 1083–1096.

[5] Stanier, C., Khlystov, A., Pandis, S. (2004a) “Ambient aerosol size distributions and number concentrations measured during the Pittsburgh Air Quality Study (PAQS)”, Atmospheric Environment 38, 3275–3284.

[6] Zhang, Q., Stanier, C., Canagaratna, M., Jayne, J., Worsnop, D., Pandis, S., Jimenez, J. (2004) “Insights into the chemistry of new particle formation and growth events in Pittsburgh based on aerosol mass spectrometry”, Environmental Science and Technology 38, 4797–4809.

[7] Guo, S., Hu, M., Peng, J., Wu, Z., Zamora, M. L., Shang, D., Du, Z., Zheng, J., Fang, X., Tang, R., Wu, Y., Zeng, L., Shuai, S., Zhang, W., Wang, Y., Ji, Y., Li, Y., Zhang, A., Wang, W., Zhang, F., Zhao, J., Gong, X., Wang, C., Molina, M., Zhang, R. (2020) “Remarkable nucleation and growth of ultrafine particles from vehicular exhaust”, with heavy-duty diesel traffic”, Atmospheric Environment, 36 (27): 4323-4335.

Federal, state, and local regulatory efforts have been focused on reducing the mass concentration of PM in the ambient air with current PM regulations focused on PM_{10} and $PM_{2.5}$. Compared to the body of literature for PM10 and PM2.5 health effects, there are few long-term human health studies examining exposures to UFPs,[8] as this species is not typically measured in monitoring networks throughout the U.S. Generally, there is little or no correlation between ambient particle numbers and mass;[9, 10, 11] therefore, measurements of ambient particle number concentrations serve to complement PM mass measurements. UFPs have a relatively short lifespan and their concentrations are strongly dependent on local sources and atmospheric conditions. Thus, their number concentrations can vary significantly on short temporal and spatial scales.[12,13,14,15] The MATES V UFP measurement efforts serve to characterize UFP concentrations in community areas that are generally not close to sources. Therefore, these measurements represent general background concentrations of UFPs, but do not reflect UFP exposures for residents who live close to major UFP sources.

5.1.2. UFP measurements during MATES V

The purpose of the MATES program is to conduct a series of studies to assess cancer risk from exposure to toxic air contaminants in the South Coast Air Basin (SCAB). These studies are the result of air toxics monitoring, development of toxic emissions inventories, regional modeling, and health risk evaluations. Continuous UFP concentration measurements began in MATES IV (July 2012 – June 2013), even though they are not technically specified as air toxics. The sampling period for all fixed stations was one year, beginning on May 1, 2018 and ending April 30, 2019. MATES V monitoring stations include Anaheim, Burbank Area, Central Los Angeles (Central LA), Compton, Huntington Park, Inland Valley San Bernardino (Inland Valley SB), Long Beach, Pico Rivera, and Rubidoux, and West Long Beach. Additional details about the monitoring sites,

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[8] Ohlwein, S., Kappeler, R., Kutlar Joss, M., Künzli, N., & Hoffmann, B. (2019) "Health effects of ultrafine particles: a systematic literature review update of epidemiological evidence", International Journal of Public Health, 64(4), 547-559.

[9] de Jesus, A. L., Rahman, M. M., Mazaheri, M., Thompson, H., Knibbs, L. D., Jeong, C., Evans, G., Nei, W., Ding, A., Qiao, L., Li, L., Portin, H., Niemi, J.V., Timonen, H., Luoma, K., Petäjä, T., Kulmala, M., Kowalski, M., Peters, A., Cyrys, J., Ferrero, L., Manigrasso, M., Avino, P., Buonano, G., Reche, C., Querol, X., Beddows, D., Harrison, R.M., Sowlat, M.H., Sioutas, C., Morawska, L. (2019) "Ultrafine Particles and PM2.5 in the Air of Cities around the World: Are They Representative of Each Other?", Environ. Int. 129, 118–135.

[10] Saha, P. K., Sengupta, S., Adams, P., Robinson, A. L., Presto, A. A. (2020) "Spatial Correlation of Ultrafine Particle Number and Fine Particle Mass at Urban Scales: Implications for Health Assessment", Environmental Science and Technology, 54 (15), 9295–9304.

[11] Sardar, S.B., Fine, P.M., Yoon, H., et al. (2004) "Associations between particle number and gaseous co-pollutant concentrations in the Los Angeles Basin", Air and Waste Management, 54: 992-1005.

[12] Kozawa, K. H., Fruin, S. A., & Winer, A. M. (2009) "Near-road air pollution impacts of goods movement in communities adjacent to the Ports of Los Angeles and Long Beach", Atmospheric Environment, 43(18), 2960–2970.

[13] Shirmohammadi, F., Sowlat, M. H., Hasheminassab, S., Saffari, A., Ban-Weiss, G., & Sioutas, C. (2017) "Emission rates of particle number, mass and black carbon by the Los Angeles International Airport (LAX) and its impact on air quality in Los Angeles", Atmospheric Environment, 151, 82–93.

[14] Zhu, Y., Hinds, H.C., Kim, S., et al. (2002a) "study of ultrafine particles near a major highway with heavy-duty diesel traffic", Atmospheric Environment, 36 (27): 4323-4335.

[15] Zhu, Y., Hinds, H.C., Kim, S., et al (2002b) "Concentration and size distribution of ultrafine particles near a major highway", Journal of Air and Waste Management Association, 52: 1032-1042.

their characteristics, and sampling protocols are provided in Chapter 2.

MATES V UFP data was collected using Teledyne Advanced Pollution Instrumentation (TAPI) Ultrafine Particle Monitors, Model 651. This monitor is a laminar flow condensation particle counter (CPC) that uses water to grow UFPs to a larger, detectable size. UFPs are grown through condensation in a controlled super-saturation environment to larger sizes and then counted using a photodetector. These CPCs can provide the total number concentration of particles between 7 nm and 0.5 µm and were operated with a cyclone restricting the upper size limit to approximately 600 nm. The CPCs were operated continuously with 1-minute time resolution. Given that the vast majority (~90%) of particles fall within the UFP size range, the PNC provided by the CPC is used herein as a proxy for UFP concentration. Additional technical details on this CPC model and the results of a test evaluation conducted by South Coast AQMD and UCLA prior to the beginning of MATES IV are reported in Lee et al.[16] For further information and maintenance instructions, please refer to the TAPI Ultrafine Particle Monitor Model 651 Operation Manual and the standard operating procedure document for this instrument (South Coast AQMD SOP00143).

5.1.3. Results and Discussion of UFP Measurements

Initial results are focused on overall MATES averages with diurnal, day of week, and seasonal variations in the following section. The MATES V UFP means and confidence intervals (error bars) for each site and the SCAB (10 site average) are shown in Figure 5-1. Ultrafine particle concentration mean and 95% confidence interval for each site and the South Coast Air Basin (10 site average). The annual average UFP concentrations for each site range from 12,182 particles/cm^3 to 22,658 particles/cm^3, with an overall SCAB concentration of 15,971 particles/cm^3. The UFP concentrations vary significantly from site to site, with the highest annual averages measured at West Long Beach and Huntington Park. These sites show mean UFP concentrations considerably greater than what was observed over the entire SCAB and are the only sites that show mean concentrations greater than 20,000 particles/cm^3. Rubidoux, an inland receptor site, shows the lowest annual UFP concentration average. Inland Valley San Bernardino, the other inland receptor site, shows relatively high UFP concentration compared to the Rubidoux location. UFP concentrations observed at the MATES designated sites are significantly lower than those observed at all South Coast AQMD near-road monitoring stations where annual average UFP concentrations exceed 29,000 particles/cm^3 (see Appendix VII). The levels observed in the South Coast Air Basin are generally higher than what is seen on a national average, but comparable with other metropolitan areas such as Boston and Pittsburgh.[17]

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[16] Lee, E.S., Polidori, A., Koch, M., et al. (2013) “Water-based condensation particle counters comparison near a major freeway with significant heavy-duty diesel traffic”, Atmospheric Environment, 68: 151-161.

[17] Presto, A.A., Saha, P.K., Robinson, A.L. (2021). Past, Present, and Future of Ultrafine Particle Exposures in North America. Atmospheric Environment: X, https://doi:org/10.1016/j.aeaoa.2021.100109.

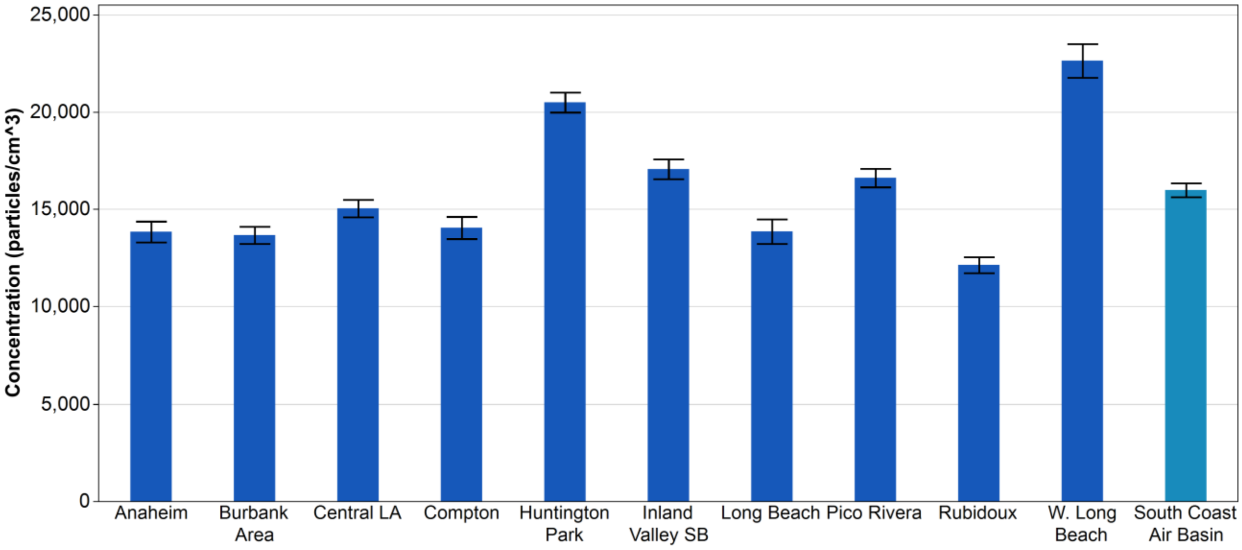

Figure 5-1. Ultrafine particle concentration mean and 95% confidence interval for each site and the South Coast Air Basin (10 site average)

The box and whisker plots in Figure 5-2. Box plots showing the daily average minimum, first quartile, median, third quartile, and maximum values at each site and SCAB (10 site average) for both MATES IV and V summarize the minimum, first quartile, median, mean, third quartile, and maximum daily average UFP concentrations at each site in MATES IV and V. The plot indicates that the Anaheim, Burbank Area, Central L.A., Inland Valley San Bernardino, and Rubidoux sites were characterized by a relatively low UFP variability during MATES V. West Long Beach station shows a much higher maximum concentration compared to the other sites during MATES V. The maximum daily concentration observed at Huntington Park is greatly reduced in MATES V compared to MATES IV, although the decrease in the average concentration is much more modest. Comparing the average UFP concentrations between measurement periods shows that there is no consistent trend in the average concentration observed at each site between MATES IV (July 2012–June 2013) and MATES V (May 2018 – April 2019). The average concentration at each site is similar between the two measurement periods; however, the direction of change differs between sites. Three sites show small increases in average UFP concentration (Anaheim, Inland Valley SB, Rubidoux), while the other seven sites show a modest decrease (Burbank Area, Central LA, Compton, Huntington Park, Long Beach, Pico Rivera, W. Long Beach). This observation, coupled with a decrease in primary particle emissions from diesel sources (e.g., black carbon; see Appendix VI), suggests that primary particles from non-traffic related sources and/or secondary particle formation may be of higher relative importance to the concentration of UFPs measured in MATES V than to those measured in MATES IV.

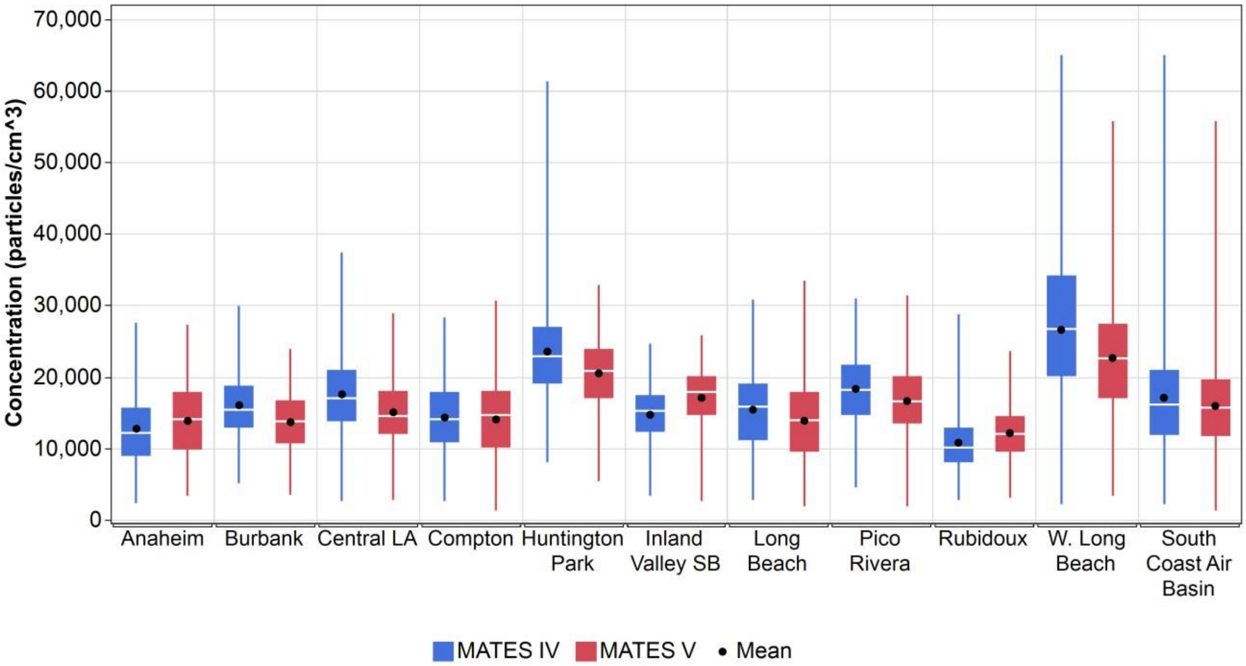

Figure 5-2. Box plots showing the daily average minimum, first quartile, median, third quartile, and maximum values at each site and SCAB (10 site average) for both MATES IV and V

5.1.4. Diurnal, day of week, and seasonal variations in UFP measurements

The effect of traffic emission sources and meteorological factors is reflected in the diurnal profiles by day of week (Figure 5-3). UFP concentrations in urban environments have been shown to closely follow the temporal variation in traffic density, with highest levels observed on weekdays during rush hours. UFP can also be formed by photochemical reactions in the atmosphere, particularly in photochemically-active sunnier seasons. This is often reflected in a mid-day peak associated with secondary particles. Moreover, the boundary layer in early mornings is much shallower than afternoon hours, which causes a lowering of the “mixing height,” less atmospheric transport and dilution, and thus a consequent increase in near ground concentrations. As a result, during the early morning, there is a pronounced UFP enhancement during weekdays, likely due to emissions associated with rush hour traffic combined with a lower atmospheric boundary layer height in early mornings. As the day progresses and the atmosphere is heated, the mixing height rises, leading to a dilution and subsequent decrease of traffic emissions. Around noon, a second peak emerges mainly due to the formation of secondary UFPs driven by photochemical reactions. The UFP concentration decreases towards the late afternoon and a third, less pronounced peak due to the trapping of overnight emissions by the nocturnal inversion layer emerges in the early evening. The lowest UFP averages are typically observed on Sundays, which is consistent with previous studies.[18, 19, 20,] Conversely, the highest average UFP level is observed on Fridays (see Appendix VII). While daily concentrations tend to be slightly lower on the weekends, especially on Sundays, the maximum hourly concentrations for each day (around noon) are not lower on the weekends despite lower traffic volumes. This suggests that secondary UFP production (i.e., photochemical reactions) and/or additional UFP sources other than traffic are important contributors to particle number concentrations.

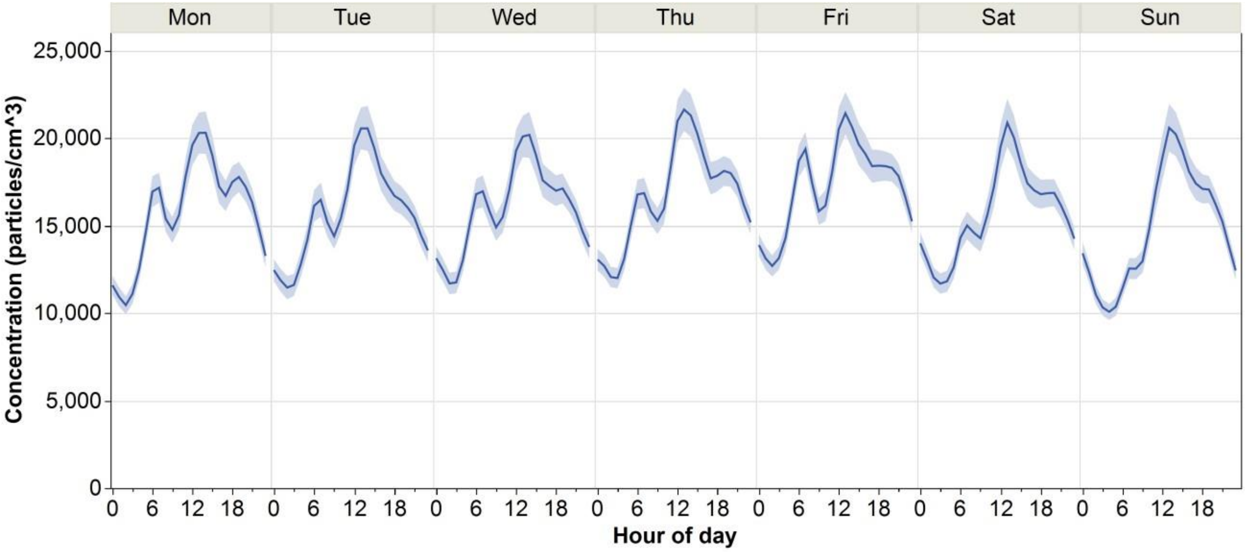

Figure 5-3. Diurnal profiles ultrafine particle concentration by day of week in the South Coast Air Basin. Error bands represent 95% confidence intervals. The hour of day times are shown for Pacific Standard Time (PST) and not adjusted for daylight savings time

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[18] Sabaliauskas, K., Jeong C., Yao, X., et al. (2013) "Cluster analysis of roadside ultrafine particle size distributions", Atmospheric Environment, 70: 64-74.

[19] Sioutas, C. (2011) "Fine-Scale Spatial and Temporal Variability of Particle Number Concentrations within Communities and in the Vicinity of Freeway Sound Walls", University of Southern California

[20] Tiwary, A., Namdeo, A, Pareira, A. (2012) "Spatial Variation on Personal Exposure of Parking Attendants to Traffic Emissions in an Urban Conurbation", The Open Atmospheric Science Journal, 6: 78-83.

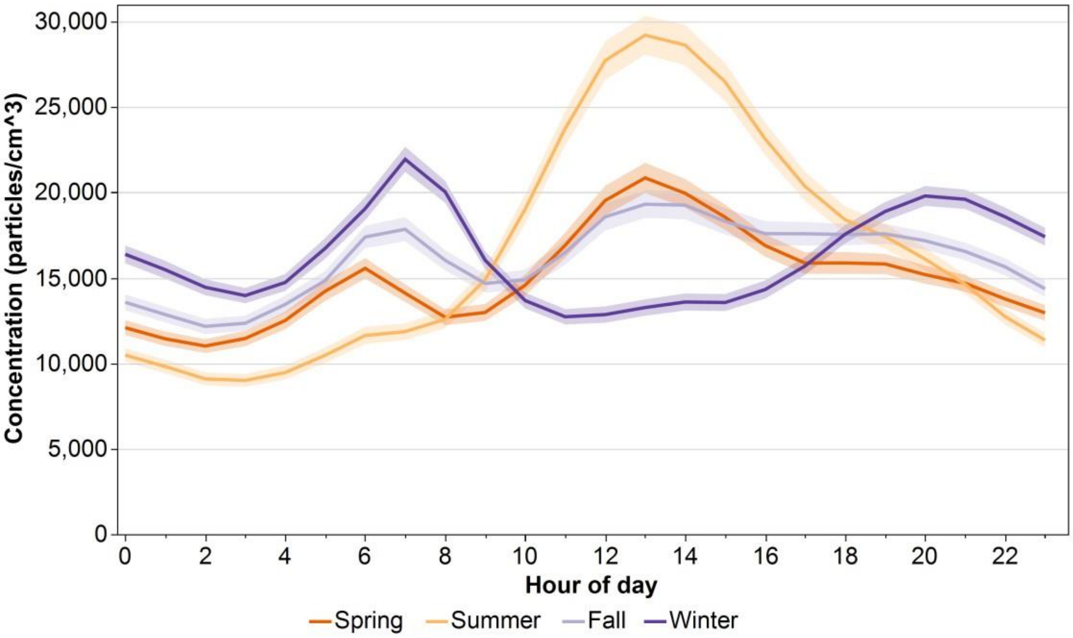

Figure 5-4. Seasonal diurnal profiles of ultrafine particle number concentration in the South Coast Air Basin (10 site average). Error bands represent 95% confidence intervals

While the overall SCAB diurnal profiles provide some information about the factors that influence the UFP concentrations in the region, these profiles are highly dependent on the season. Diurnal UFP profiles are averaged by season to characterize these variations (Figure 5-4. Seasonal diurnal profiles of ultrafine particle number concentration in the South Coast Air Basin (10 site average). Error bands represent 95% confidence intervals). Seasons are divided into winter (December-February), spring (March-May), summer (June-August), and fall (September-November). The winter profile is characterized by two peaks and is distinctly different from the diurnal profile observed in the summer. Traffic emissions generated during the morning commute in the winter produce a peak during rush-hour (6:00 to 9:00) that extends until late morning. As the temperature increases in the afternoon, the mixing height rises and the UFP concentrations drop, reaching a minimum around noon or early afternoon. When evening approaches, the nocturnal inversion layer causes an elevation in particle number count, producing a peak that persists throughout the late evening hours. Previous studies by Singh et al. (2006)[21] and Wang et al. (2012)[22] have found similar wintertime diurnal trends. In addition to the nocturnal inversion layer, the evening rush-hour traffic likely also contributes to the winter season evening peak, since the inversion layer is already reforming during the evening traffic hours. In contrast, the summer months do not show these traffic-related peaks and instead show a large midday peak (10:00 to 17:00) related to secondary formation of UFP through photochemical reactions. In these months, the inversion layer

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[21] Singh, M., Phuleria, H.C., Bowers, K., et al. (2006) "Seasonal and spatial trends in particle number concentrations and size distributions at the children's health study sites in Southern CA", Journal of Exposure Science and Environmental Epidemiology, 16: 3-18

[22] Wang, Y., Hopke, P.K., Utell, M.J. (2012) "Urban-Scale Seasonal and Spatial Variability of Ultrafine Particle Number Concentrations", Water Air and Soil Pollution, 223: 2223-2235.

reforms or lowers later in the evening and the mixing layer is shallow, so the traffic peak is finished before the mixing is significantly restricted. Spring and fall diurnal patterns show intermediate profiles between those observed in winter and summer with both morning/evening peaks and a midday photochemical peak. Comparable spring and fall diurnal profiles are also observed in previous studies conducted in the SCAB.[23] Although there is consistency between the diurnal profiles observed here and in previous studies, seasonal diurnal profiles vary significantly by site (see Appendix VII).

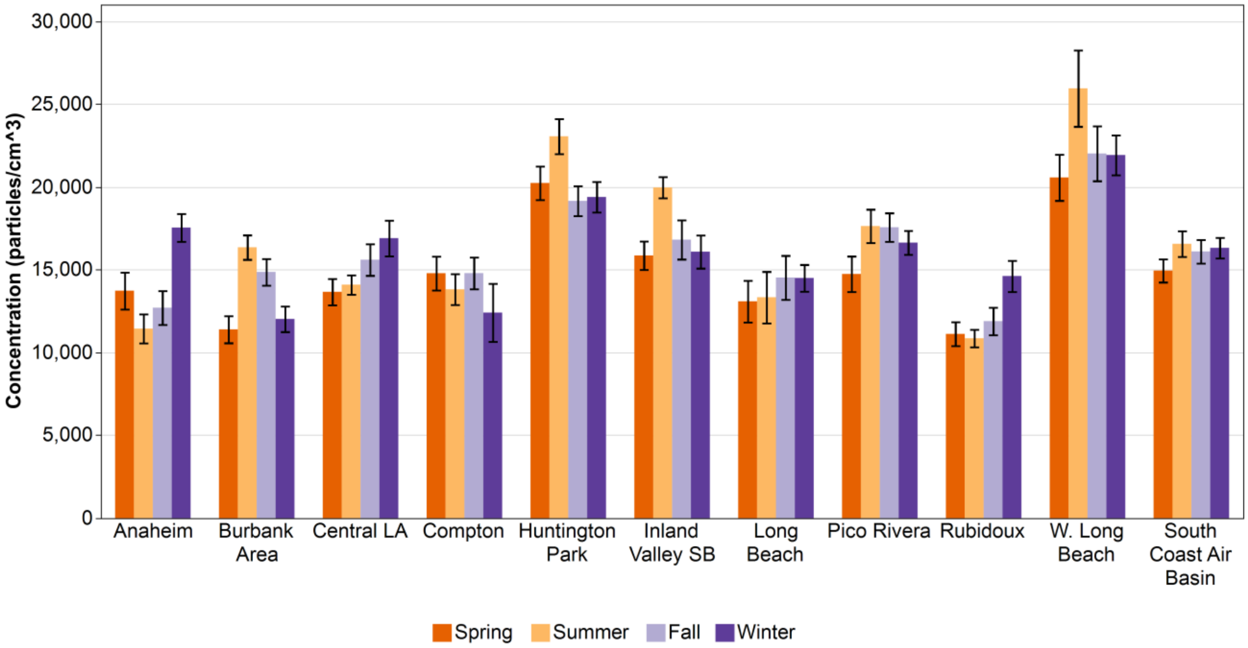

Figure 5-5. Average seasonal particle number concentration for each site and in the South Coast Air Basin (10 site average). Error bars represent 95% confidence intervals

The previous section discussed the overall trends of UFP concentrations observed in the South Coast Air Basin (i.e., all ten MATES V sites averaged together). However, since UFP concentrations are highly spatially variable, it is important to consider the differences between sites as well (Figure 5-5. Average seasonal particle number concentration for each site and in the South Coast Air Basin (10 site average). Error bars represent 95% confidence intervals). The highest average UFP levels observed for all seasons are in West Long Beach. In most instances, the highest average particle number concentrations at all sites are observed during the winter or summer months. In the wintertime, emissions from primary sources dominate the UFP concentrations due to stagnant atmospheric conditions. In addition, the coastal region experiences

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[23] Sioutas, C. (2011) "Fine-Scale Spatial and Temporal Variability of Particle Number Concentrations within Communities and in the Vicinity of Freeway Sound Walls", University of Southern California

surface-based temperature inversions and weak onshore wind flow during this time of the year, leading to increased UFP levels near coastal regions. During the summertime, increased UFP concentrations inland are influenced by local emission sources, long-range advection of upwind sources due to a strong onshore flow and enhanced photochemical activity. UFP concentrations have decreased in winter for many sites going from MATES IV to MATES V, although summer concentrations have remained relatively constant (see Appendix VII). Overall, variations in UFP concentrations based on season and time of day depend on site location, meteorology, and the proximity/location of UFP sources and their precursors. See Appendix VII for a more detailed examination of wind direction and potential sources on UFP concentrations by site.

5.1.5. Summary of UFP measurement results

Continuous real-time UFP measurements collected at ten South Coast AQMD monitoring sites during MATES V show high temporal and spatial variability. A variety of factors, such as the distance to the nearest emission source, type of emission source, traffic volume, wind speed, wind direction, relative humidity, and temperature (among other factors), can all influence the concentration, composition, and dispersion of UFPs. Atmospheric parameters can fluctuate rapidly throughout the day, therefore high time frequency data (hourly or faster) need to be used to examine diurnal UFP profiles. Despite the high spatial and temporal differences measured across the SCAB, the average diurnal UFP concentrations at most MATES V sites follow similar trends, with distinct peaks during the early morning commute, midday, and evening commute times. However, there are clear differences in the observed diurnal and seasonal profiles, with the absolute UFP concentrations dependent on the location of the specific monitoring site where measurements are taken.

Several traffic and meteorological factors contribute to the diurnal variability in the concentration of UFPs; these include:

- High traffic volume during the morning and evening rush hours lead to increased particle number concentration in most seasons.
- Mixing layer height, which can lead to increased particle number concentration when the layer is shallow in the evening and morning and decreased concentrations when the mixing layer height is higher during mid-day.
- High photochemical activity around noon, which favors secondary particle formation.

Meteorological factors modulate these diurnal profiles and contribute to the seasonal variability in the concentration of atmospheric PM and UFPs; these include:

- Lower mixing layer height and greater atmospheric stability in winter, which tend to increase particle levels by limiting vertical atmospheric mixing.
- Lower winter temperature, which leads to increased nucleation of volatile combustion products, particularly during morning rush hours.
- High photochemical activity in the summer, which favors secondary particle

formation.

Due to these factors, the highest seasonal UFP concentrations are usually observed in the winter or summer months. As shown here and reported in previous studies, the ambient UFP concentration in urban environments is related to the temporal variation in traffic density, with high levels observed on weekdays during rush hours.[24, 25, 26] However, high photochemical activity during midday hours can also lead to very high UFP during the summer, oftentimes exceeding maximum hourly wintertime levels. Very high summertime UFP concentrations are likely indicative of nearby sources of precursor gases (e.g. volatile organic compounds and SO_2) which may react and nucleate secondary particles when photochemistry is active.

In addition to the variability observed between sites, there is no consistent trend in observed UFP concentrations across sites between the MATES IV (July 2012 – June 2013) and MATES V (May 2018 – April 2019) measurement periods. Despite decreases in diesel exhaust emissions, some of the MATES sites showed increases in average UFP concentrations during this time period. This suggests that any potential controls on particle number concentration may need to target UFP precursor gases in order to be effective in decreasing overall UFP levels. Measurements of UFPs at near-road sites are relatively new; these measurements are ongoing, but do show a decreasing trend in UFP concentrations, pointing to decreased levels from on-road traffic sources, such as trucks. Continued measurements are needed to make robust conclusions on the long-term trends and spatial patterns of UFPs.[27] Although our understanding of UFPs is increasing, additional information about UFP sources, precursors, and exposures would help improve the understanding of this type of pollution in the South Coast Air Basin.

5.2. Black Carbon Measurements at Fixed Sites

5.2.1. Background on Black Carbon Measurements

A common goal of the MATES studies is to identify and quantify health risks associated with major known toxic air contaminants within the South Coast Air Basin (SCAB). Previous MATES studies assessed the carcinogenic risk due to exposure to air toxics and found that emissions from diesel powered engines accounted for 86% and 80% of inhalation air toxics

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[24] Hussein, T., Puustinen, A., Aalto, P., Makela, J., Hameri, K., Kulmala, M. (2004) “Urban aerosol number size distributions”, Atmospheric Chemistry and Physics Discussions 4, 391–411.

[25] Morawska, L., Ristovski, Z., Jayaratne, E.R., et al (2008) “Ambient nano and ultrafine particles from motor vehicle emissions: characteristics, ambient processing and implications on human exposure”, Atmospheric Environment, 42: 8113-8138.

[26] South Coast Air Quality Management District, 2015. “Multiple Air Toxics Exposure Study in the South Coast Air Basin (MATES IV).”

[27] Presto, A.A., Saha, P.K., Robinson, A.L. (2021). Past, Present, and Future of Ultrafine Particle Exposures in North America. Atmospheric Environment: X, https://doi:org/10.1016/j.aeaoa.2021.100109.

cancer risk during MATES III and MATES IV, respectively.[28,29]

During diesel fuel combustion, multiple gaseous pollutants and particulate matter are formed due to the incomplete nature of the combustion process. Diesel particulate matter (diesel PM) is the major fraction of these emissions that are comprised of soot, organic compounds (OC), and trace amounts of inorganic compounds.[30, 31, 32] Soot particles are agglomerates of nanometric spherical particles, that are formed in the combustion engine under high heat-and-pressure and consists of mostly elemental carbon (EC) or black carbon (BC)[33], depending on the measurement method used (see Chapter 2 for details). The structure and properties of soot particles are like those of impure graphite. The organic fraction of diesel emissions consists of a large variety of organic compounds including volatile, and less volatile to non-volatile compounds, e.g. long-chain hydrocarbons originating from lubricating oils and polyaromatic hydrocarbons (PAHs). Due to the high temperature of the combustion process, the vapors of the organic compounds and soot particles cool down upon their emission to the atmosphere. When the mixture cools down, soot particles can absorb the OC vapors, i.e. a coating of OC is formed on the soot particles. Thus, significant quantities of potentially toxic organic compounds can accumulate on the carbonaceous particles. While soot may not be a major direct toxic component of fine particles ($PM_{2.5}$), it operates as a universal carrier of a wide variety of chemicals that cause adverse health effects.

The presence of high fractions of soot within diesel exhaust is a unique property of this combustion source; therefore, in urban areas, soot is often considered a good proxy for diesel PM.[34] While the major source of soot in an urban area is diesel-powered vehicles, other sources, e.g., non-road mobile machinery, ship emissions, residential heating (such as wood-burning stoves), and open biomass burning (e.g., forest fires or burning of agricultural waste) also contribute to the observed levels. Although soot is currently unregulated, the implementation of national, state, and local regulations and programs to mitigate fine PM emissions and the toxic impacts of diesel emissions, often result in reduction of soot levels.[35]

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[28] South Coast Air Quality Management District, 2008. "Multiple Air Toxics Exposure Study in the South Coast Air Basin (MATES III)."

[29] South Coast Air Quality Management District, 2015. "Multiple Air Toxics Exposure Study in the South Coast Air Basin (MATES IV)."

[30] Abu-Allaban, M., Rogers, C.F., Gertler, A.W., 2004. A quantitative description of vehicle exhaust particle size distributions in a highway tunnel. J. Air Waste Manage. Assoc. 54, 360–366.

[31] Lloyd, A.C., Cackette, T.A., 2001. Diesel engines: environmental impact and control. J. Air Waste Manage. Assoc. 51, 809–847.

[32] Wang, X., Wang, Y., Bai, Y., Wang, P., Zhao, Y., 2019. An overview of physical and chemical features of diesel exhaust particles. J. Energy Inst. 92, 1864–1888.

[33] BC and EC both refer to impure carbon particles resulting from combustion processes. While these terms are often used interchangeably, they are two methodologically-defined species that are measured using optical and thermaloptical methods, respectively.

[34] Schauer, J.J., 2003. Evaluation of elemental carbon as a marker for diesel particulate matter. J. Expo. Sci. Environ. Epidemiol. 13, 443–453.

[35] Schraufnagel, D.E. (2020) "The health effects of ultrafine particles", Exp Mol Med, 52, 311–317.

In MATES V, we examined the diurnal, daily, seasonal, and yearly variations of BC concentration and studied the temporal variations in BC concentrations. Spatial variations were also studied by comparing the collected BC data across each sampling site. These variations allow to identify potential source contributions throughout SCAB. Detailed information regarding the equipment used for BC sampling, the location of the sampling sites, data processing and the complete set of results are provided in Appendix VI to this report.

5.2.2. Black Carbon Measurements during MATES V

The Aethalometer (Magee Scientific, Berkeley, CA) is a photometer that provides a real-time readout of the BC concentration particles in an air stream. The operating principles of the Aethalometer are described in detail elsewhere.[36] Briefly, the instrument collects airborne particulate matter on a filter while continuously measuring the light transmission through the filter. The attenuation in light intensity is caused by light absorption of BC-containing particles that accumulate on the filter over time. This measurement needs to be post-processed to obtain ambient aerosol absorption coefficients which are then converted to BC concentrations. One drawback of this measurement method, inherent in all filter-based photometers, is the nonlinearity of the measurements due to PM loading on the filter media, which reduces the sensitivity of the measurements. Numerous studies have focused on developing algorithms to correct the Aethalometer non-linearity. The Magee Aethalometer model AE33 performs this correction automatically.

During MATES V, aerosol particles were sampled through a ¼” inlet with a $PM_{2.5}$ cyclone with a sampling flow rate of 5 $L{\cdot}min^{-1}$. The Aethalometers were operated in air-conditioned trailers. Typical maintenance operations included flow rate calibration, clean air zero test, filter taper replacement (once every two weeks in locations with high BC concentrations), and cleaning.

The sampling period for all fixed stations was one year, beginning on May 1, 2018 and ending April 30, 2019. MATES V monitoring stations include Anaheim, Burbank Area, Central Los Angeles (Central LA), Compton, Huntington Park, Inland Valley San Bernardino (Inland Valley SB), Long Beach, Pico Rivera, and Rubidoux, and West Long Beach. Additional details about the monitoring sites, their characteristics, and sampling protocols are given in MATES V Chapter 2. Further information on the instrument and detailed methodology and data validation procedures are available in Appendix III and Appendix V.

5.2.3. Black Carbon Results and Discussion

Overall, the annual average BC concentrations for each site range from 720 to 1213 ng/m^3, with an overall SCAB concentration of 1019 ng/m^3 (Figure 5-6). The annual average BC concentration across the 10 sites in the SCAB is 22% lower than what was measured during MATES IV.

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[36] Hansen, A.D.A., Rosen, H., Novakov, T., 1984. The aethalometer—an instrument for the real-time measurement of optical absorption by aerosol particles. Sci. Total Environ. 36, 191–196.

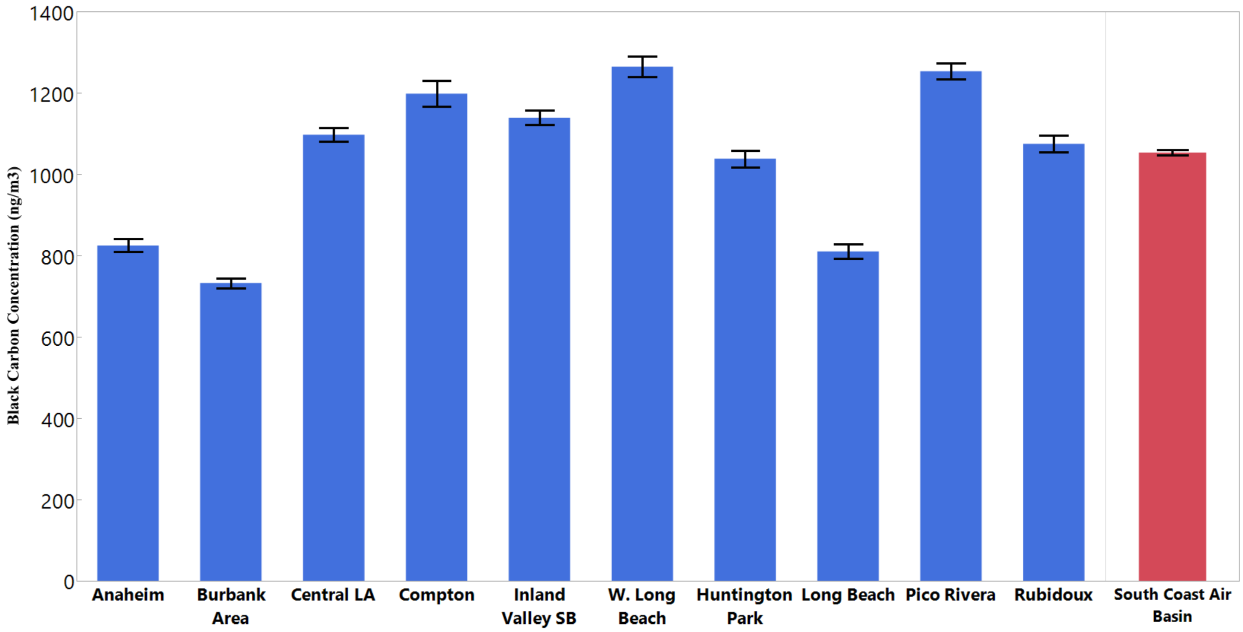

Figure 5-6. Black Carbon concentration average and 95% confidence interval for each site and the South Coast Air Basin (10 site average)

5.2.4. Spatial Variations of Black Carbon Measurements and Comparison with MATES IV

Figure 5-7. A comparison between the spatial distribution of BC levels during MATES IV and MATES V. *Refers to sites that have been relocated between the two study periods. presents the median and average BC concentration at each site for the duration of the study. Data is displayed based on six number values (in order from the bottom): minimum, 1st quartile, median, 3rd quartile, and the higher whisker equal to 3rd quartile plus 1.5 times of the interquartile range.

Solid circles represent the annual average in each site. Figure 5-7. A comparison between the spatial distribution of BC levels during MATES IV and MATES V. *Refers to sites that have been relocated between the two study periods. demonstrates that the averaged BC levels was significantly reduced in comparison to MATES IV levels, in almost all sites. In addition, the median BC levels, and the range of measured levels (the box length) decreased as well.

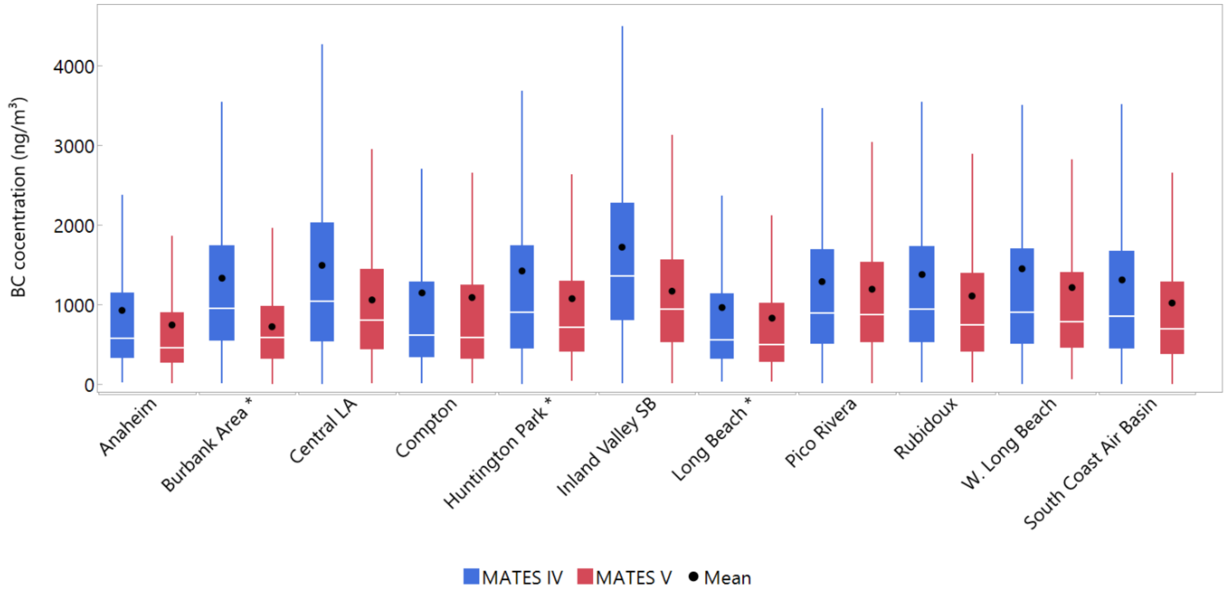

Figure 5-7. A comparison between the spatial distribution of BC levels during MATES IV and MATES V. *Refers to sites that have been relocated between the two study periods.

5.2.5. Comparison with Near-Road Sites

In addition to the MATES V sites, South Coast AQMD operates several near-road monitoring stations where BC levels are measured continuously. These sites include near-road stations in Ontario near CA-60 (60NR), Anaheim near I-5 (AHNR), Ontario near I-10 (ONNR), and Long Beach near I-710 (W710). BC concentrations measured at the near-road monitoring stations during the MATES V period are significantly elevated compared to the ten MATES V sites (Figure 5-8). BC concentrations measured at these near-road stations are, on average, about 60% higher than concentrations at the MATES V sites (Figure 5-8). These data point to the contributions of roadway sources, such as diesel truck emissions, to BC levels in locations where there are a large number of diesel trucks routinely traversing the area. The average daily volume of total traffic and truck traffic near these near-road sites is summarized in Table 5-1. Average volume of daily traffic and truck traffic* near the South Coast AQMD Near-Road monitoring sites for May 1, 2018-April 30, 2019.

Table 5-1. Average volume of daily traffic and truck traffic* near the South Coast AQMD Near- Road monitoring sites for May 1, 2018-April 30, 2019

Near-Road Monitoring Site	Average daily traffic (vehicles per day)	Average daily truck traffic (vehicles per day)
60NR (CA-60)	91,237	865
AHNR (I-5)	123,354	4,531
ONNR (I-10)	107,029	2,675
W710 (I-710)	95,852	10,092

* Traffic volume data was measured and reported by the CalTrans Performance Measurement System (PeMS) Data Source (https://dot.ca.gov/programs/traffic-operations/mpr/pems-source).

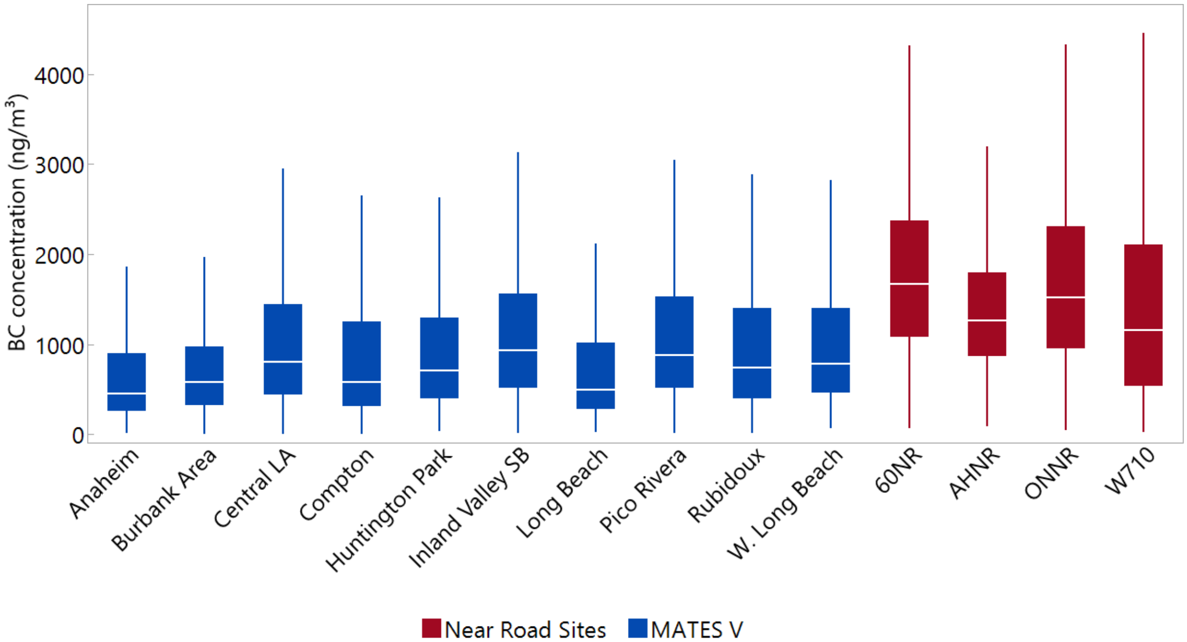

Figure 5-8. Boxplot comparison of BC concentrations between MATES V sites (blue) and near- road sites (red).

5.2.6. Diurnal Variations of Black Carbon Measurements

Typically, BC exhibits a distinct diurnal profile at most sites. BC is associated with primary combustion activities and is widely considered as one of the best indicators of local mobile sources (i.e. diesel emissions in urban environments). The 10-site average diurnal variation of BC concentrations (indicative of the typical diurnal BC trend in the South Coast Air Basin) is shown in Figure 5-9. The distinct increase in BC mass starts as early as 4:00 am. BC concentration reaches its maximum around 7:00 am and then decreases during the morning hours. This pattern is associated with rush-hour traffic during stagnant atmospheric conditions in the morning.

As the day progresses, the increased solar heating leads to greater dispersion of aerosols due to increased turbulent effects and deeper boundary layer. The dispersion of aerosols near the surface along with diminished traffic density in the afternoon results in a gradual decrease in BC concentrations in the late morning and early afternoon hours. The BC concentration continues to be relatively low until 4:00 pm and then increases again during the evening hours, partly because of the evening rush hour traffic. In addition, lower wind speeds at night and shallow inversion layer lead to a rapid decline in ventilation. Overnight, there is a progressive and strong reduction in the traffic density and BC generation; however, stable meteorological conditions and a lower boundary layer result in accumulation of BC near the surface until the next morning.

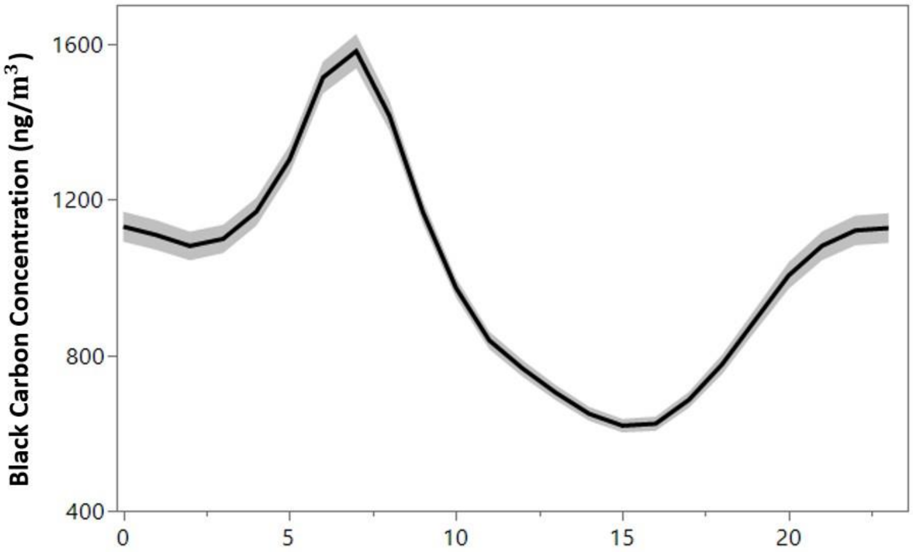

Figure 5-9. Diurnal variation of black carbon concentrations in the South Coast Air Basin during MATES V. Shaded area represents the 95% confidence level of the measurement.

5.2.7. Daily and Seasonal Variability of Black Carbon

Motor vehicle traffic, including diesel traffic, in particular, has a direct impact on ambient BC concentrations. At most locations, traffic density during weekdays is higher than on weekends. In addition, BC levels show a distinct seasonal dependence. Due to meteorological conditions, the boundary layer during the winter is much shallower than in the summer, resulting in an increase in the BC concentrations during the colder months. The daily and seasonal dependence is presented in Figure 5-9. For each season, the BC concentrations measured during weekdays is typically higher than on Saturdays and Sundays. We note that ash South Coast AQMD fire smoke advisory[37] days were included in this analysis. Otherwise, if BC measurements during the active smoke advisories are excluded, BC levels during summer would have been ~10% lower.

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[37] http://www.aqmd.gov/home/air-quality/air-quality-advisories

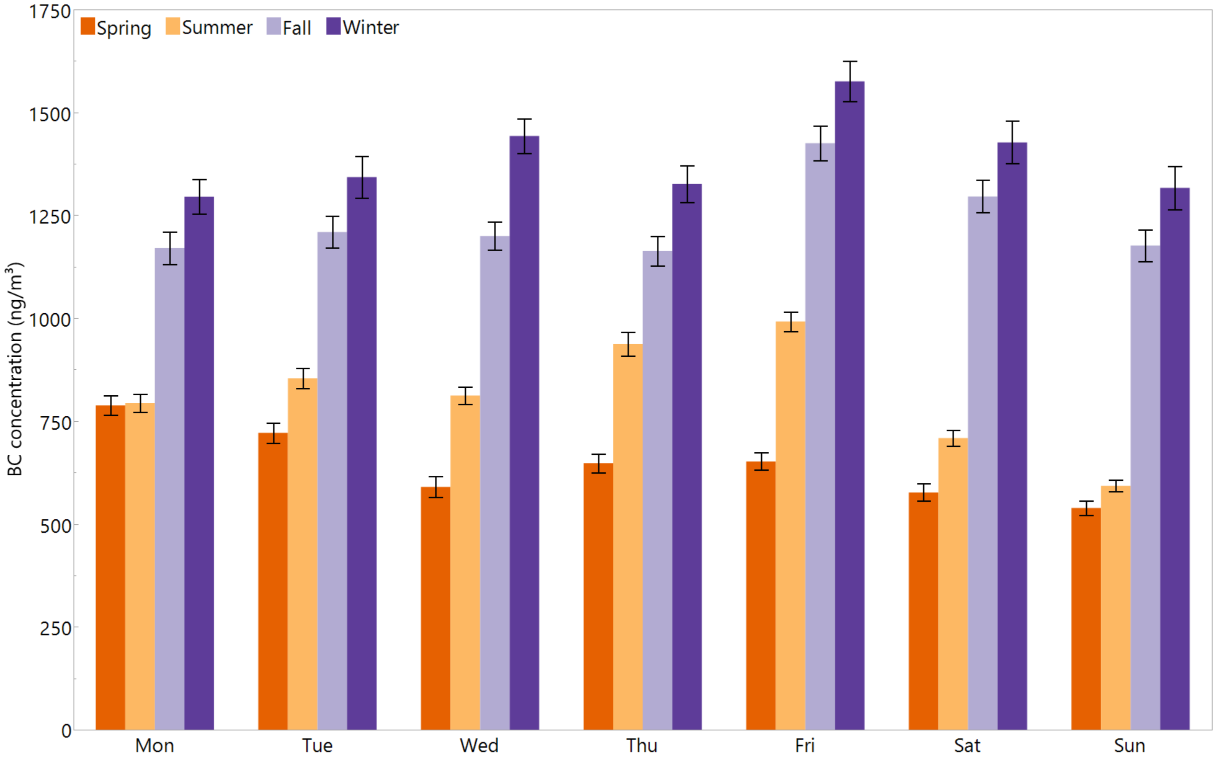

Figure 5-10. Seasonal day-of-week comparison of BC concentrations in the South Coast Air Basin during MATES V.

5.2.8. Summary of Black Carbon Measurements during MATES V

As part of MATES V, long-term measurements of BC concentrations were carried out from May 2018 to April 2019 in a network of 10 sampling sites located in the SCAB. These measurements were used to characterize the spatial and temporal variations in BC concentrations and their association to meteorology and local sources, most notably, vehicle traffic.

The average levels of BC across the SCAB were 22% lower during MATES V (1019 ng/m^3) than they were during MATES IV (1319 ng/m^3). BC levels were significantly higher at sites located closer to traffic corridors.

BC levels show significant temporal variation on all scales, i.e. annual, seasonal, diurnal and weekday/weekend variations. A distinct diurnal cycle with a morning peak that is associated with increased traffic density during rush hours was observed at most sites. BC levels on weekdays were higher than during the weekend. These diurnal and day-of-week observations are associated with increased traffic density during rush hours and working days.

The seasonal variations are mostly affected by changes in meteorology and the boundary layer dynamics. This effect is particularly pronounced during the colder months when higher traffic density is coupled with a shallower mixing height. Moreover, biomass burning smoke may contribute to the observed elevated BC concentrations during the colder months. In general, local traffic sources, meteorological conditions, and boundary layer dynamics are the most important parameters influencing the BC concentrations.

Various regulations and emission reduction strategies can result in lower atmospheric concentrations of BC, either directly by reducing diesel emissions, or indirectly by reducing total PM emissions. Measures to mitigate BC will also reduce OC and PM emissions. Therefore, mitigating emissions of BC from diesel-engine and biomass burning sources would lead to a reduction in air toxic and PM exposure.