BOARD MEETING DATE: August 6, 2021 AGENDA NO. 26

PROPOSAL: Multiple Air Toxics Exposure Study V (MATES V) Final Report

SYNOPSIS: The Multiple Air Toxics Exposure Study V (MATES V) evaluates air toxics and their health impacts, and is part of the Board's Environmental Justice Initiative. MATES V includes a monitoring program, an updated emissions inventory of toxic air contaminants, and a modeling effort to characterize health risks from air toxics exposures. The study focuses on the carcinogenic risk from exposure to air toxics and MATES V also includes an exploratory analysis of chronic non-cancer health impacts. Results from MATES V highlight the continued impacts of air toxics exposures, with diesel participate matter being the main contributor to air toxics cancer risk. Compared to MATES IV, which was conducted in 2012-2013, air toxics cancer risk has decreased by about 50 percent. Communities along the goods movement and transportation corridors continue to have the highest air toxics cancer risks.

COMMITTEE: Mobile Source, April 16, 2021, Reviewed

RECOMMENDED ACTION:
Receive and file.

Wayne Nastri
Executive Officer

SR:JKG:jn

Background

South Coast AQMD's groundbreaking Multiple Air Toxics Exposure Study (MATES) program began in 1987 to characterize the concentrations of airborne toxic compounds in the South Coast Air Basin and the cancer risks associated with air toxics. The MATES program is part of the Board's Environmental Justice (EJ) Initiative, as air toxics pollution disproportionately impacts EJ communities. Whereas the criteria air pollutants have national ambient standards to evaluate progress toward attainment, there are no ambient standards for air toxics. Therefore, the MATES program serves the important purpose of evaluating progress on reducing overall exposures to air toxics. The program also provides public information about ambient air toxics levels in the South Coast AQMD.

Four previous MATES studies have been completed, with MATES II in 1998-1999, MATES III in 2004-2006, and MATES IV in 2012-2013. MATES V reflects data from 2018-2019, and included a monitoring program with 10 stations, an updated air toxics emissions inventory, and a regional modeling analysis of carcinogenic risks from air toxics. MATES V also includes an evaluation of non-cancer health impacts based on one year of monitoring data. Additional work being done through the MATES V program includes several advanced monitoring projects, which will be described in a separate report.

Results

The MATES V report provides valuable data on air toxics levels and their health impacts in the South Coast AQMD based on both modeling and monitoring data. Since these studies were first conducted, numerous emission control programs have been implemented at the national, state, and local levels, and overall toxics emissions continue to decline. The report provides information about these air toxics trends based on data from the MATES program. Some of the key improvements implemented in MATES V include:

- Expanding the modeling domain to include most of the Coachella Valley;
- Using real-time sensor data to help characterize emissions from on-road traffic and ocean-going vessels;
- Analyzing health impacts based on multiple exposure pathways;
- Analyzing chronic non-cancer health impacts;
- Applying advanced statistical methods to enhance data comparability across current and historical MATES studies; and
- Providing online tools to enhance public access to the MATES data and increase public knowledge of air toxics health impacts.

MATES V estimates the overall multi-pathway population-weighted air toxics cancer risk in the South Coast Air Basin and Coachella Valley to be 455-in-a-million and 250-in-a-million, respectively. This reflects a decrease in air toxics cancer risk by about 50 percent since MATES IV. Diesel particulate matter continues to be the main driver of air toxics cancer risk, and the goods movement and transportation corridors are the most impacted areas. EJ communities experienced decreases in air toxics cancer risk since MATES IV, although these communities continue to experience higher air toxics cancer risks compared to other communities. In the exploratory analysis of chronic non-cancer health impacts, the chronic hazard index ranged from 5 to 9 across the ten monitoring stations.

Public Process

A Technical Advisory Group was established that included technical experts from a variety of backgrounds, including academia, industry, governmental and non-governmental organizations. The Technical Advisory Group met several times during the planning stages of MATES V and reconvened to discuss the results and conclusions. The draft results were presented to the Technical Advisory Groups in April 2021, and the advisory group members provided feedback.

The Draft MATES V chapters were released beginning on April 16, 2021, and additional chapters and appendices were released in the following weeks through June 2, 2021. Seven comment letters were received (see Appendix XIV for comments received and Appendix XV for Responses to Comments). The majority of comments were technical in nature, including suggestions on the description of the health impact estimation methods and interpretation, explanation of the choice of statistical methods, and uncertainty in estimating diesel PM based on elemental carbon measurements. Some commenters made suggestions for future studies, including characterizing air toxics levels in areas near sources. The MATES V Advanced Monitoring Study will include detailed measurement data that characterizes emissions and near-source impacts of refineries, and these results will be presented in a separate report, which is anticipated to be released by June 2022. Additional near-source monitoring is also being conducted through the Rule 1180 Refinery Fenceline and Community Monitoring efforts and the AB 617 community air monitoring plans.

Attachments:

1. MATES V Draft Final Report
2. MATES V Draft Final Appendices
3. Board Meeting Presentation

MATES V

Multiple Air Toxics Exposure Study in the South Coast AQMD

FINAL REPORT
AUGUST 2021

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

Multiple Air Toxics Exposure Study V

MATES V

DRAFT FINAL REPORT

August 2021

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

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
GOVERNING BOARD

AUTHORS AND CONTRIBUTORS

South Coast Air Quality Management District

Executive Officer
Wayne Nastri

Chief Operating Officer
Jill Whynot

Deputy Executive Officer
Planning, Rule Development & Area Sources
Sarah Rees, PhD

Assistant Deputy Executive Officer
Planning, Rule Development & Area Sources
Susan Nakamura

Assistant Deputy Executive Officer
Planning, Rule Development & Area Sources
Ian MacMillan

Health Effects Officer
Planning, Rule Development & Area Sources
Jo Kay Ghosh, PhD, MPH

Deputy Executive Officer
Science and Technology Advancement
Matt Miyasato, PhD

Assistant Deputy Executive Officer
Science and Technology Advancement
Jason Low, PhD

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
Fred Lurmann, MS	Sonoma Technology, Inc.
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

Table of Contents

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.

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

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.

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.

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.

---

[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.

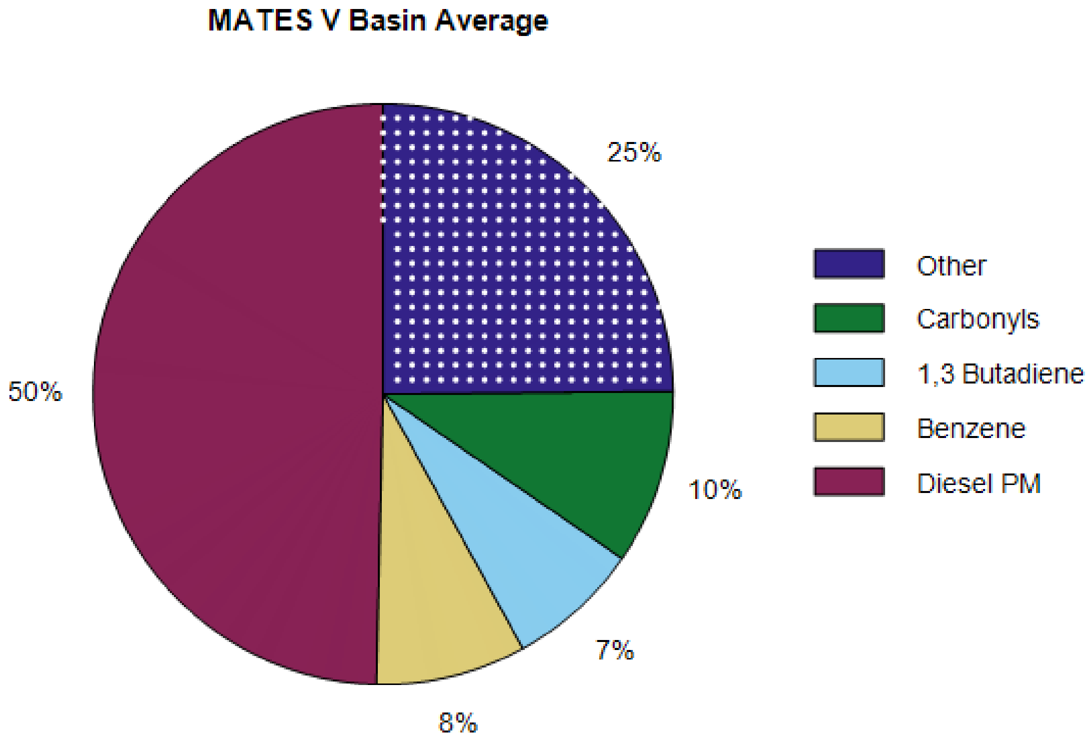


Figure ES-2: Average MATES V Cancer Risk at MATES Monitoring Sites by pollutant type. The "Other" category is marked with gray dots because some species in this category have higher uncertainty due to incomplete data or a large fraction of measurements below detection limits. Numbers may not sum to 100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

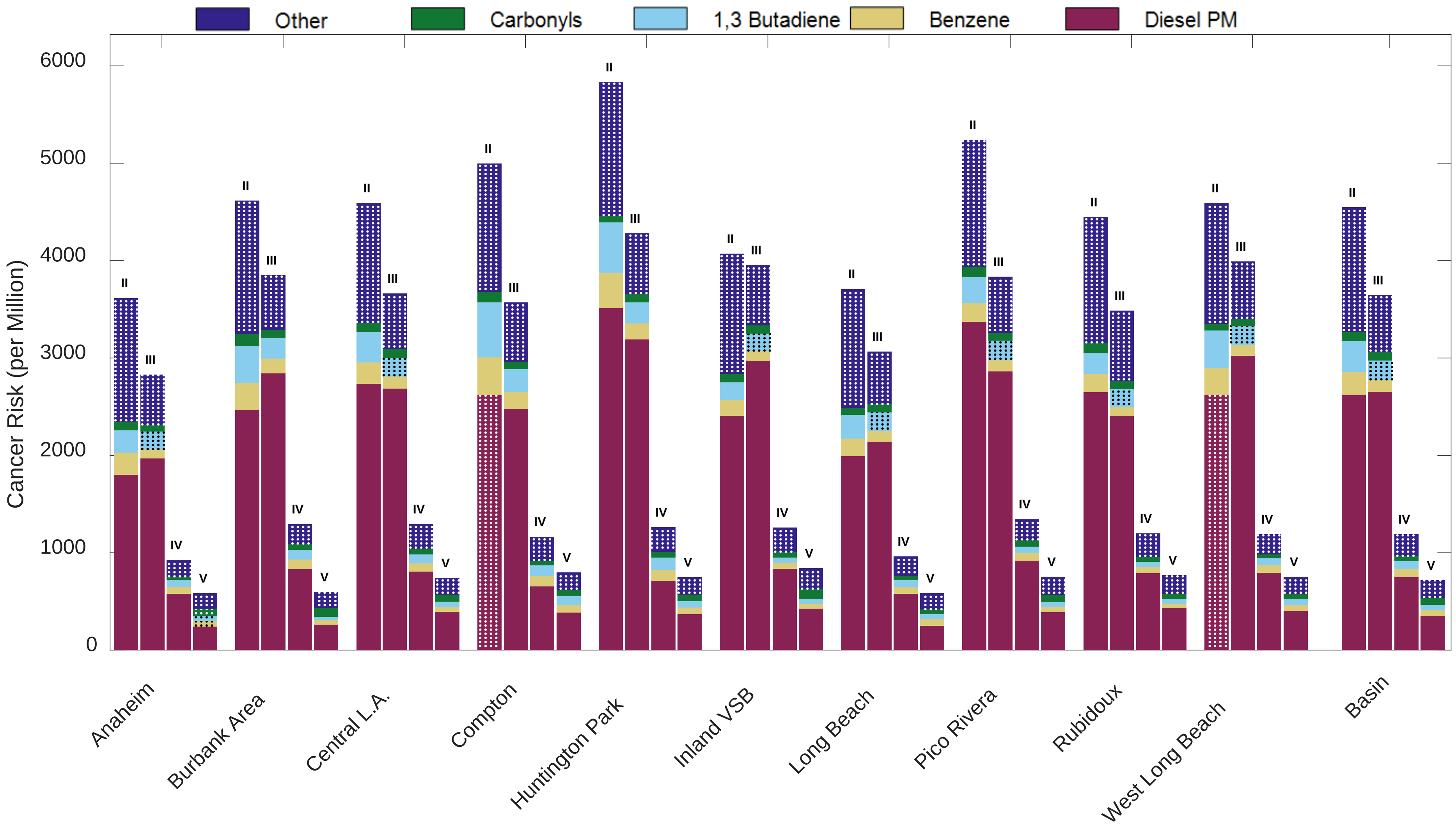


Figure ES-3: Trend in Average Cancer Risk at MATES Monitoring Sites. Segments marked with dots have higher uncertainty due to incomplete data or a large fraction of measurements below detection limits.

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.

---

[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.

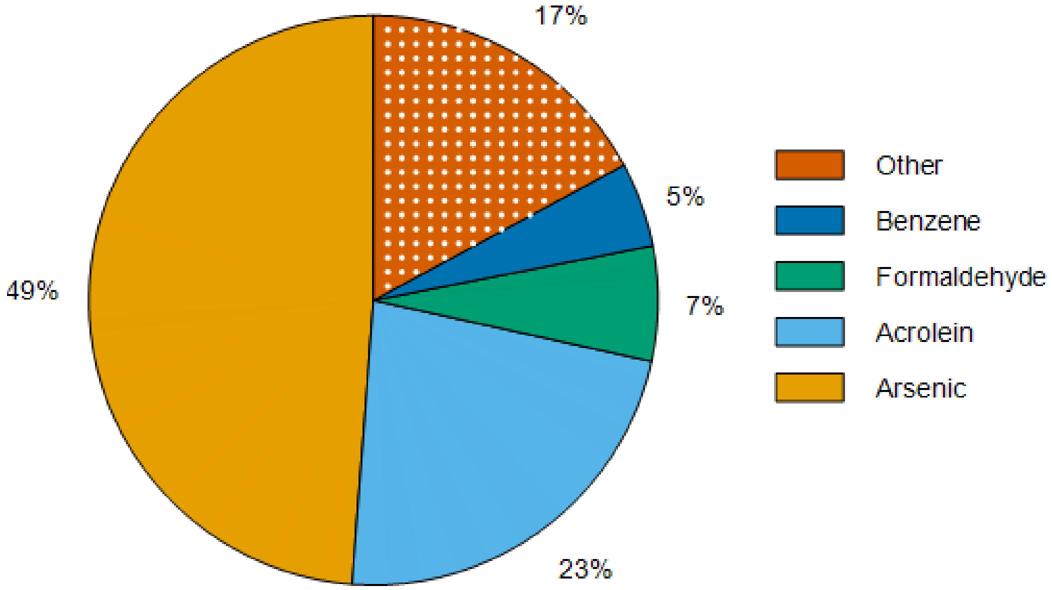


Figure ES-4: Relative contributions to the basin-wide chronic HI at the MATES V monitoring sites. The “Other” category is marked with gray dots because some species in this category have higher uncertainty due to incomplete data or a large fraction of measurements below detection limits. Numbers may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

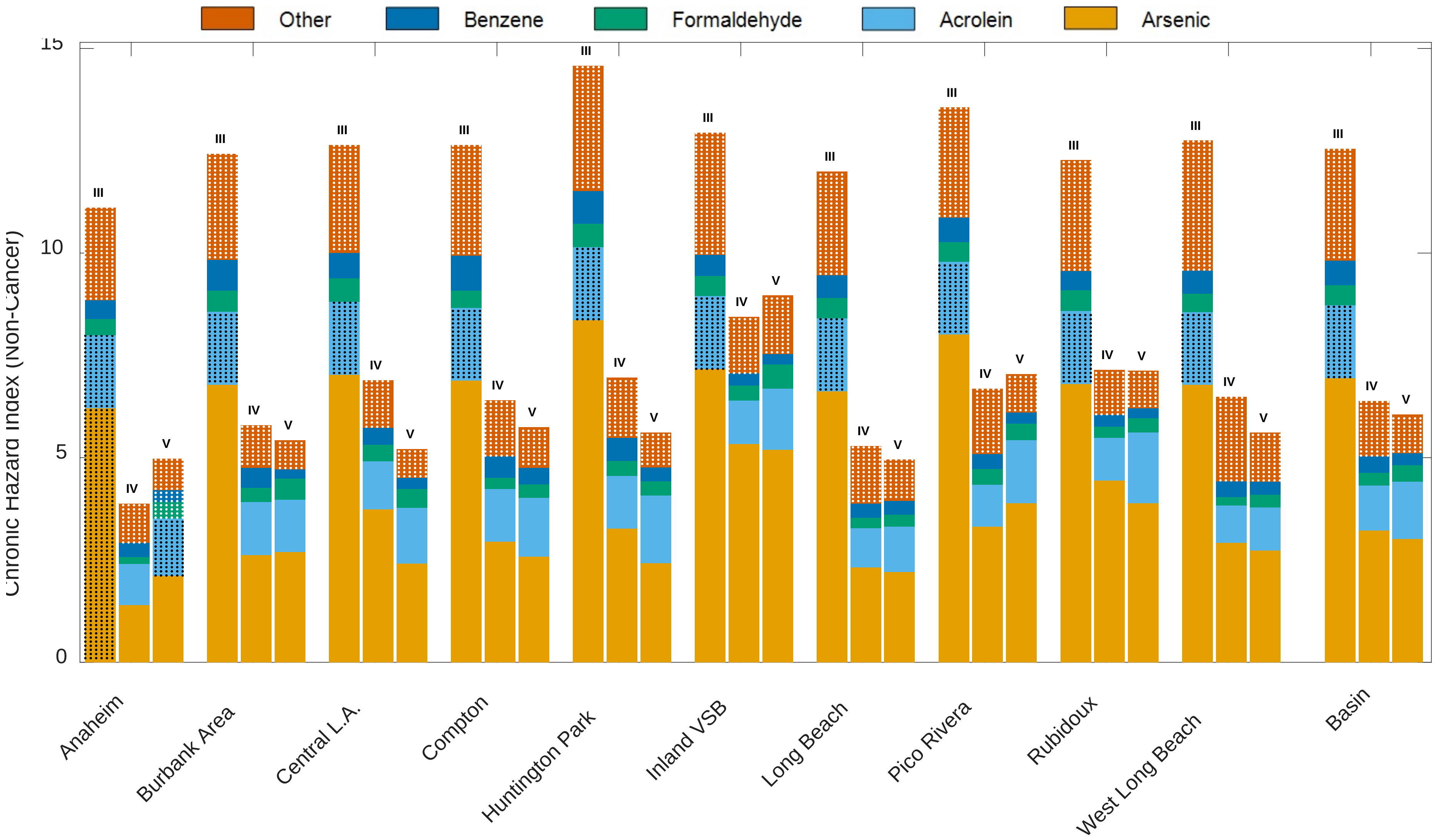


Figure ES-5: Chronic HI trends at MATES Monitoring Sites. Segments marked with dots have higher uncertainty due to incomplete data or a large fraction of measurements below detection limits.

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.

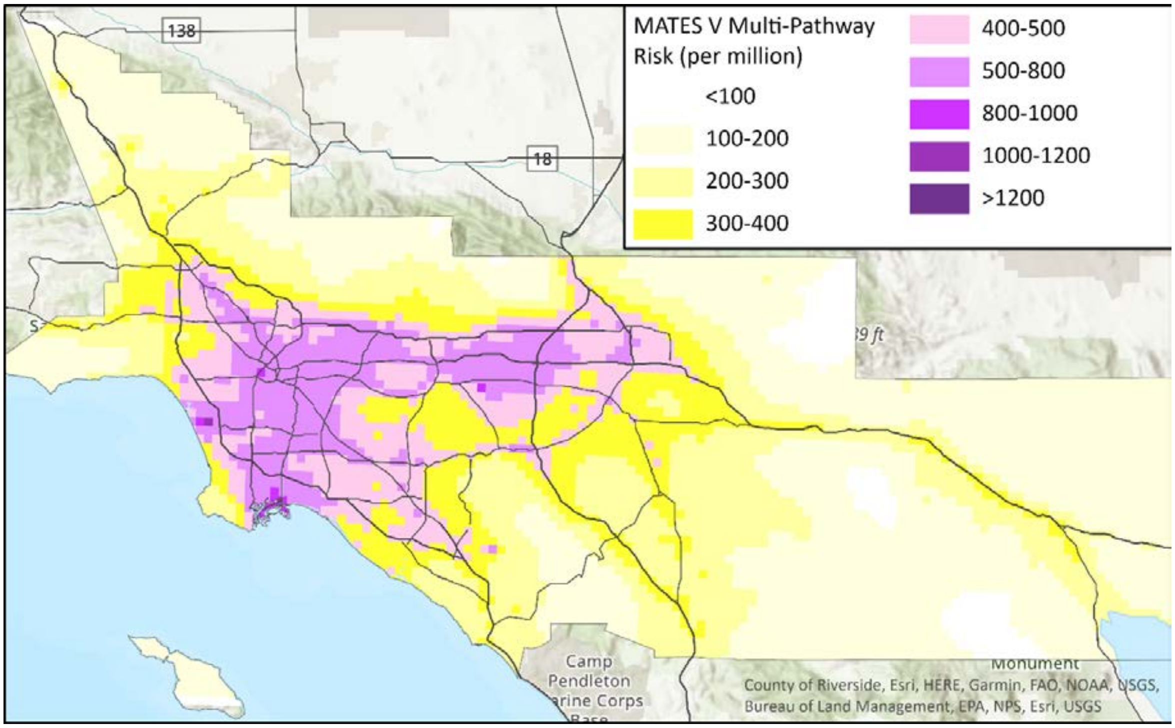


Figure ES-6: Modeled Air Toxics Cancer Risk for MATES V (multiple exposure pathways)

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.

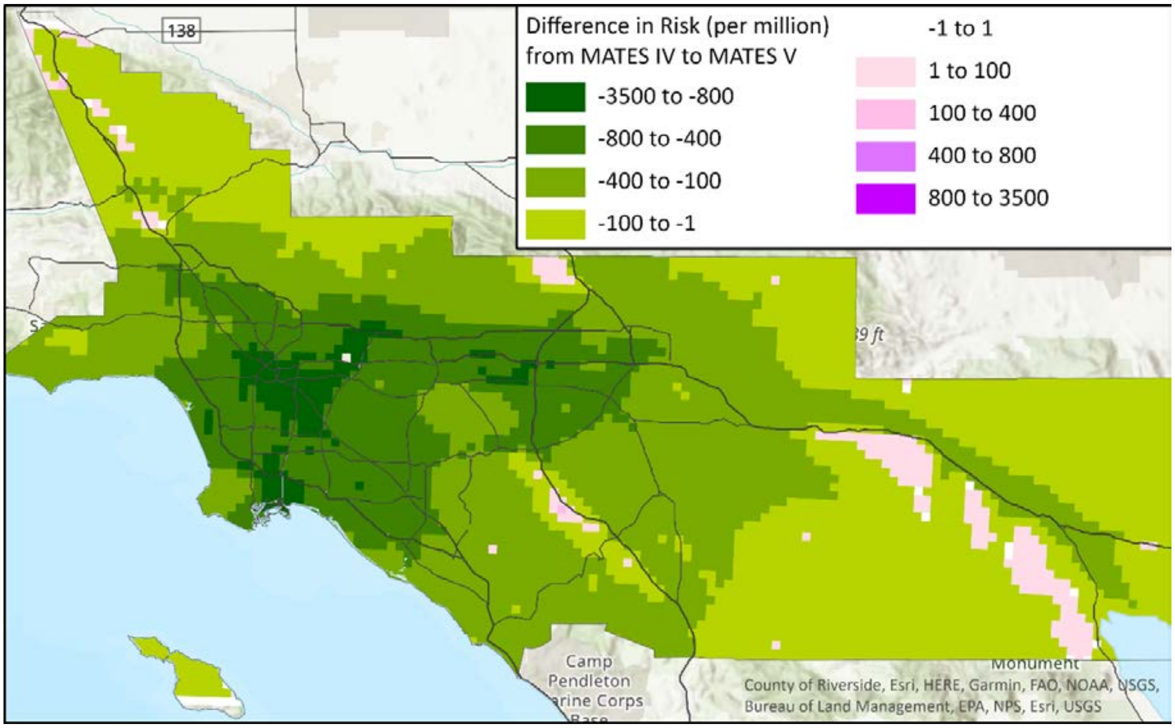


Figure ES-7: Difference in Modeled Air Toxics Cancer Risk from MATES IV to MATES V (multiple exposure pathways)

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.

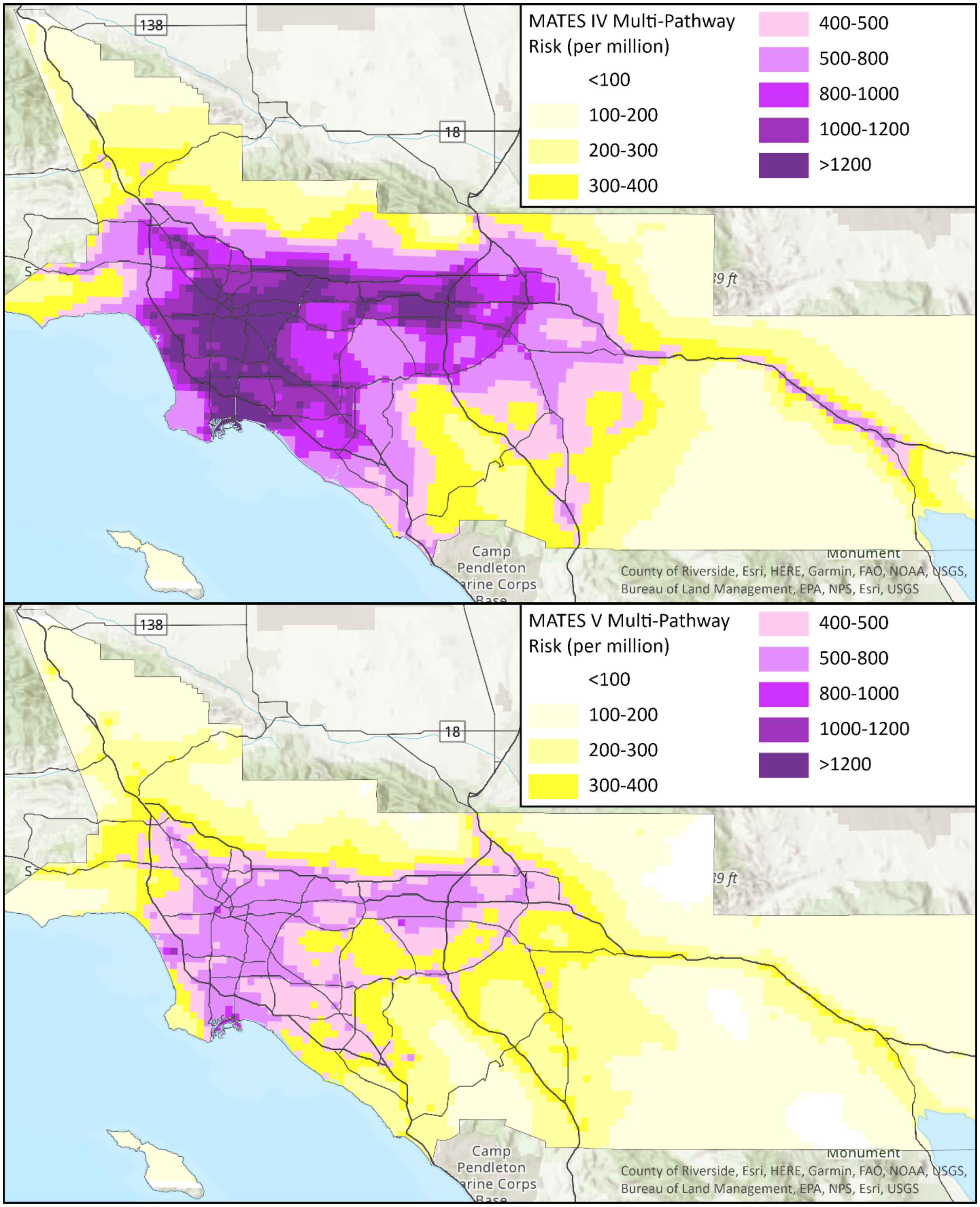
MATES V was the first of these studies to explore chronic non-cancer health impacts across the

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.



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

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 ≤0.1 µm (≤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

---

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

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

---

[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].

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 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.

---

[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].

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). 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

---

[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].

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.

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

---

[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.

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 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.

---

[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 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.

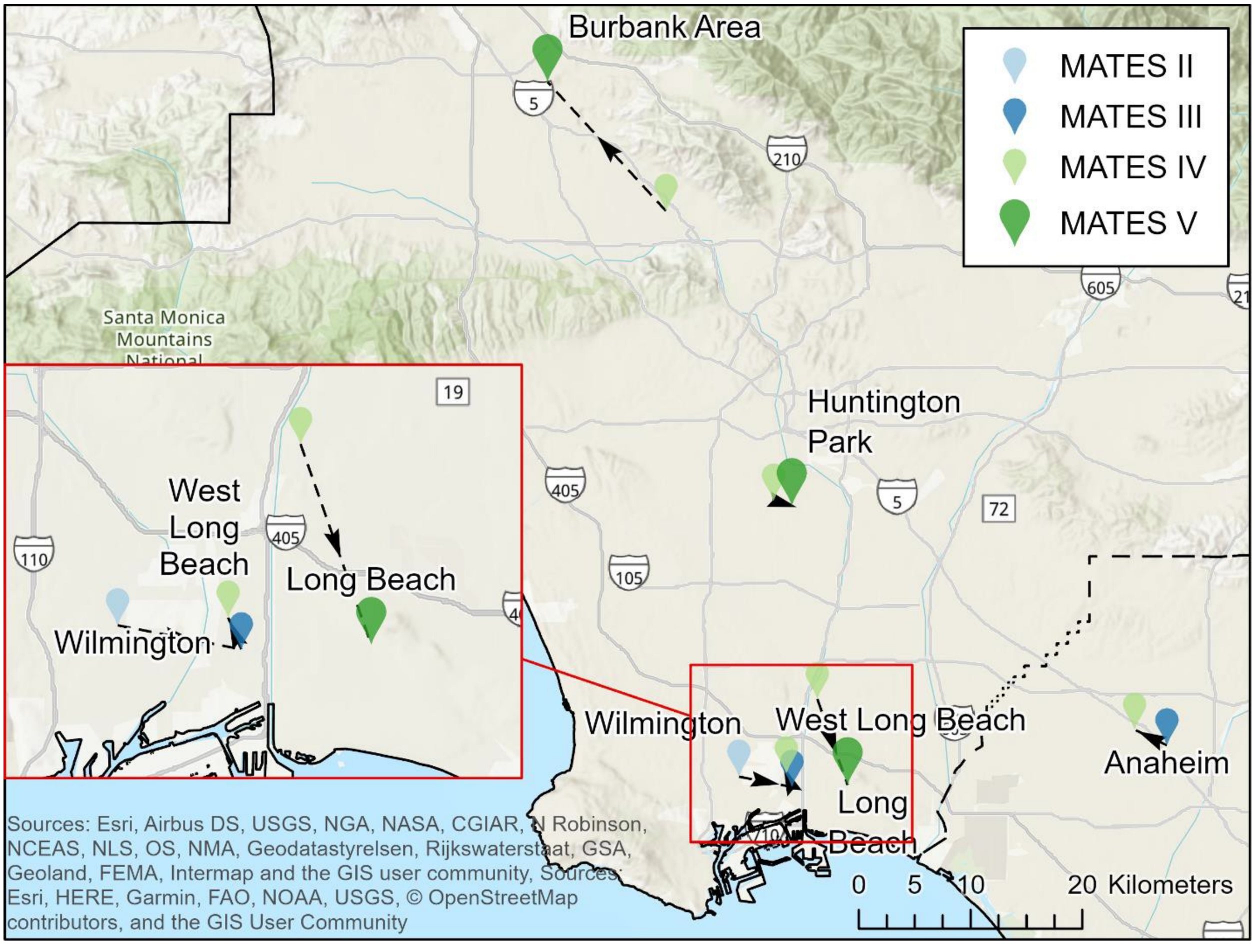
Table 2-2 MATES V Site Locations

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.

---

[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.

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.

---

[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 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.

---

[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.

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

---

[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.

    hematologic system, reproductive and development system, cardiovascular system, central nervous system, eyes, kidney, bone and teeth, immune 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]

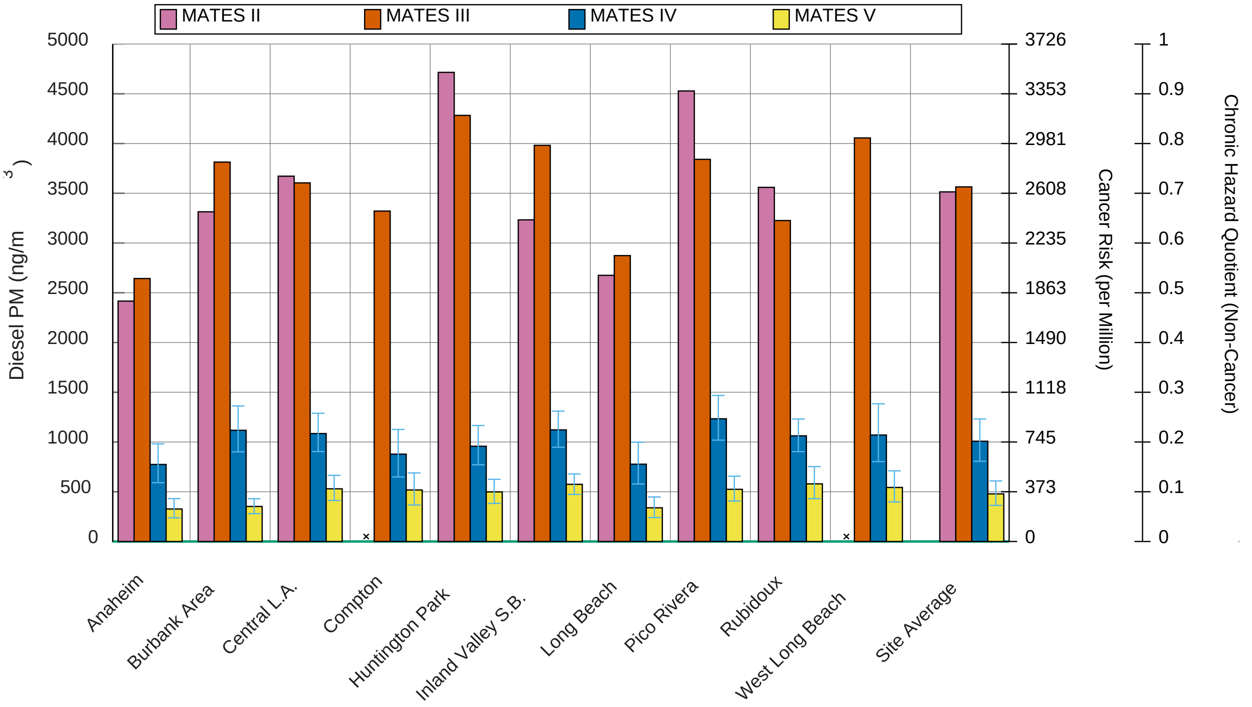


Figure 2-3 Diesel PM Concentration Estimates. "x" indicates that there is no data for a given station/MATES iteration.

---

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

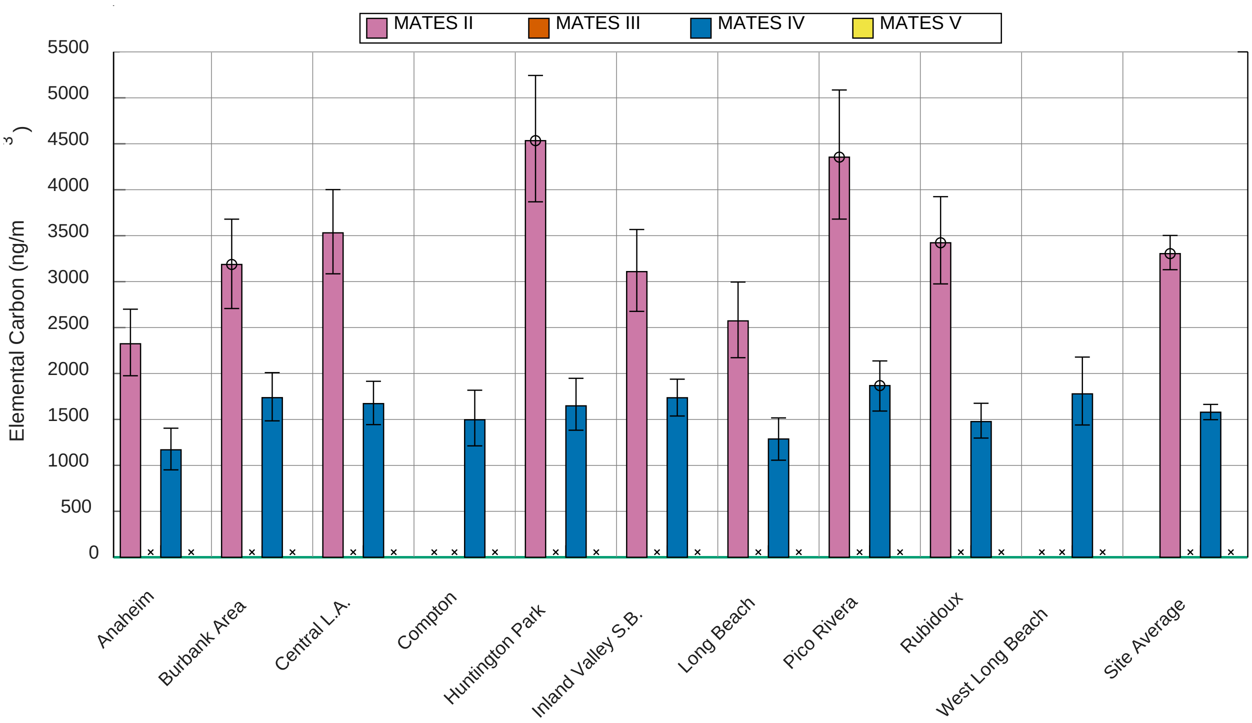


Figure 2-4 Annual Average Concentrations of Elemental Carbon in the PM10 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

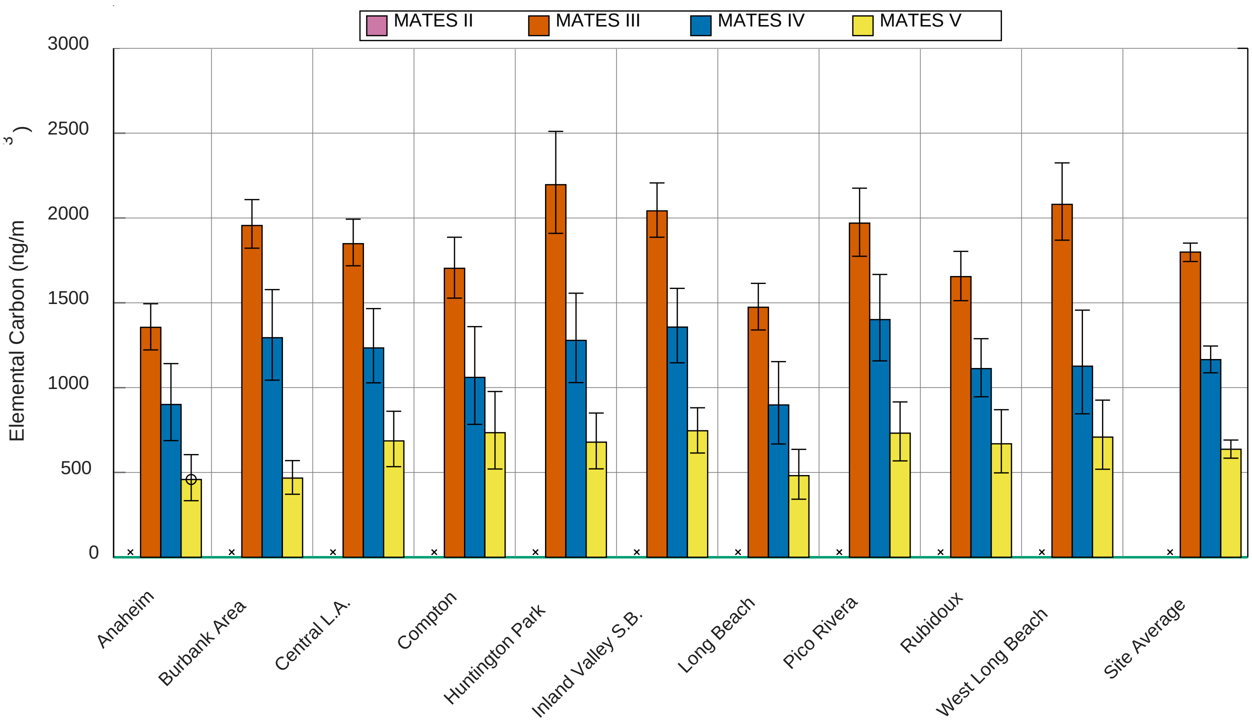


Figure 2-5 Annual Average Concentrations of Elemental Carbon in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

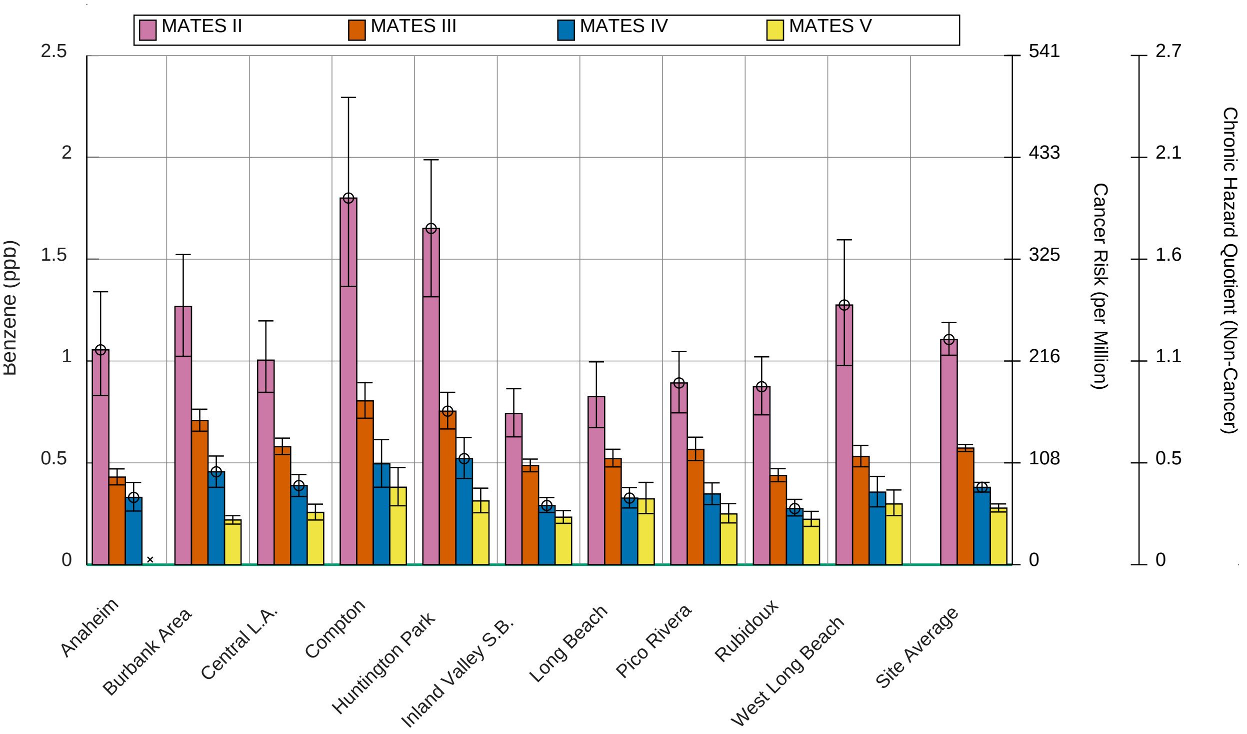


Figure 2-6 Average Concentrations of Benzene. "x" indicates that there is no data for a given station/MATES iteration. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

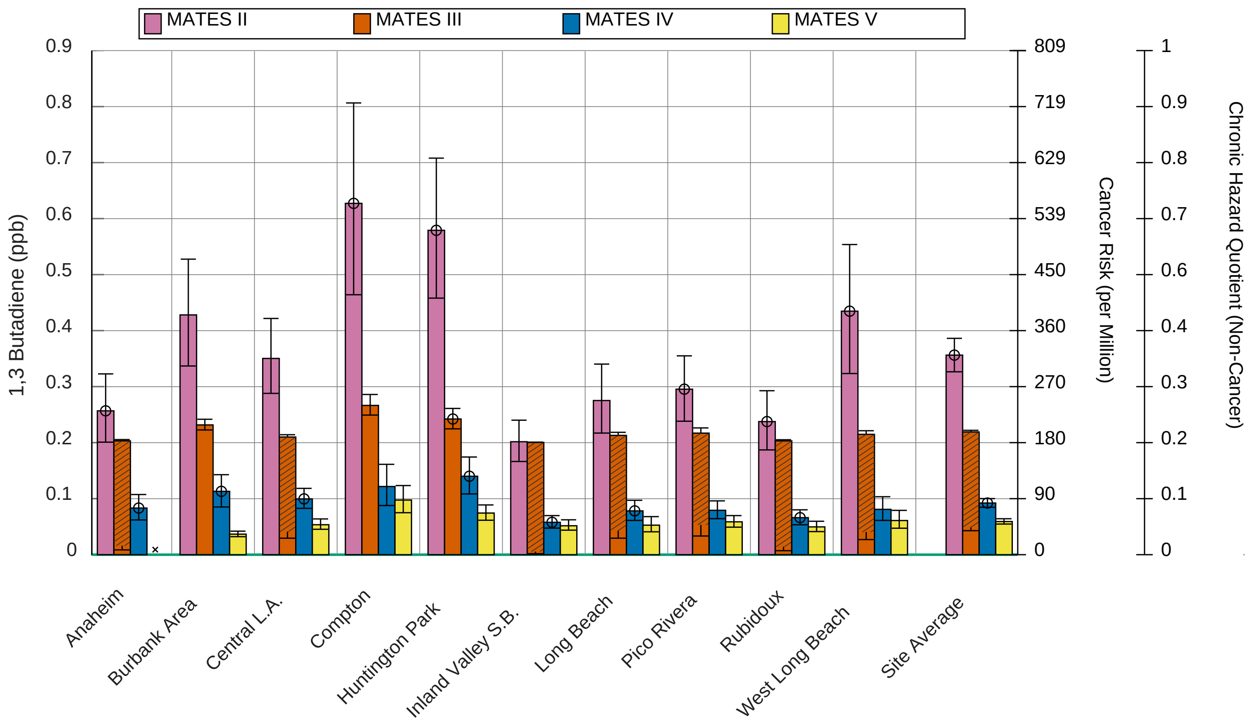


Figure 2-7 Average Concentrations of 1,3 Butadiene. The diagonal lines (shading) on some of the bars for the MATES III stations indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

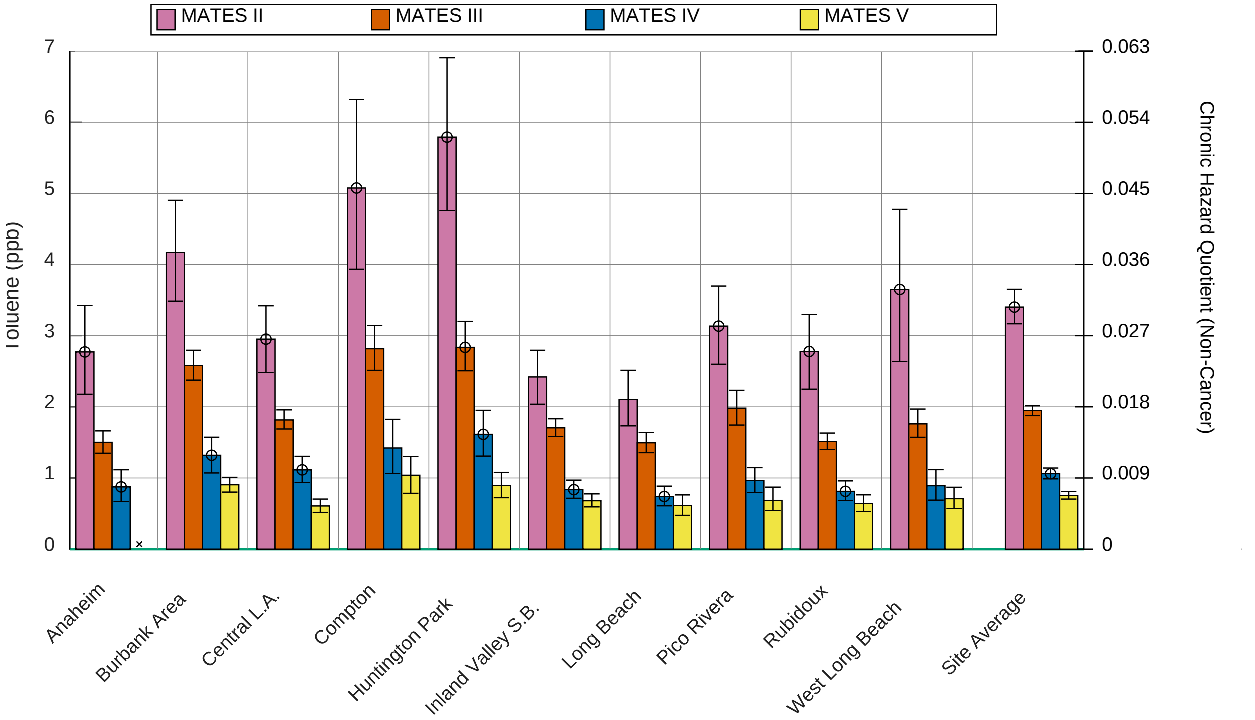


Figure 2-8 Average Concentrations of Toluene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters.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

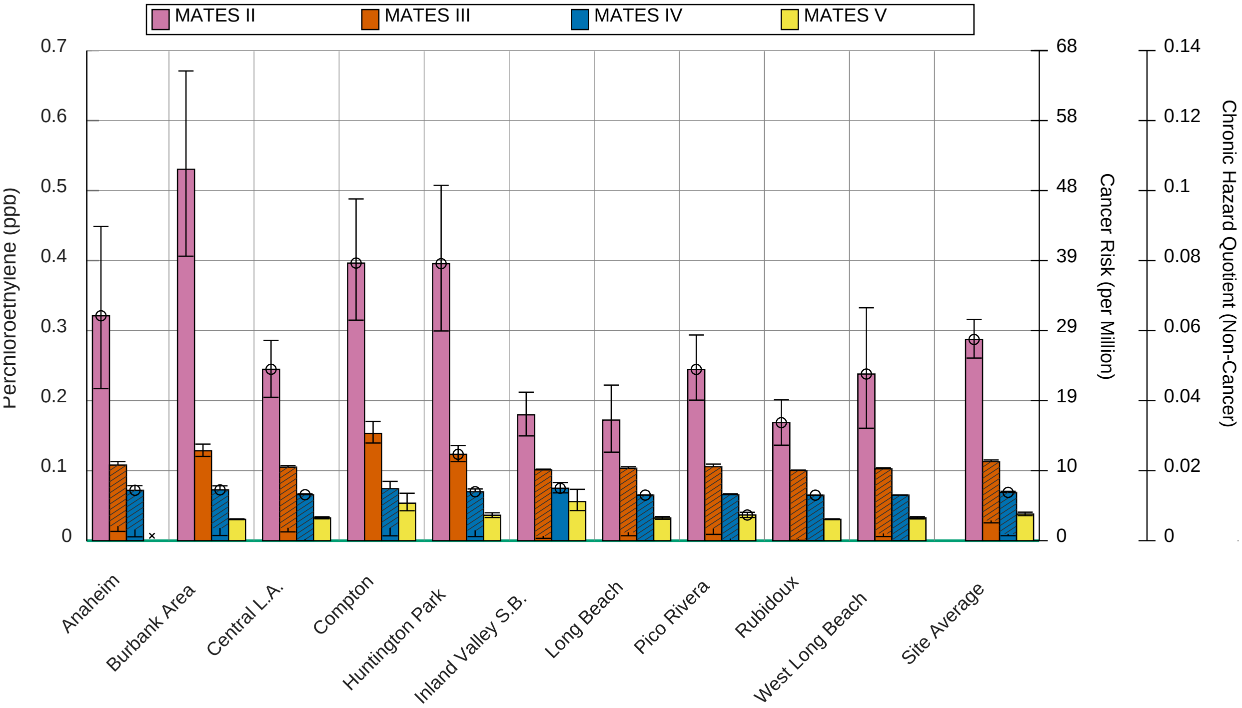


Figure 2-9 Average Concentrations of Perchloroethylene. The diagonal lines (shading) on some of the bars for the MATES III stations indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

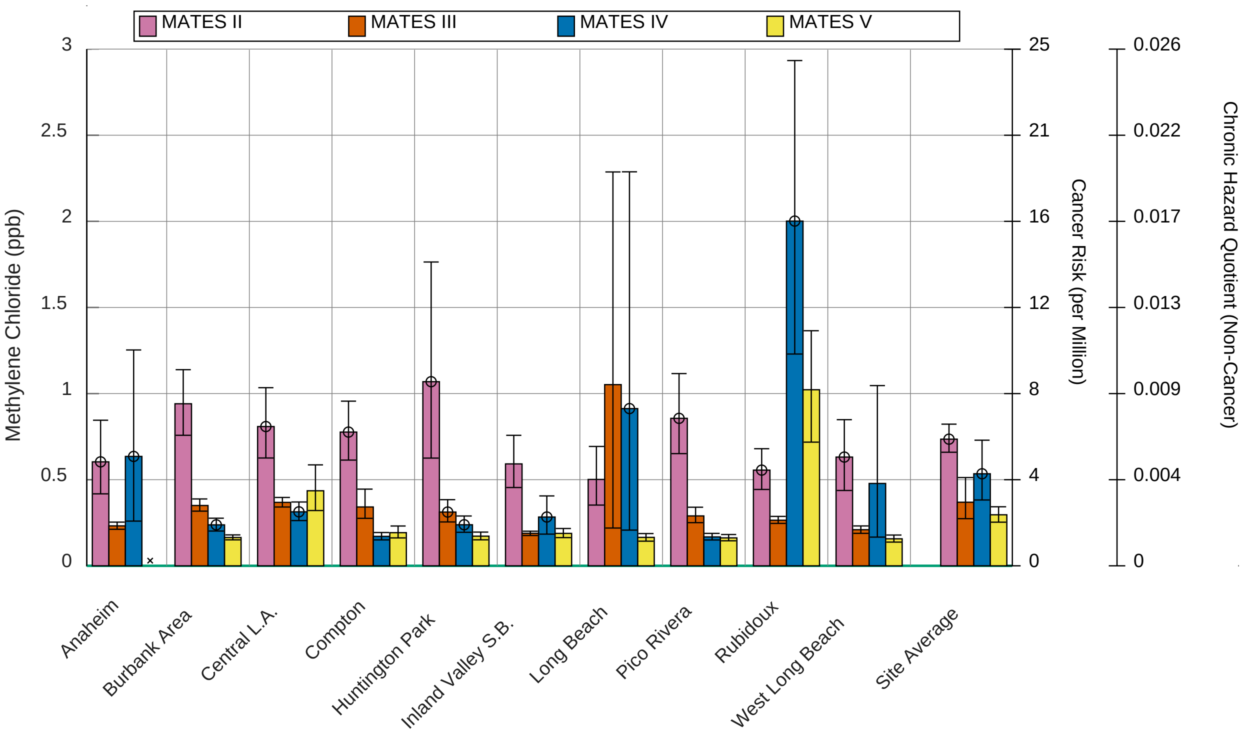


Figure 2-10 Average Concentrations of Methylene Chloride. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in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

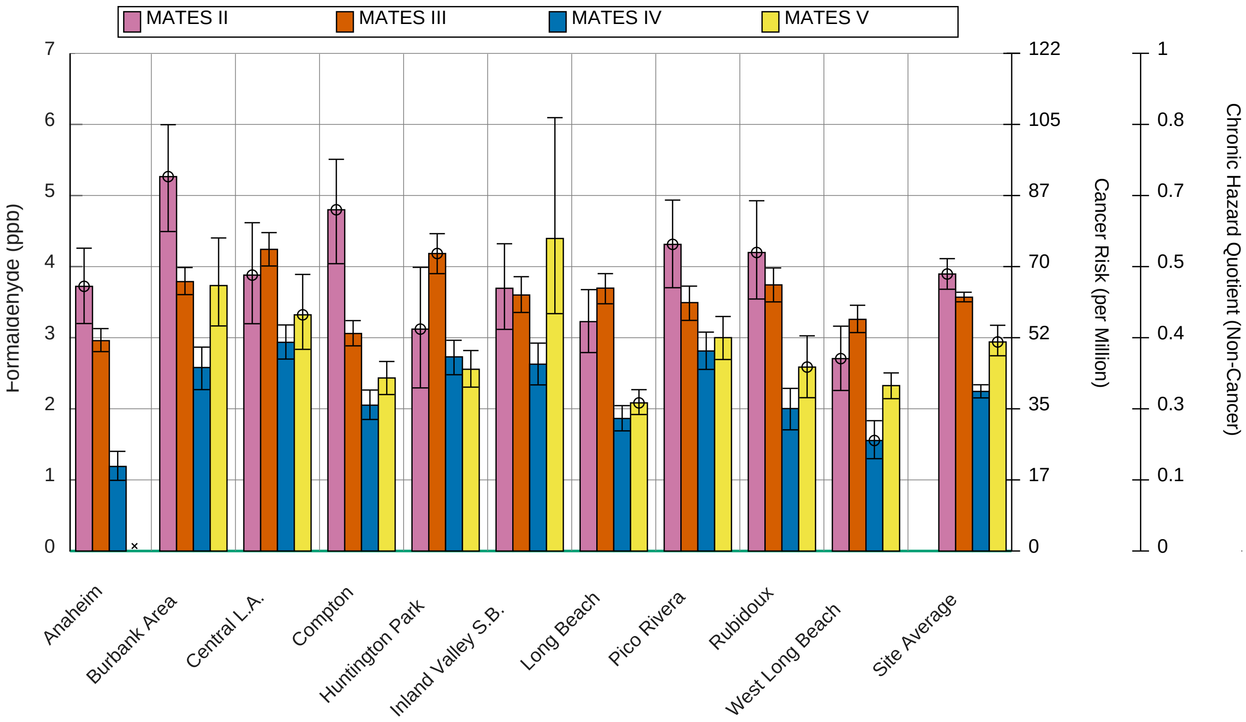


Figure 2-11 Average Concentrations of Formaldehyde. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters.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

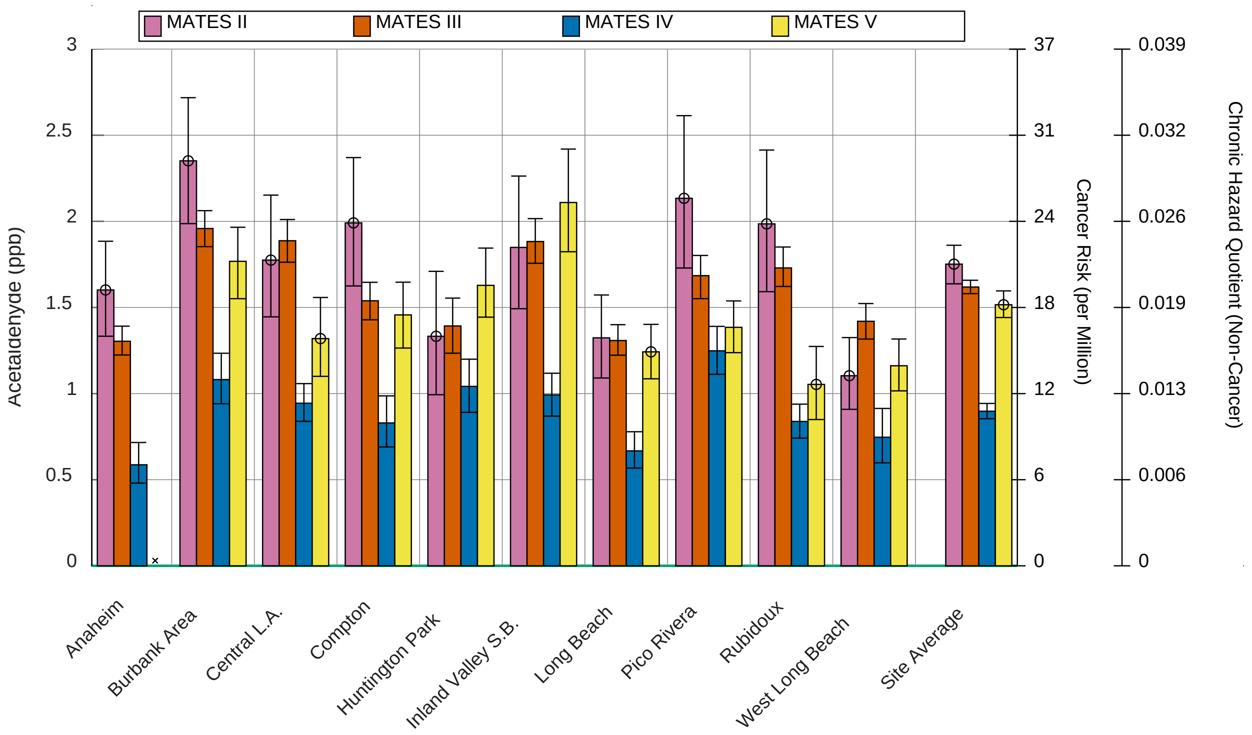


Figure 2-12. Average Concentrations of Acetaldehyde. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all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

---

[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

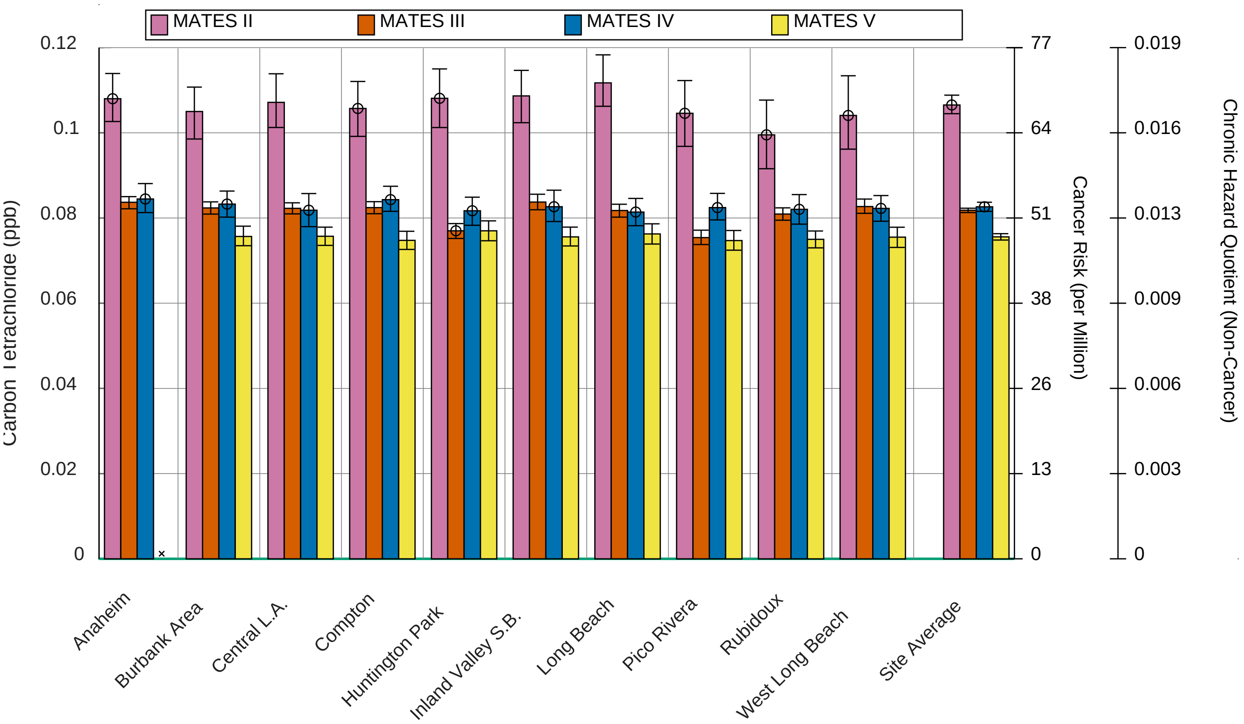


Figure 2-13 Average Concentrations of Carbon Tetrachloride. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days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

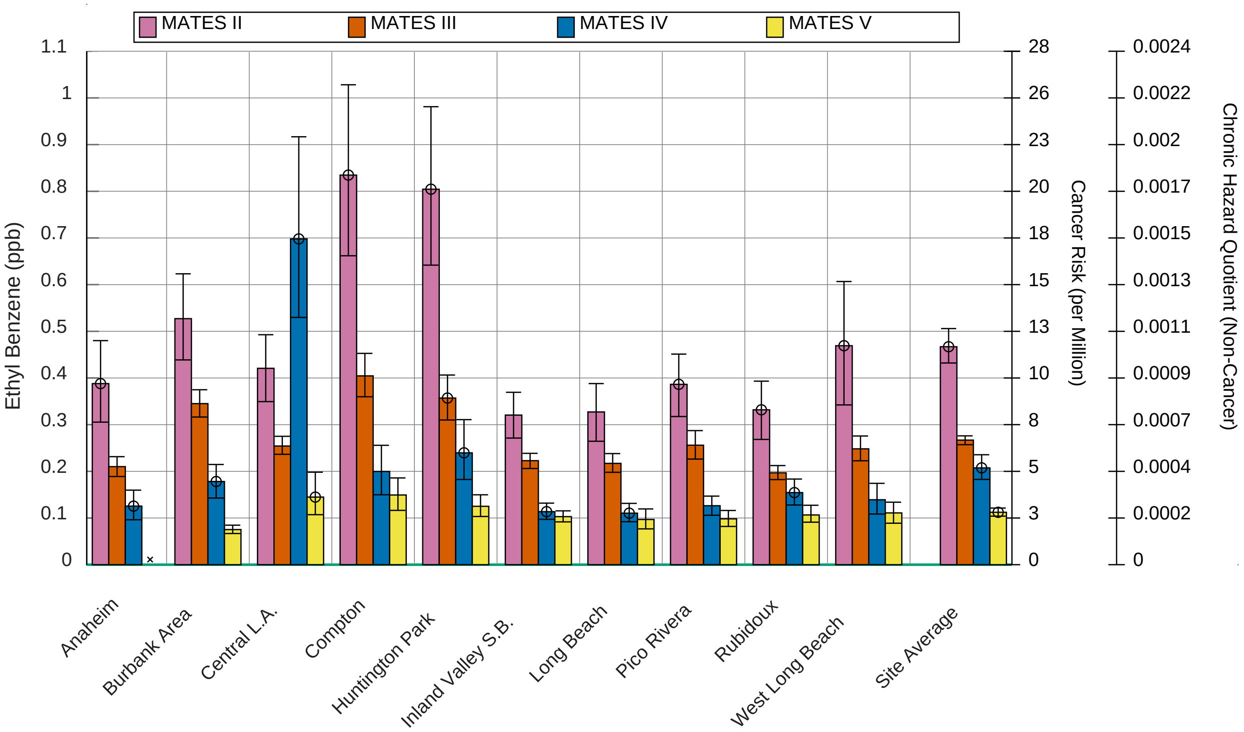


Figure 2-14 Average Concentrations of Ethyl Benzene. “x” in the place of a bar indicates that there are no data for a given station/MATES iteration. “o” at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all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

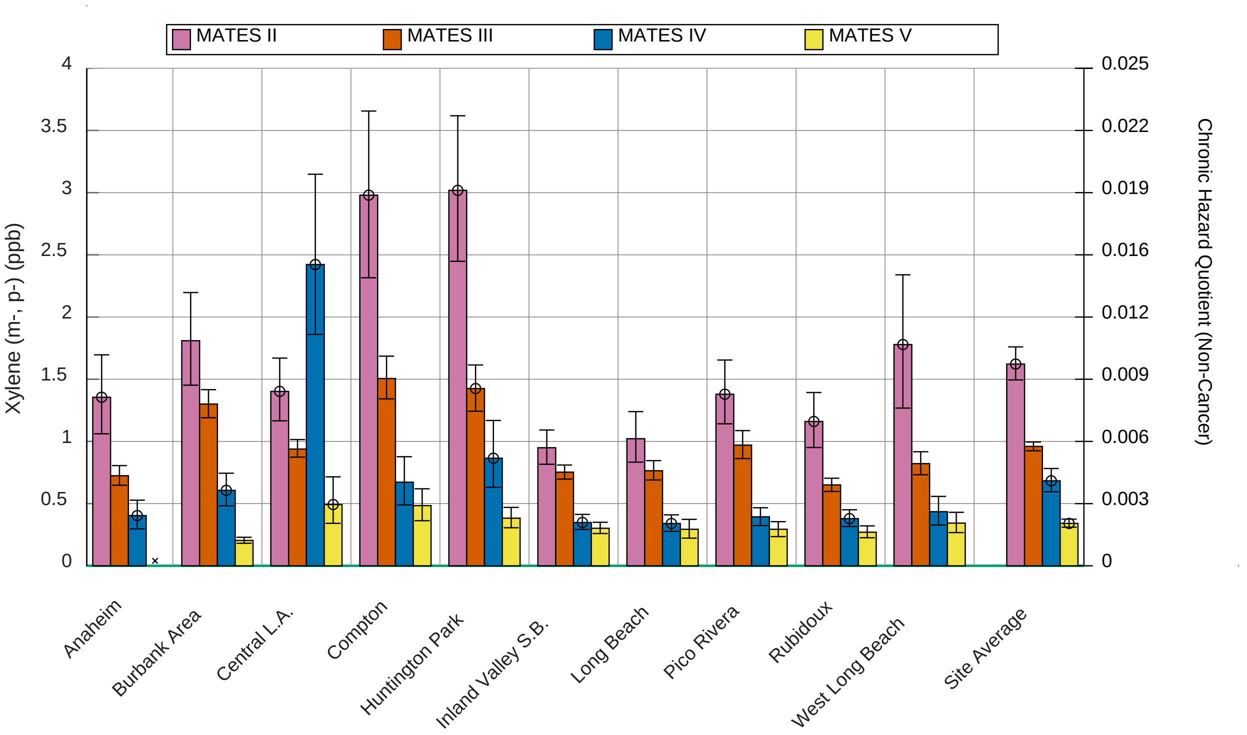


Figure 2-15 Average Concentrations of Xylene (m-, p-). "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all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

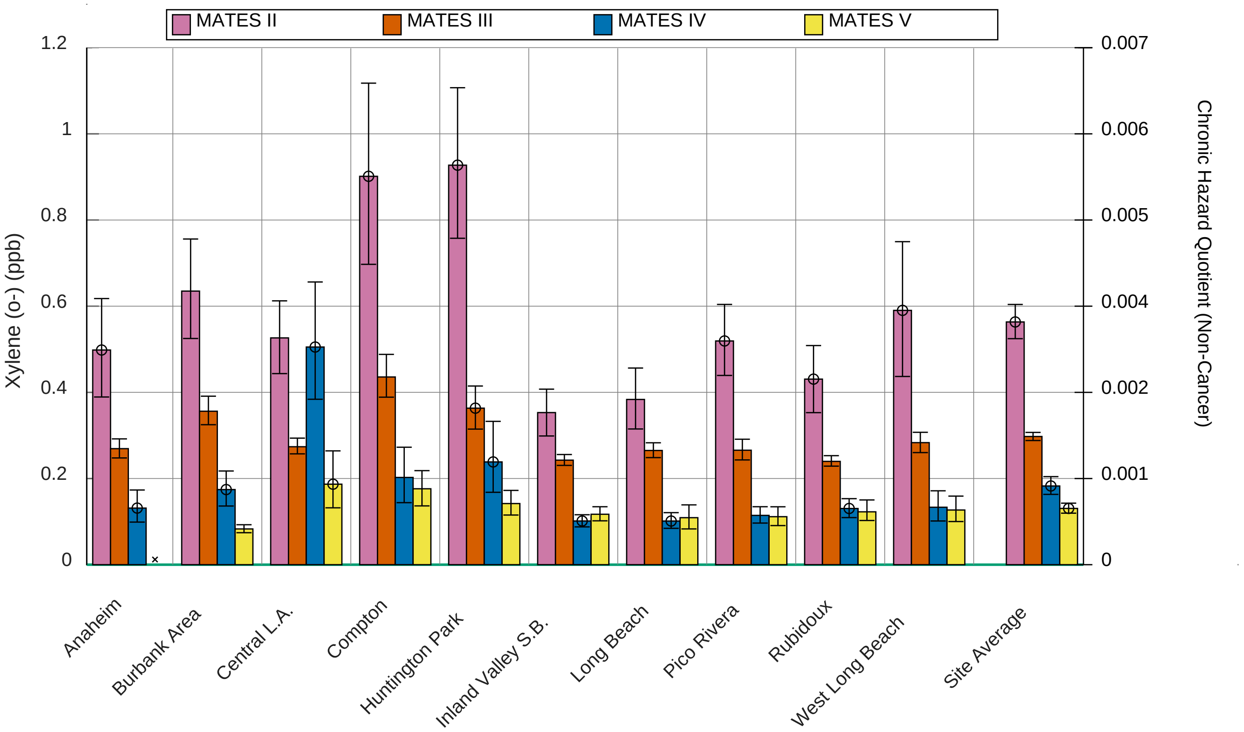


Figure 2-16 Average Concentrations of Xylene (o-). "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters.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

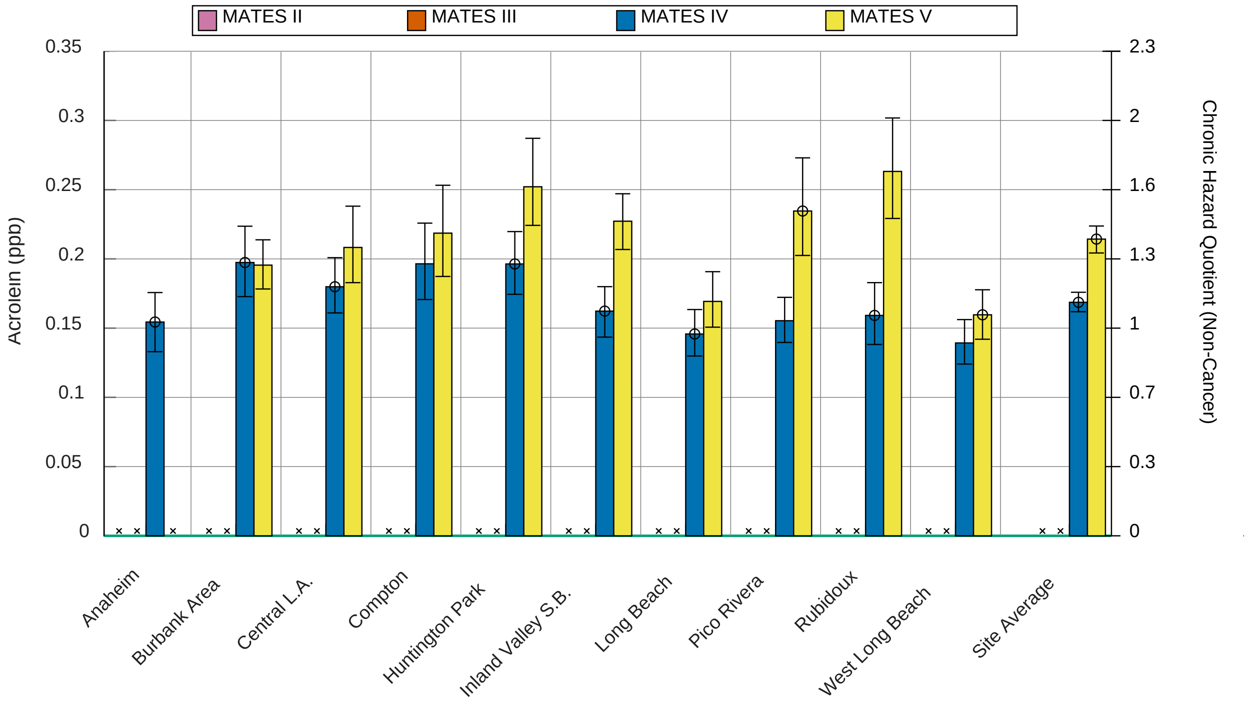


Figure 2-17 Average Concentrations of Acrolein. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters.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

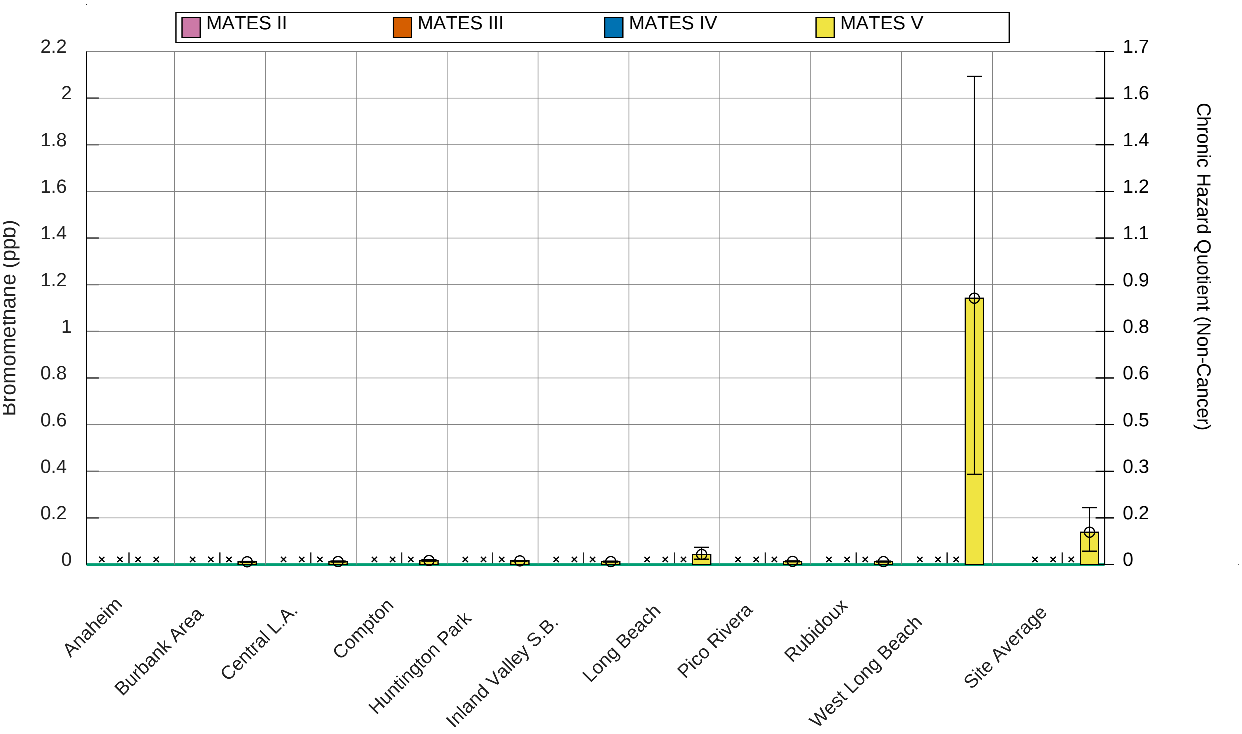


Figure 2-18 Average Concentrations of Bromomethane. "x" indicates that there is no data for a given station/MATES iteration. Note that bromomethane measurements began on August 12, 2018 and therefore, do not constitute a complete year of measurements. "o" indicates that valid measurements do not exist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

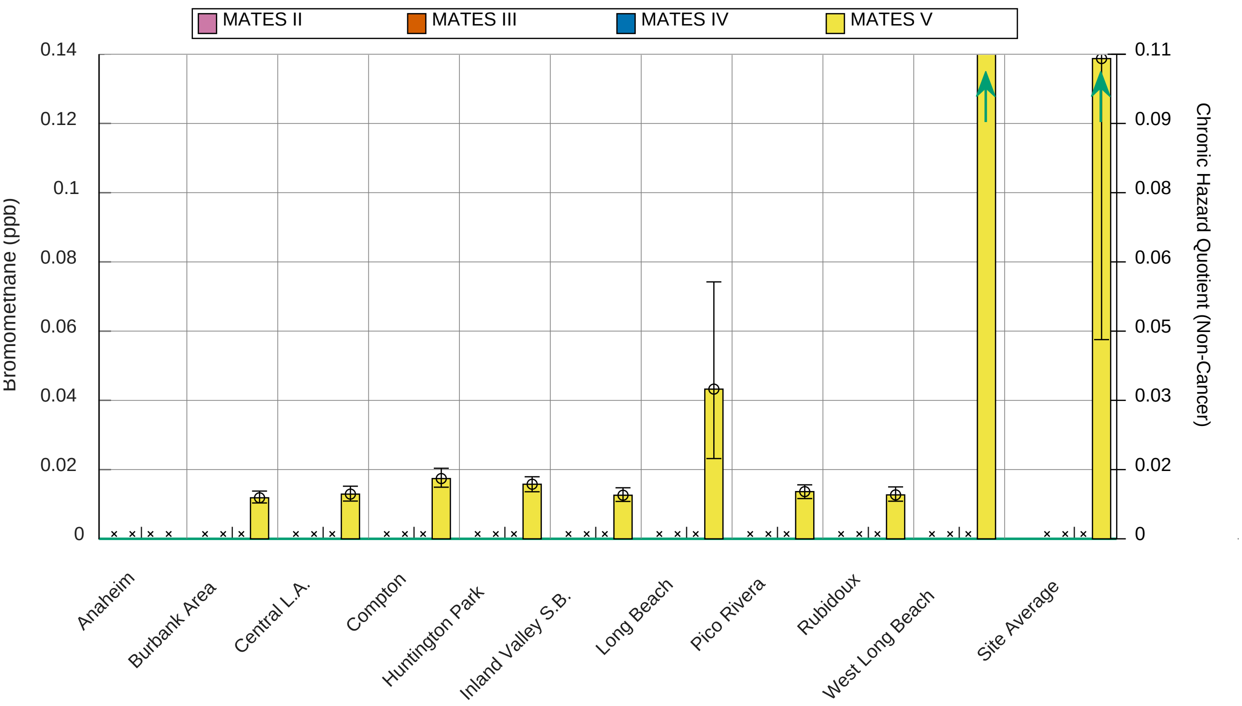


Figure 2-19 Average Concentrations of Bromomethane. "x" indicates that there is no data for a given station/MATES iteration. Note that bromomethane measurements began on August 12, 2018 and therefore, do not constitute a complete year of measurements. "o" indicates that valid measurements do not exist 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.

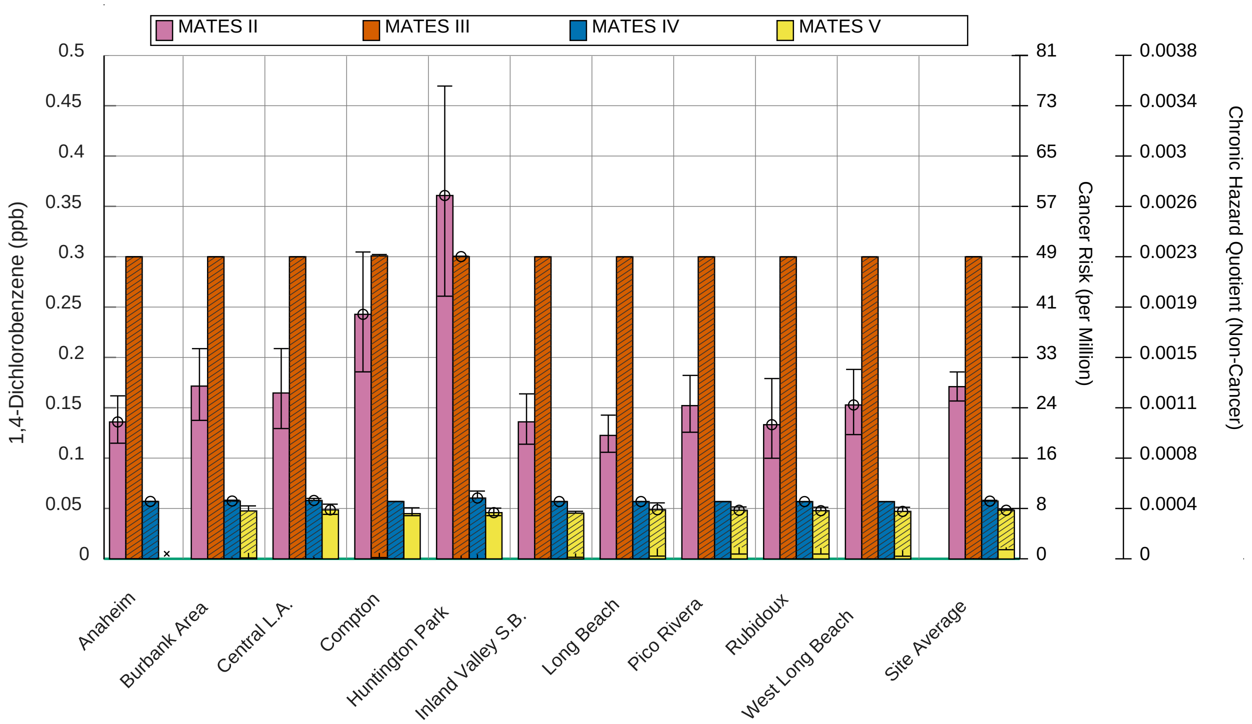


Figure 2-20 Average Concentrations of 1,4-Dichlorobenzene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements 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.

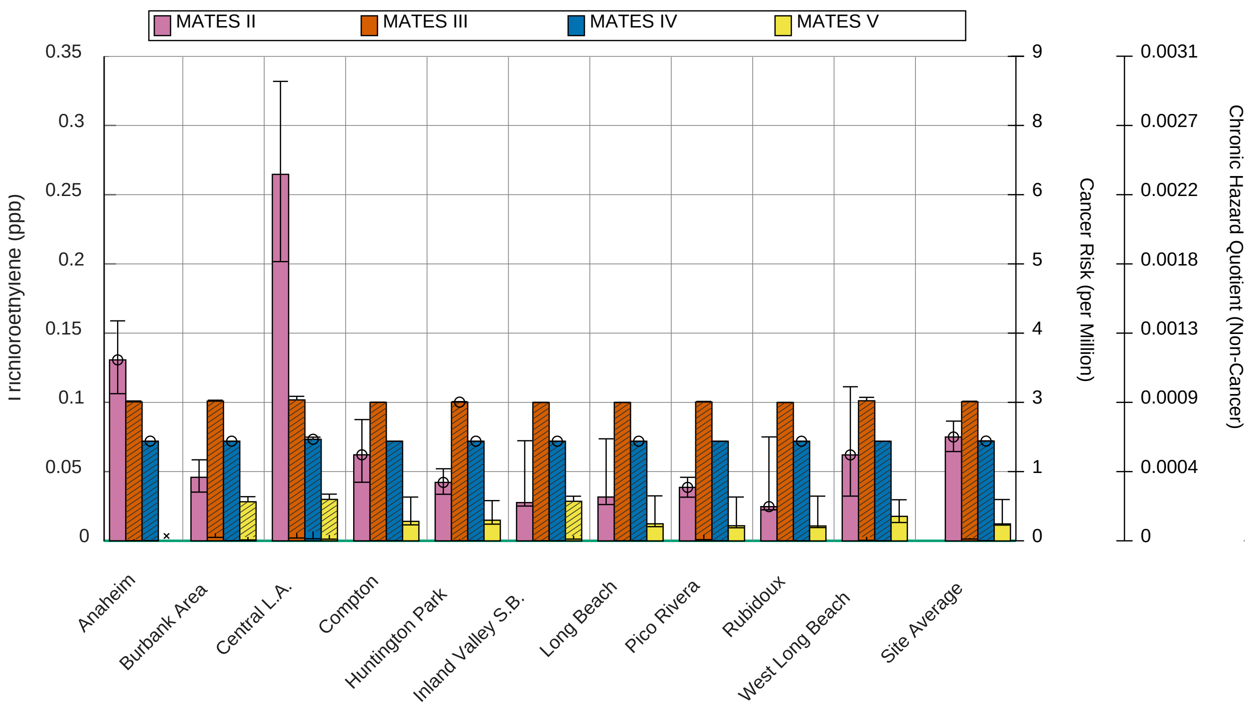


Figure 2-21 Average Concentrations of Trichloroethylene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below 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.

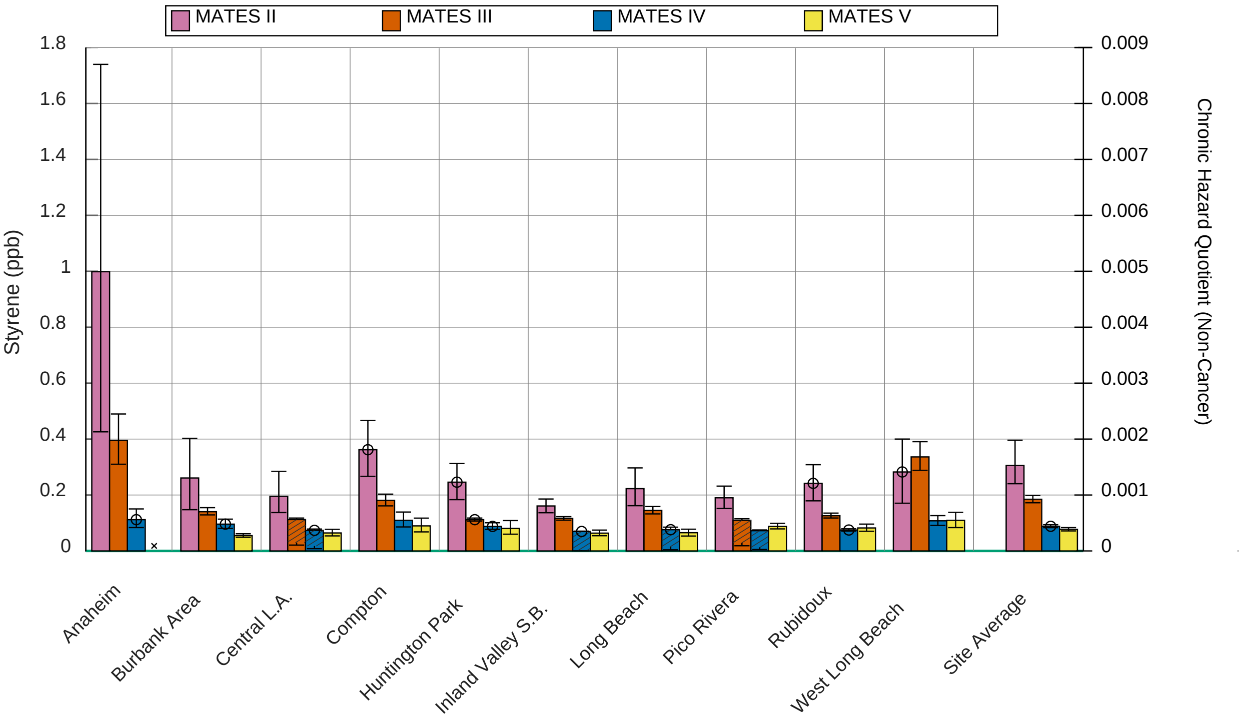


Figure 2-22 Average Concentrations of Styrene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the MDL. 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.

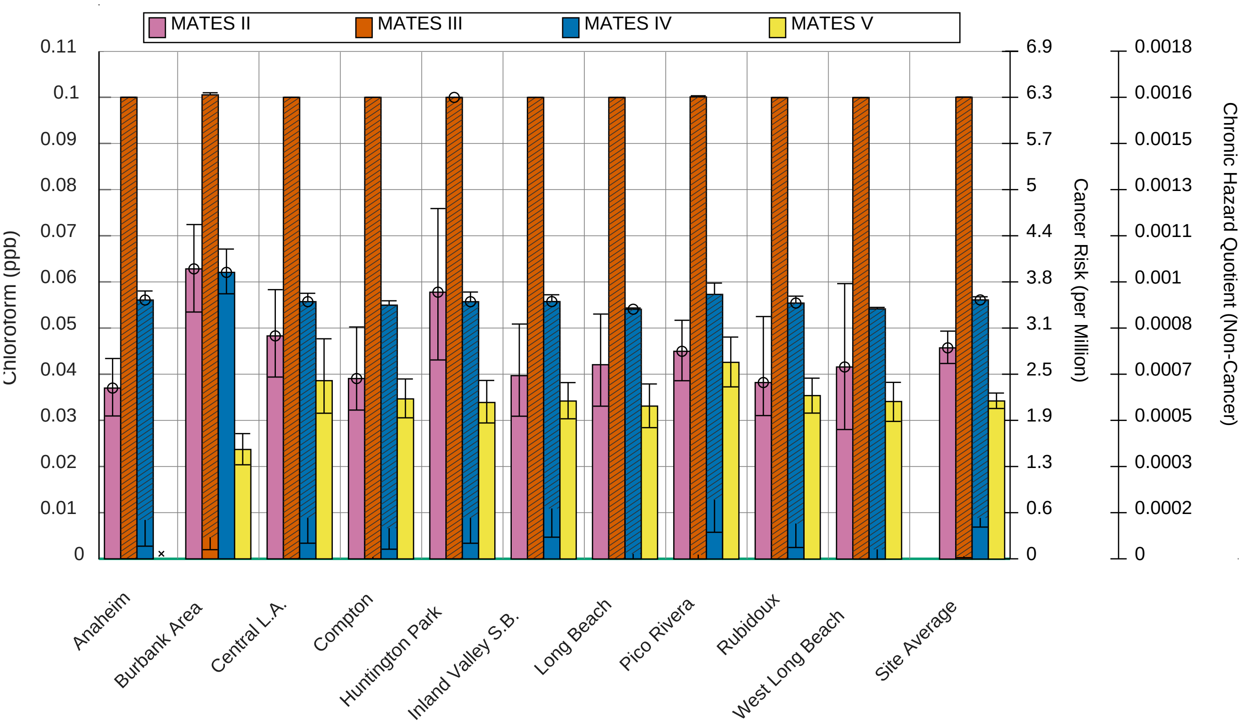


Figure 2-23 Average Concentrations of Chloroform. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the 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.

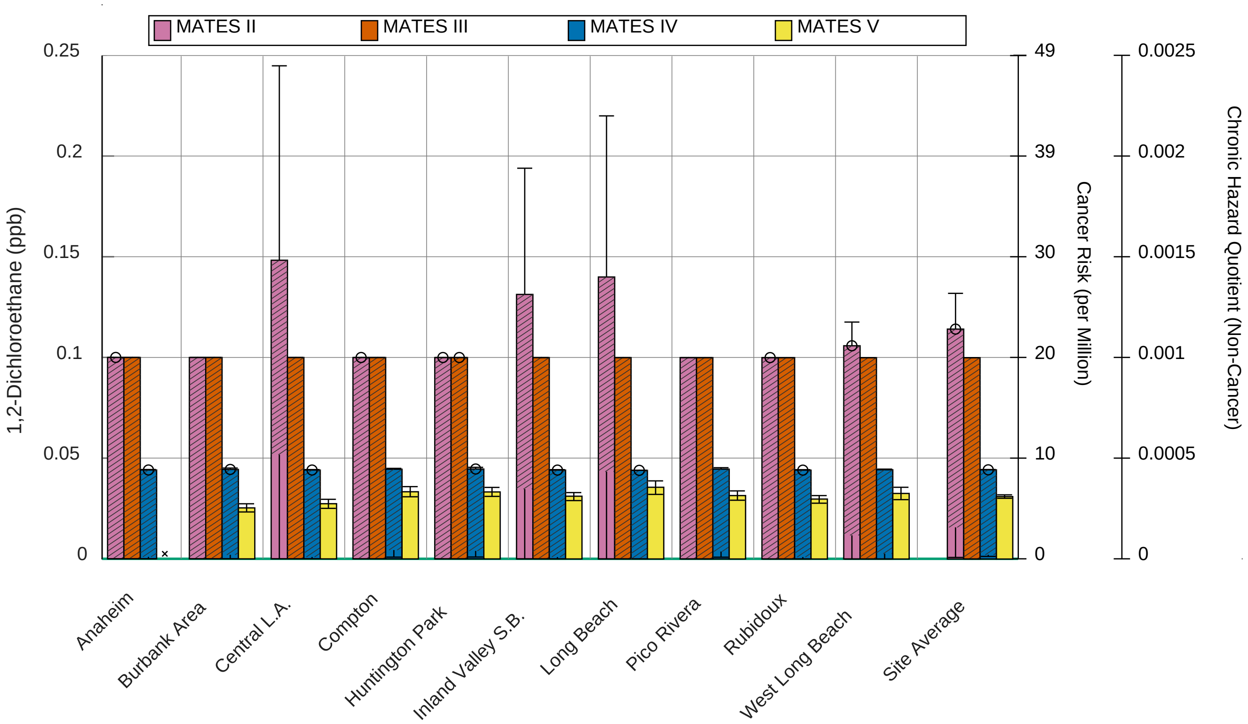


Figure 2-24 Average Concentrations of 1,2-Dichloroethane. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements 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.

---

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

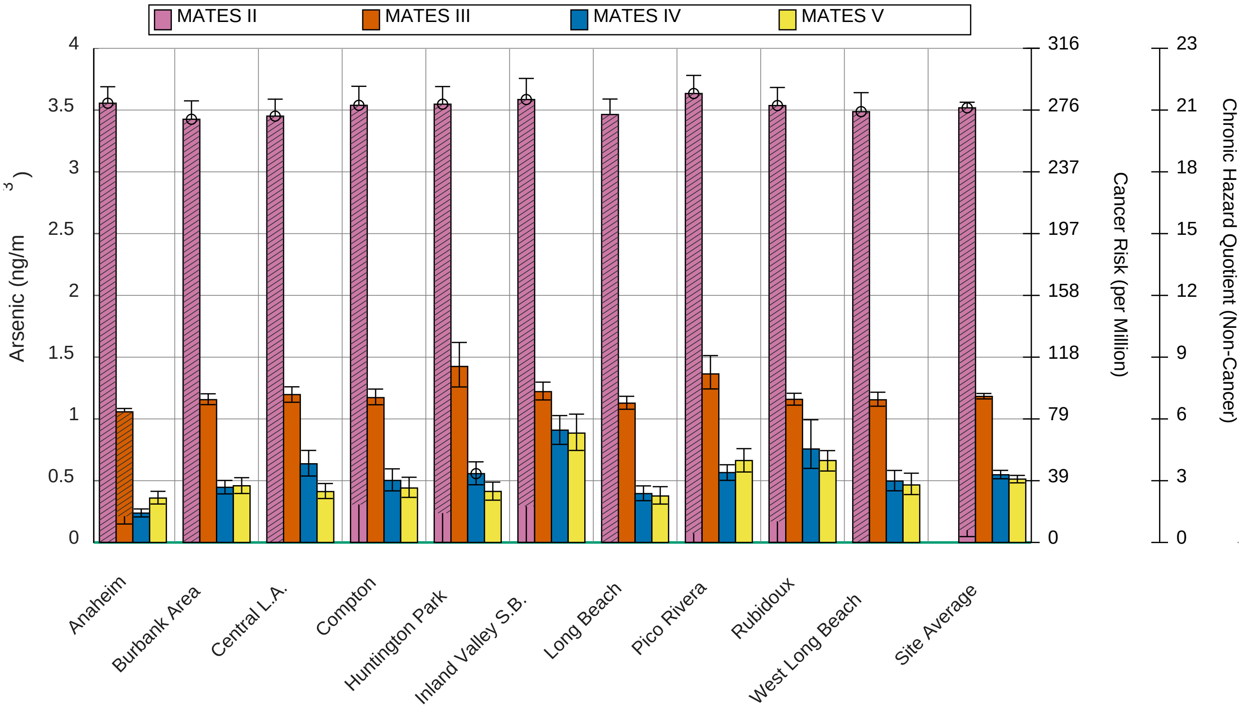


Figure 2-25 Average Concentrations of Arsenic in Total Suspended Particulate (TSP). The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

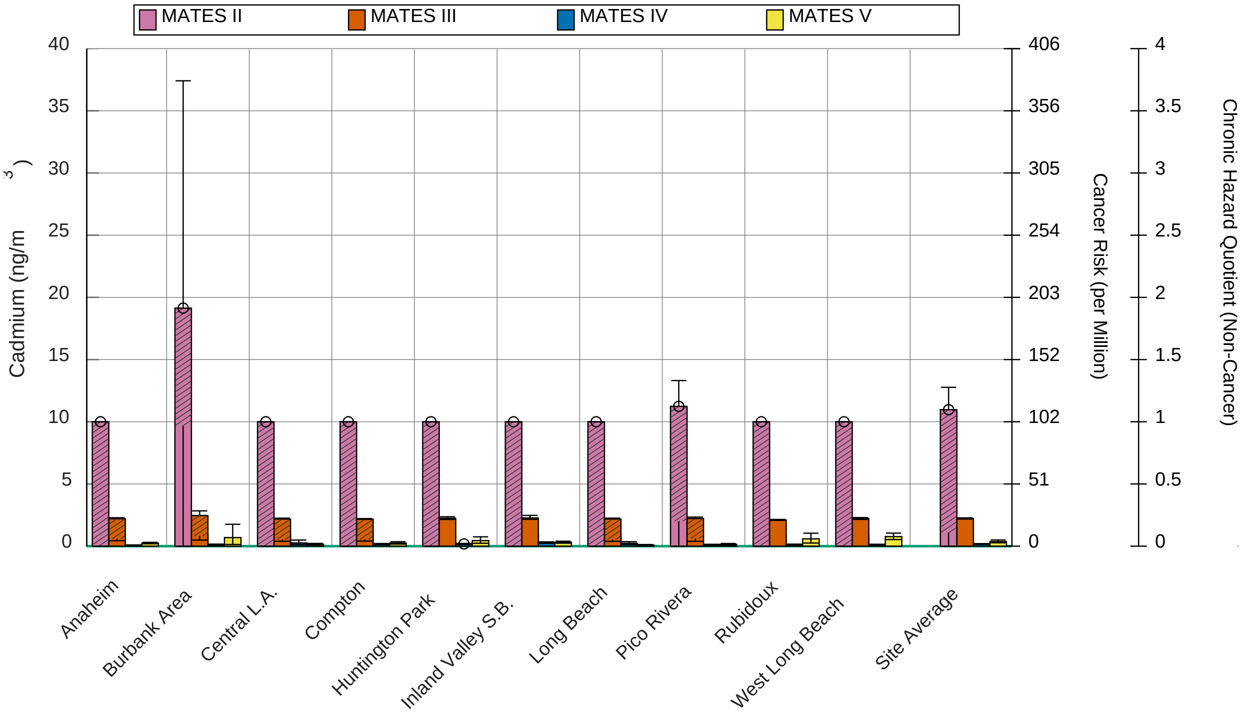


Figure 2-26 Average Concentrations of Cadmium in Total Suspended Particulate (TSP). The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

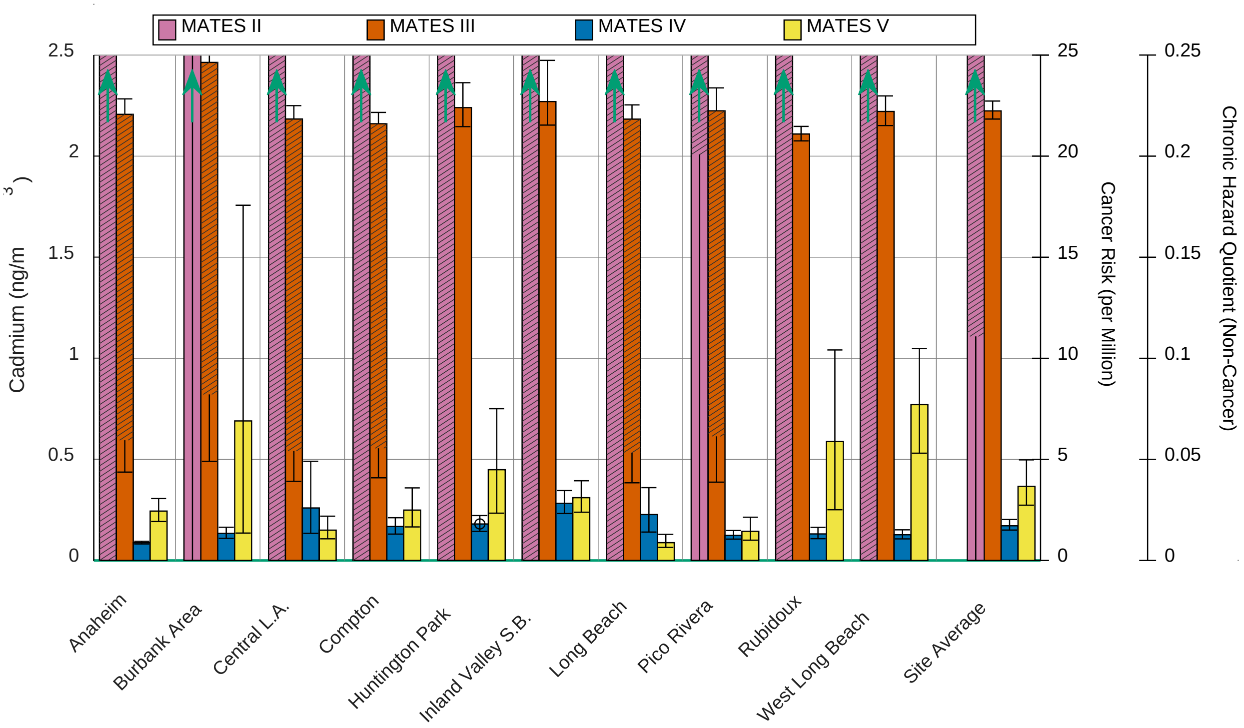


Figure 2-27 Average Concentrations of Cadmium in Total Suspended Particulate (TSP). The upward arrows indicate that the data extends above the y-axis shown. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (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.

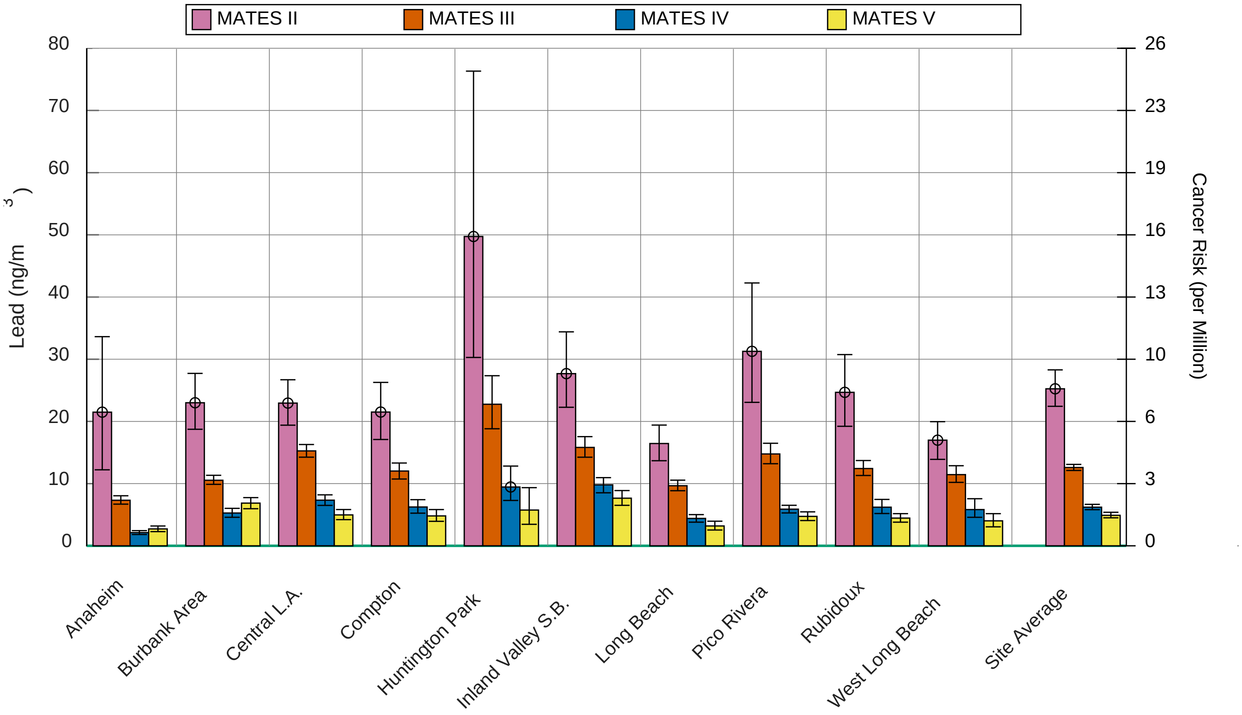


Figure 2-28 Average Concentrations of TSP Lead. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

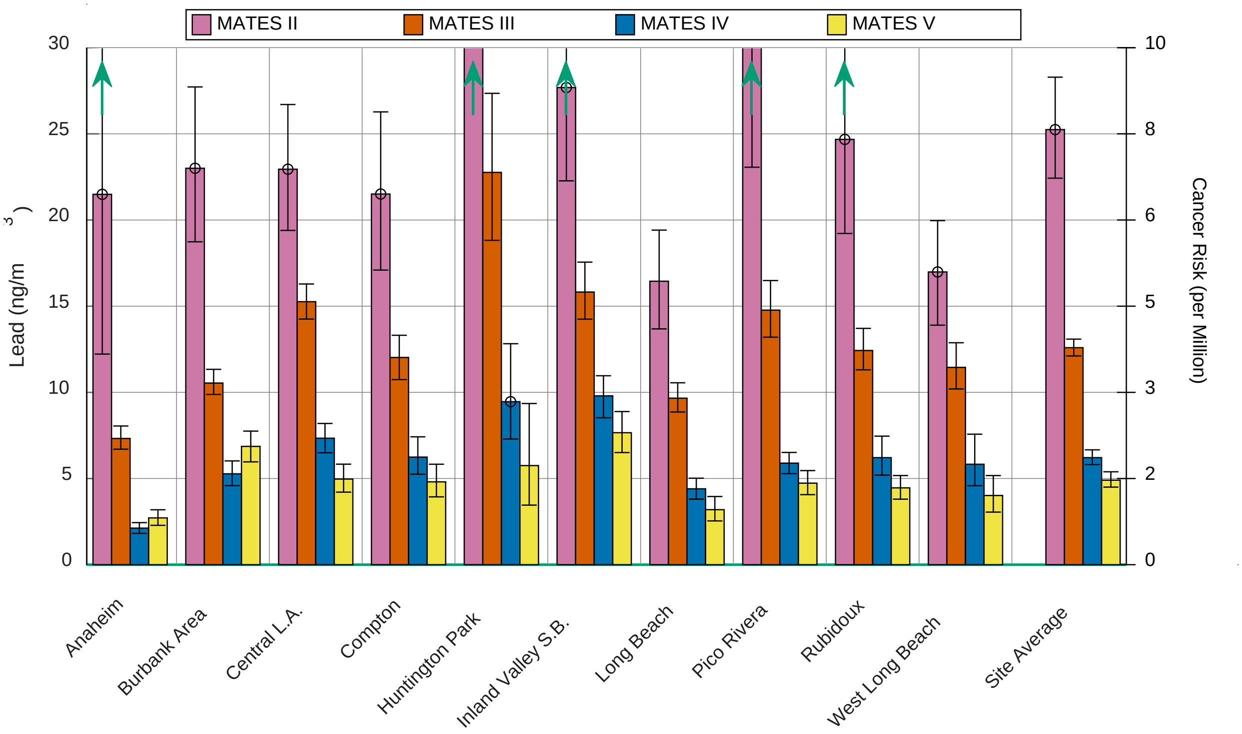


Figure 2-29 Average Concentrations of TSP Lead. The upward arrows indicate that the data extends above the y-axis shown. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

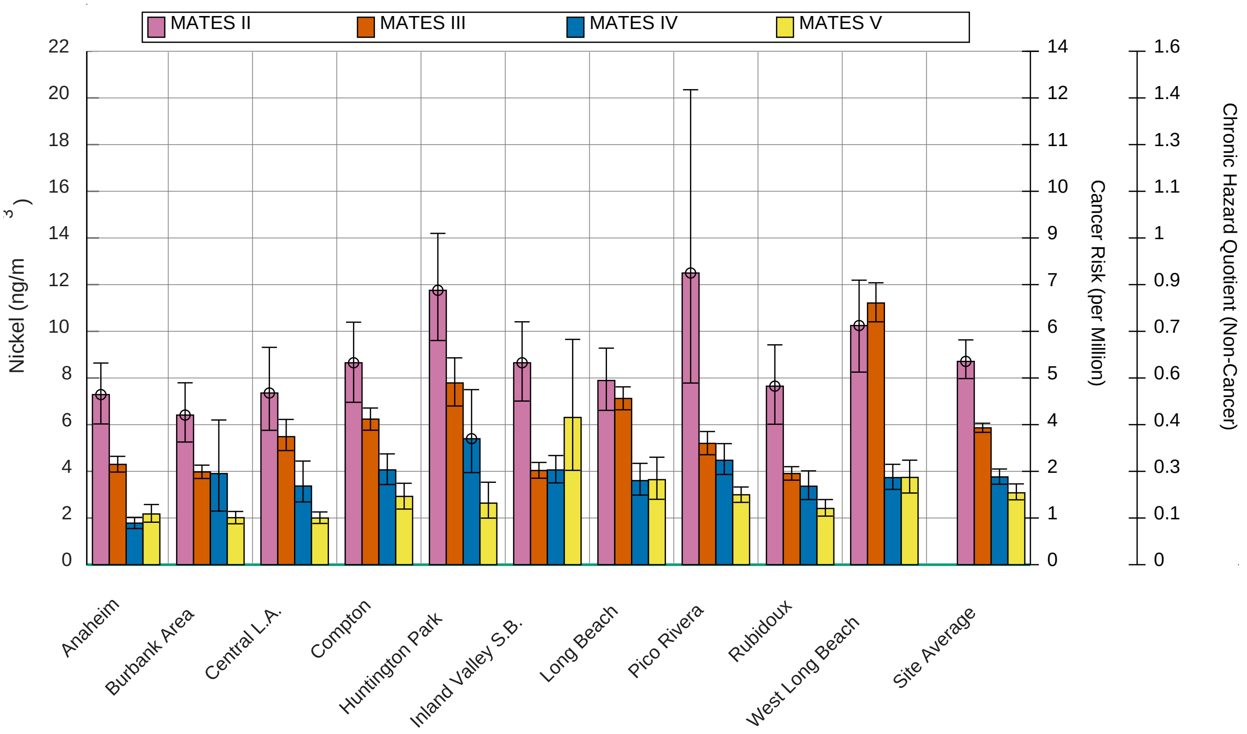


Figure 2-30 Average Concentrations of TSP Nickel. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

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.

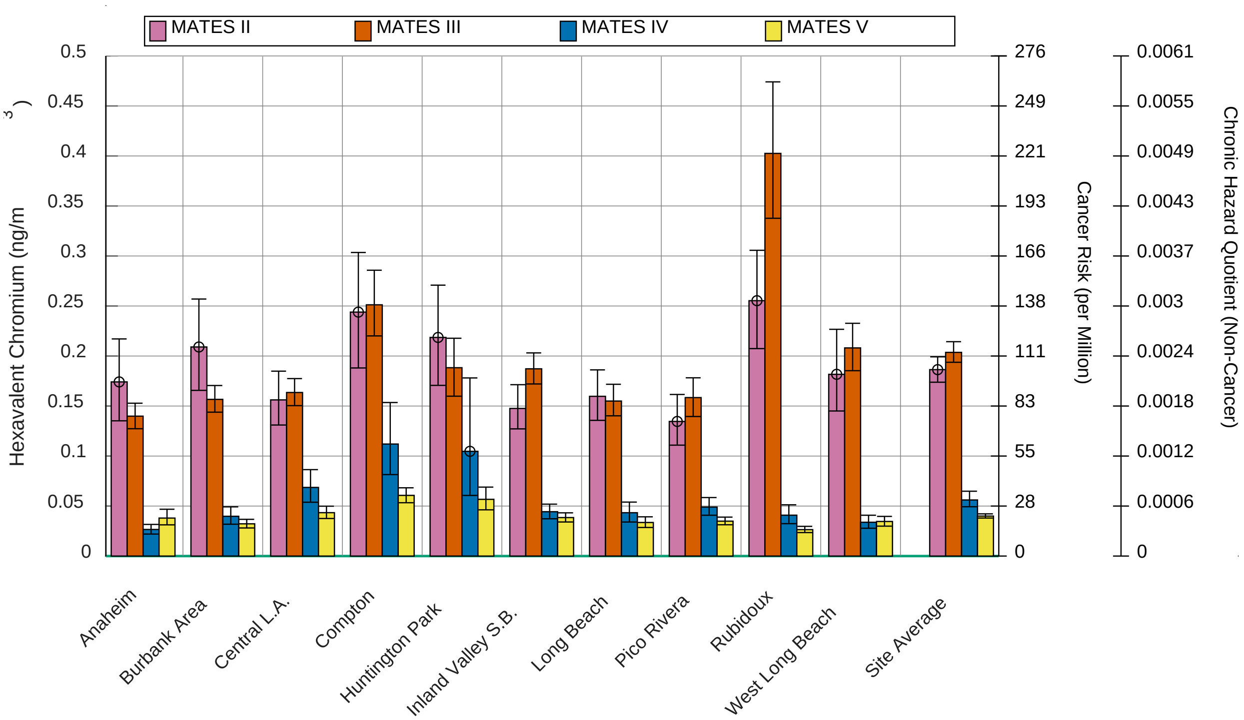


Figure 2-31 Average Concentrations of TSP Hexavalent Chromium. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

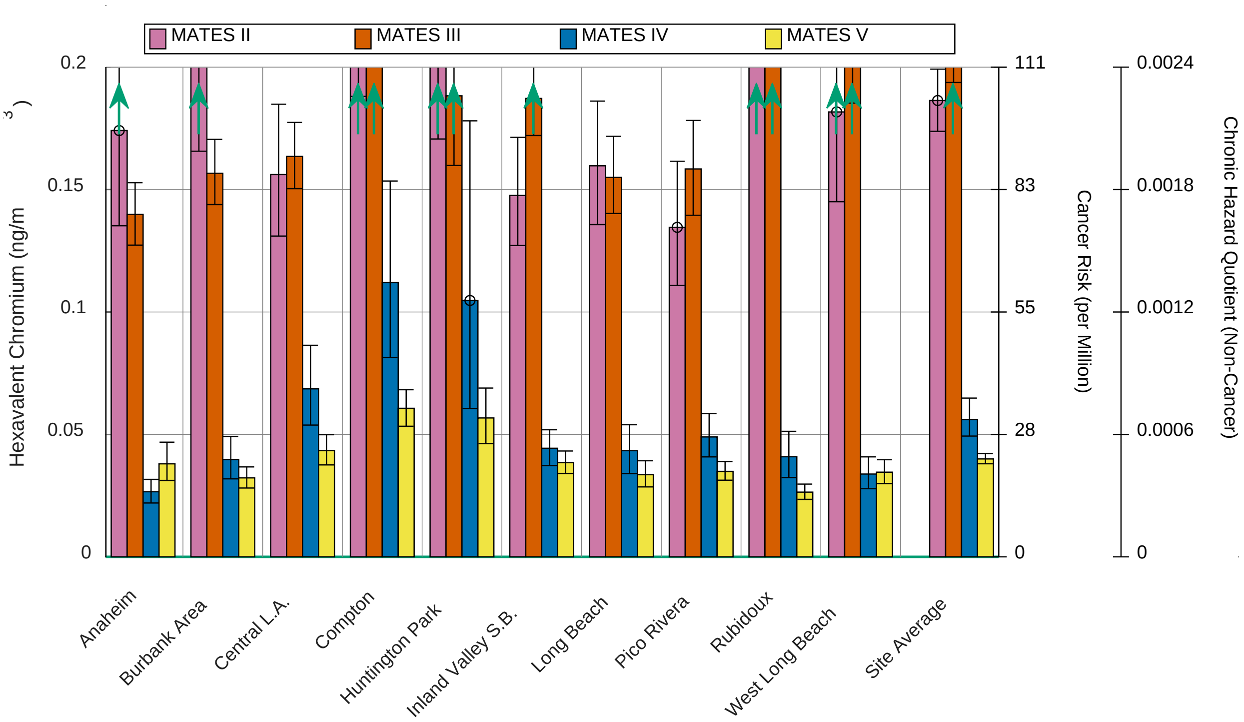


Figure 2-32 Average Concentrations of TSP Hexavalent Chromium. The upward arrows indicate that the data extends above the y-axis shown. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

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.

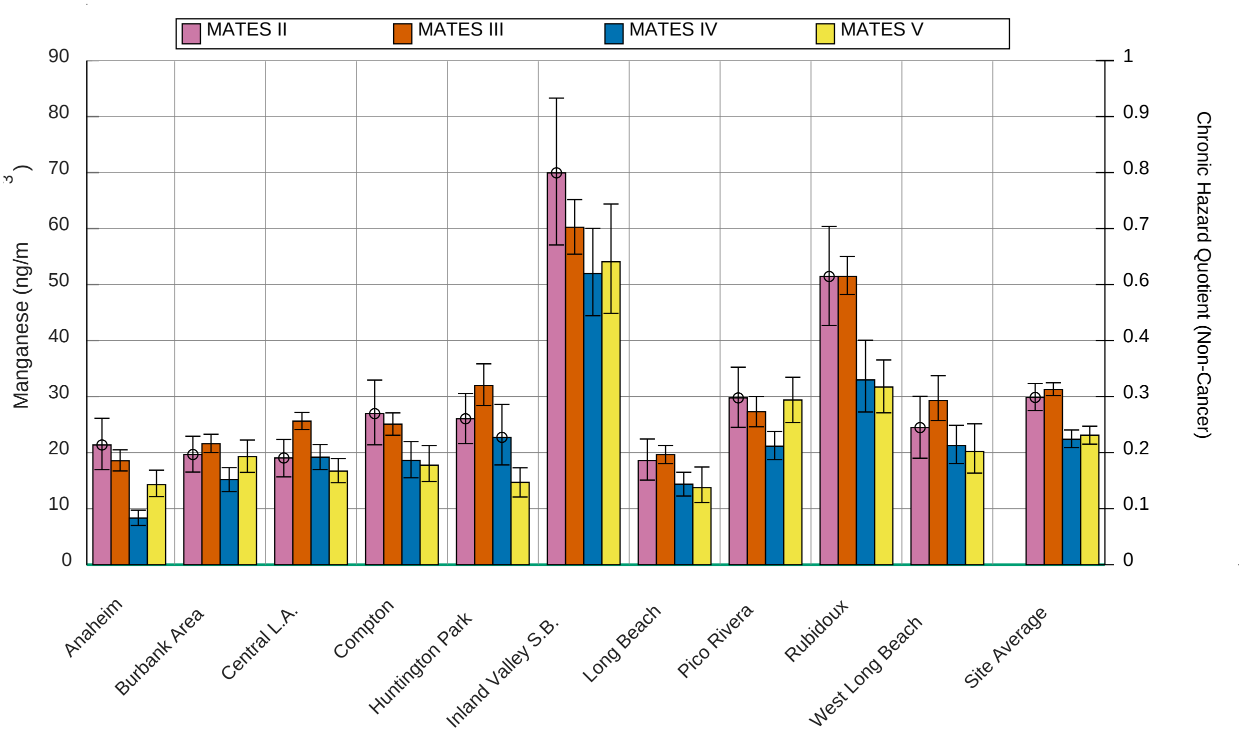


Figure 2-33 Average Concentrations of TSP Manganese. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

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.

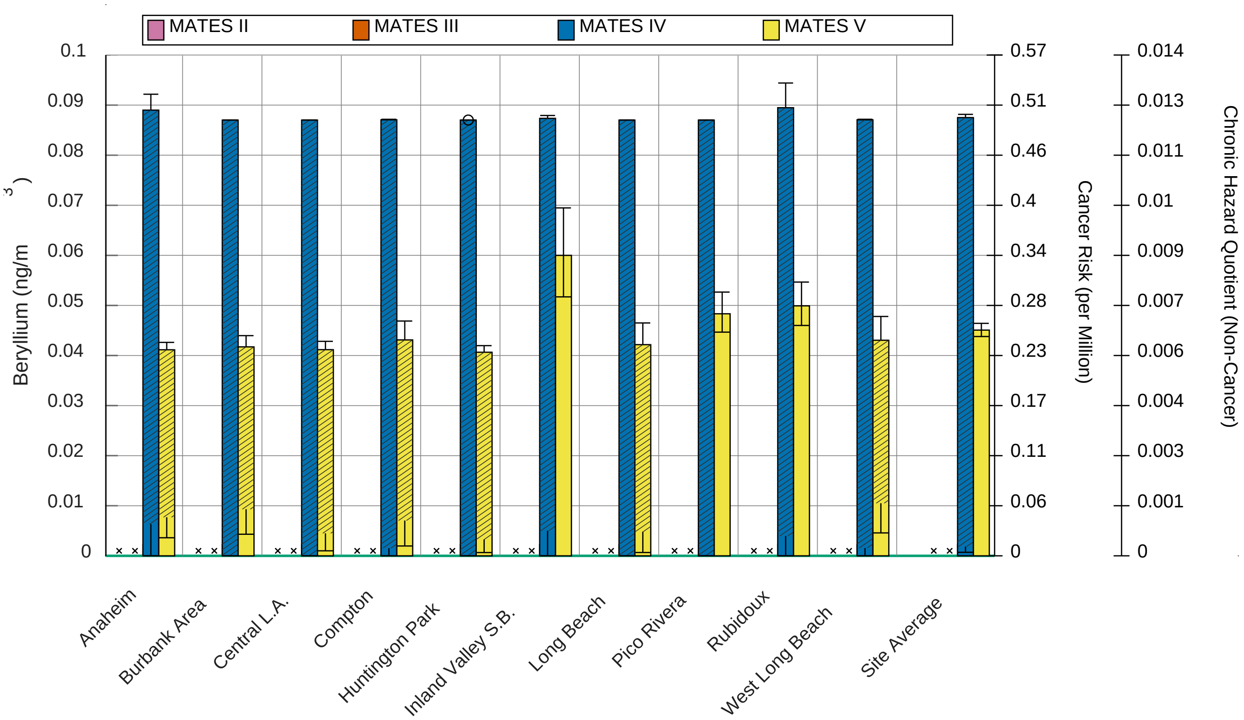


Figure 2-34 Average Concentrations of Beryllium. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the 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.

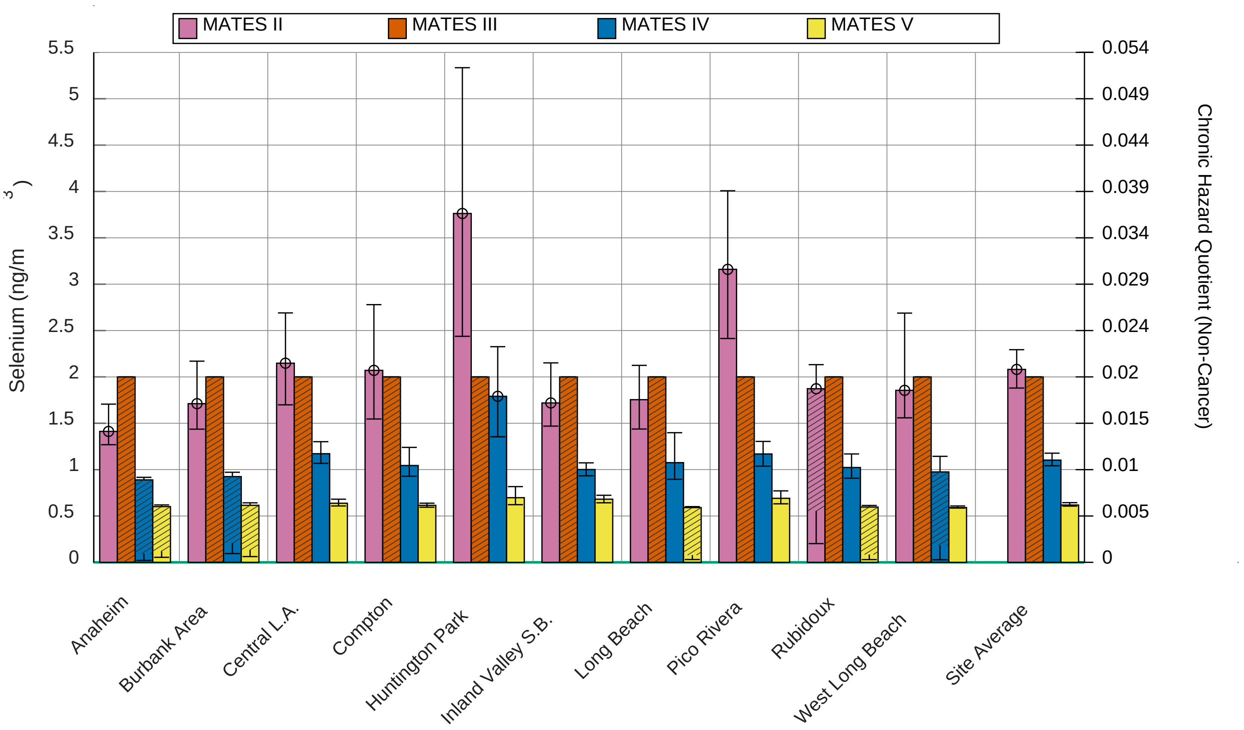


Figure 2-35 Average Concentrations of TSP Selenium. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below 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.

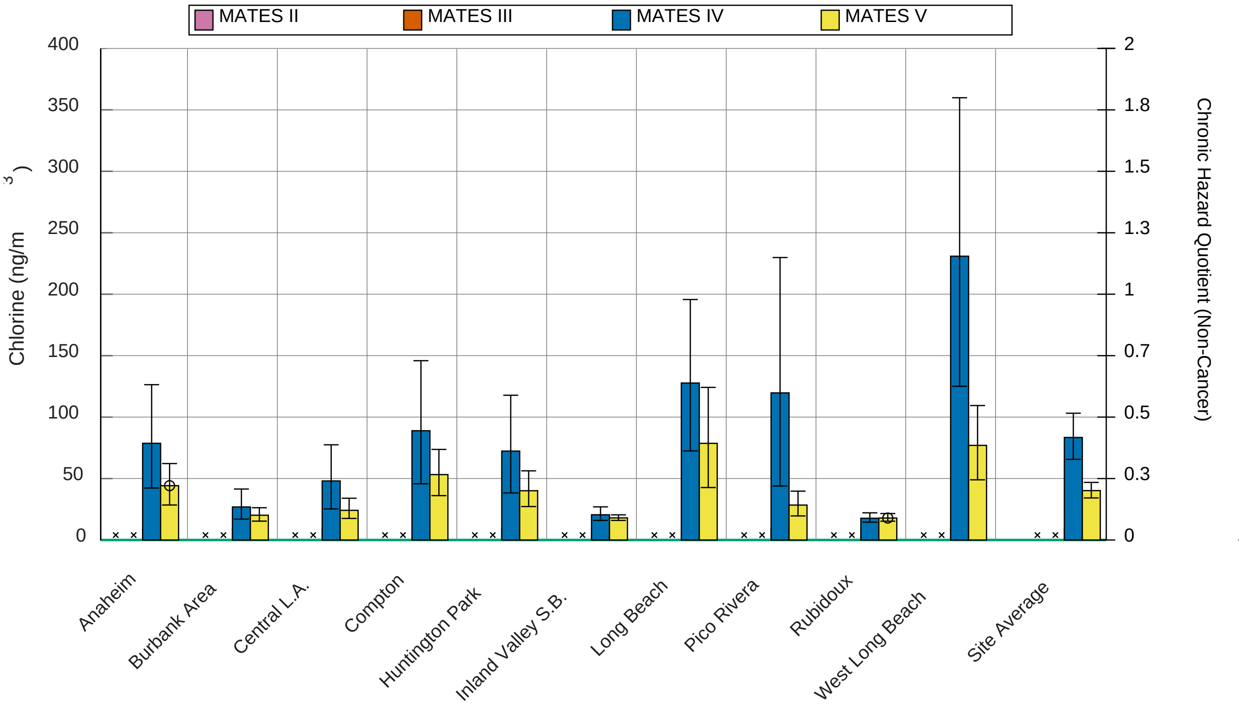


Figure 2-36 Average Concentrations of PM2.5 Chlorine. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all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

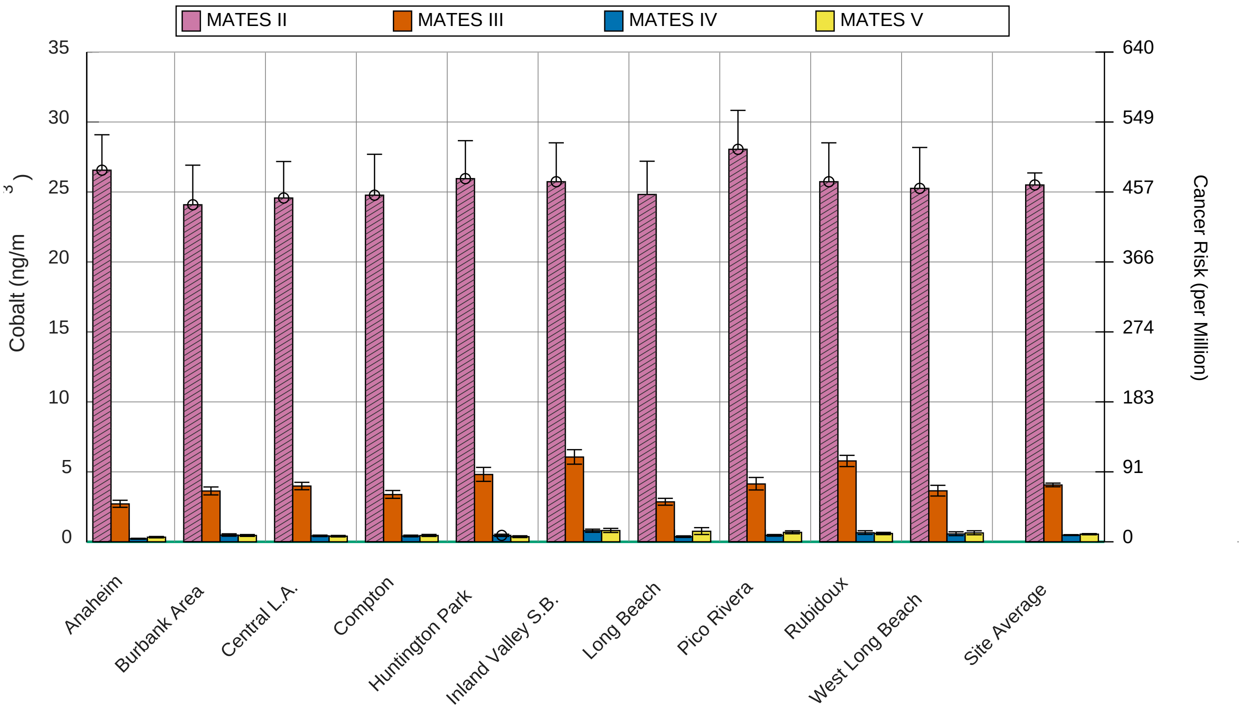


Figure 2-37 Average Concentrations of TSP Cobalt. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below the 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.

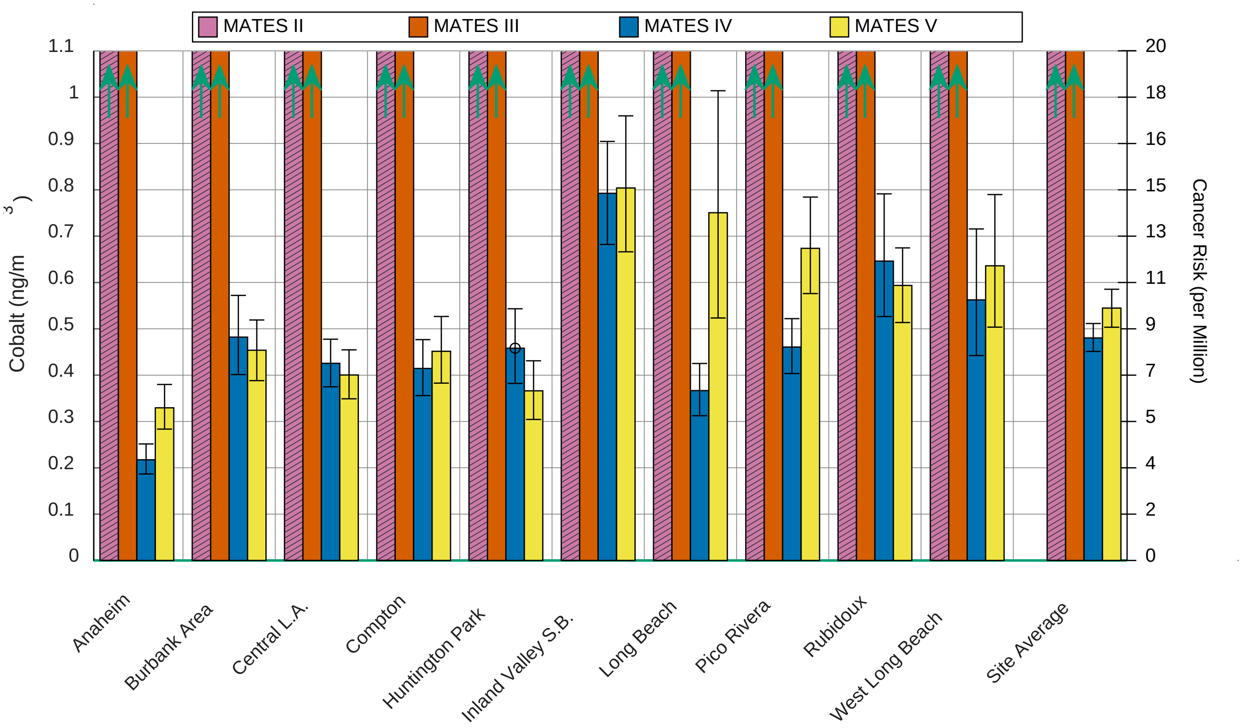


Figure 2-38 Average Concentrations of TSP Cobalt. The upward arrows indicate that the data extends above the y-axis shown. "o" indicates that valid measurements do not exist for at least 75% of the sampling days in each quarter. Error bars denote the 95% confidence interval.

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.

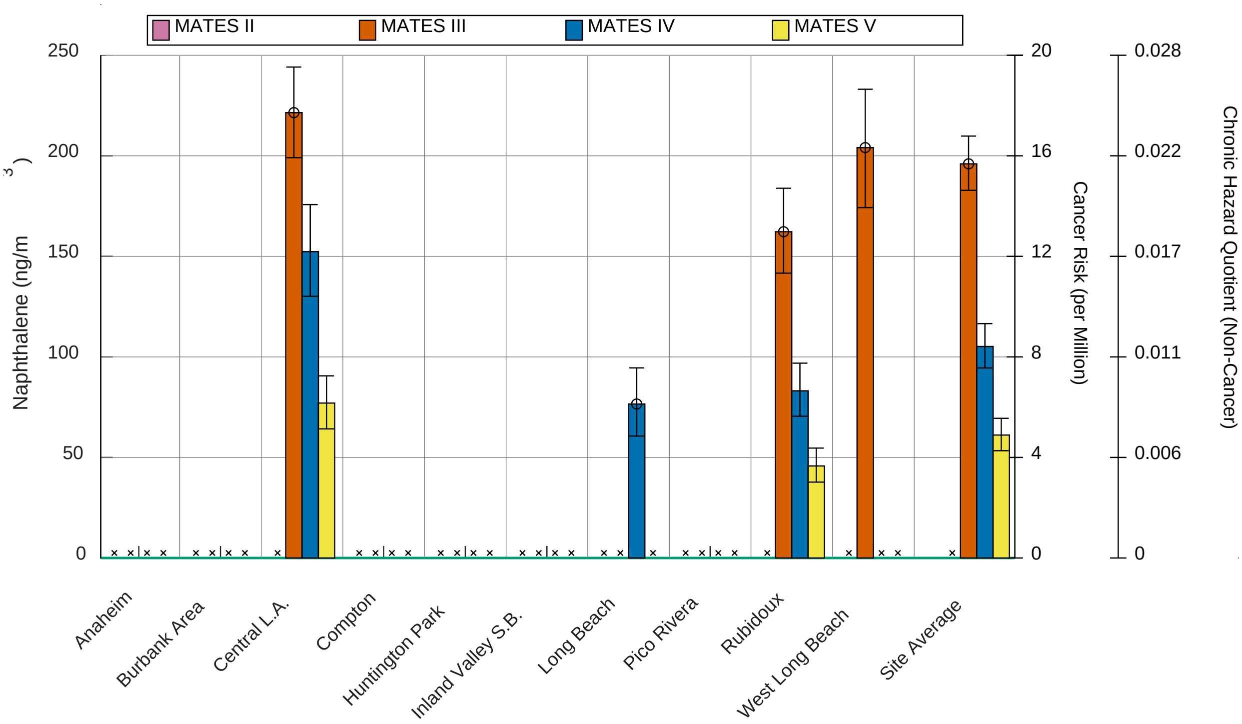


Figure 2-39 Average Annual Concentrations of Naphthalene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in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

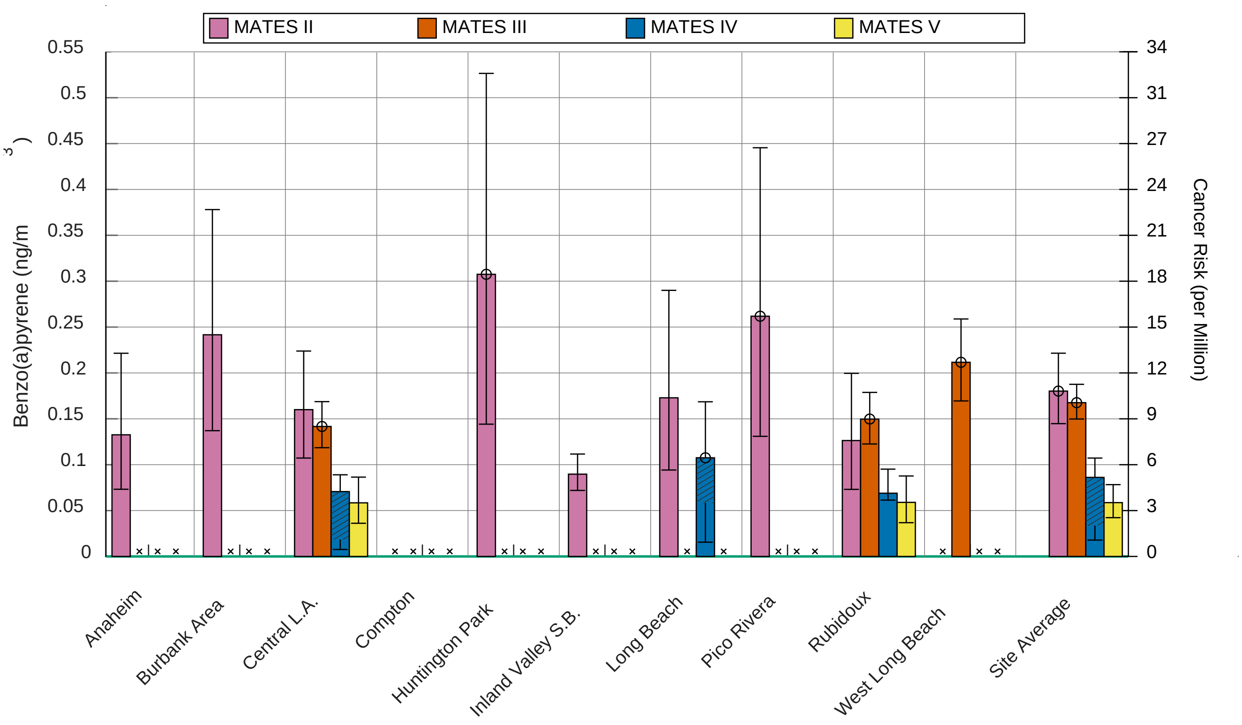


Figure 2-40 Average Concentrations of Benzo(a)pyrene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements below 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).

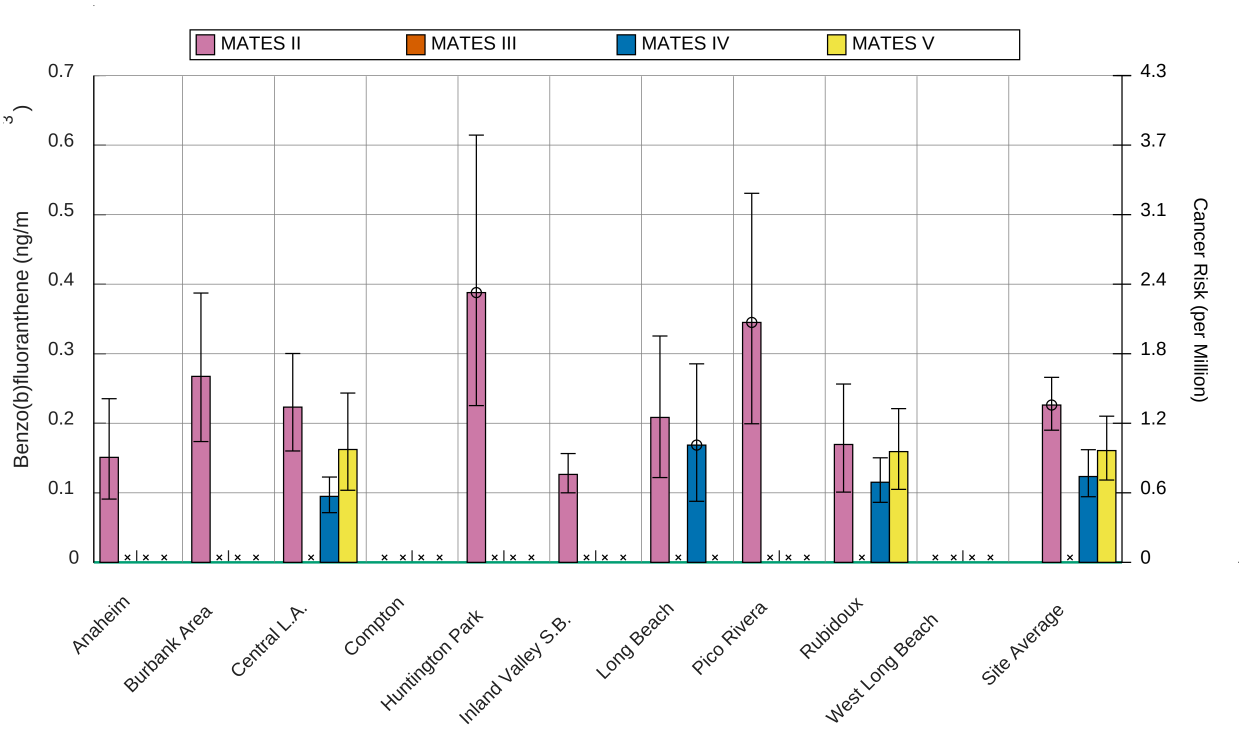


Figure 2-41 Average Concentrations of Benzo(b)fluoranthene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days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

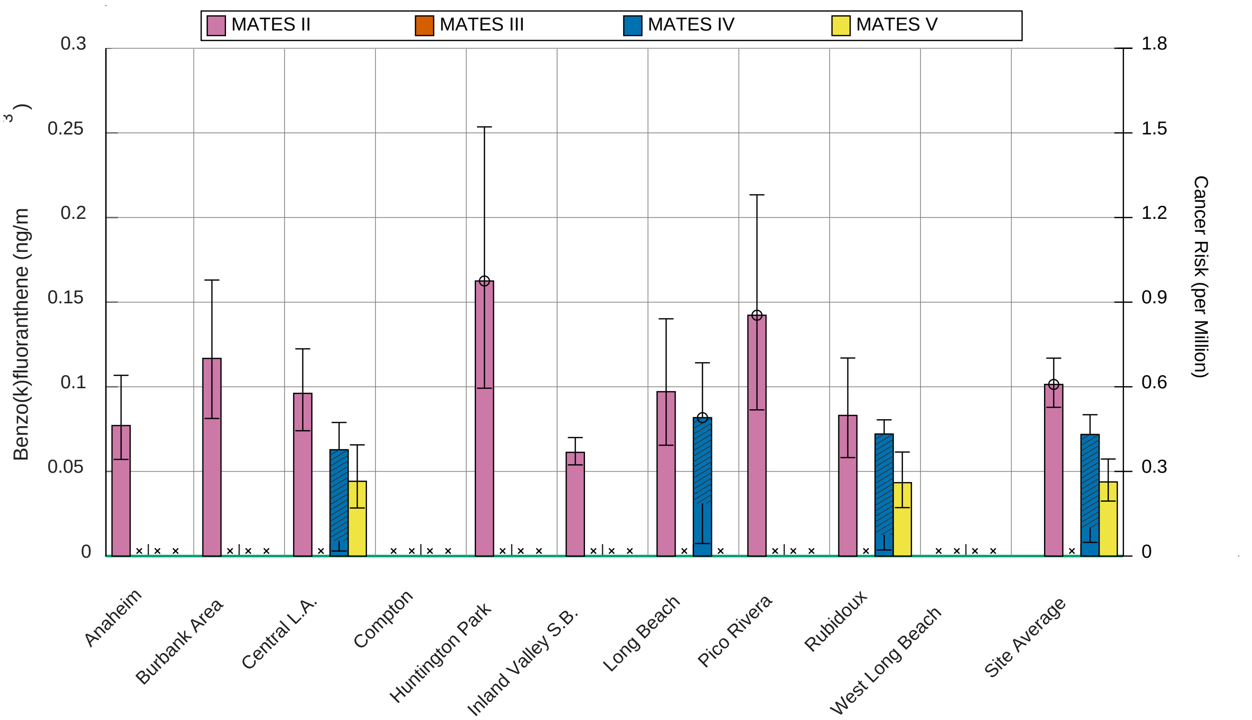


Figure 2-42 Average Concentrations of Benzo(k)fluoranthene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements 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.

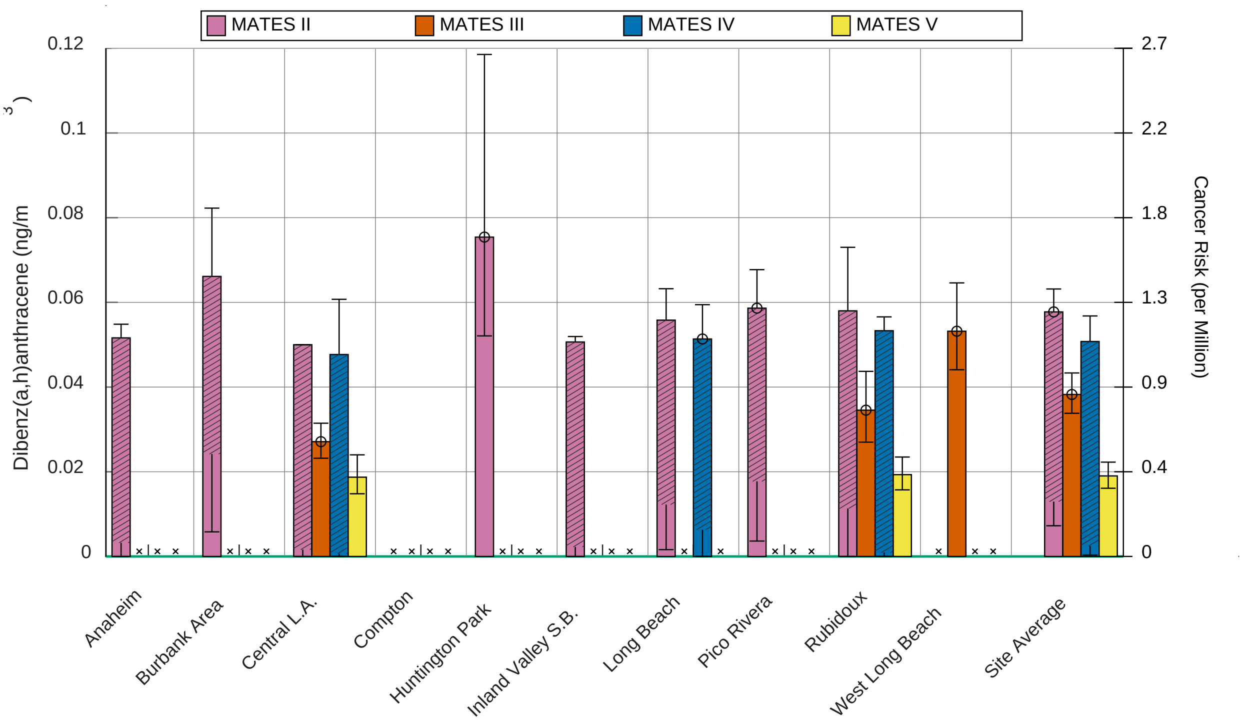


Figure 2-43 Average Concentrations of Dibenz(a,h)anthracene. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for all measurements 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.

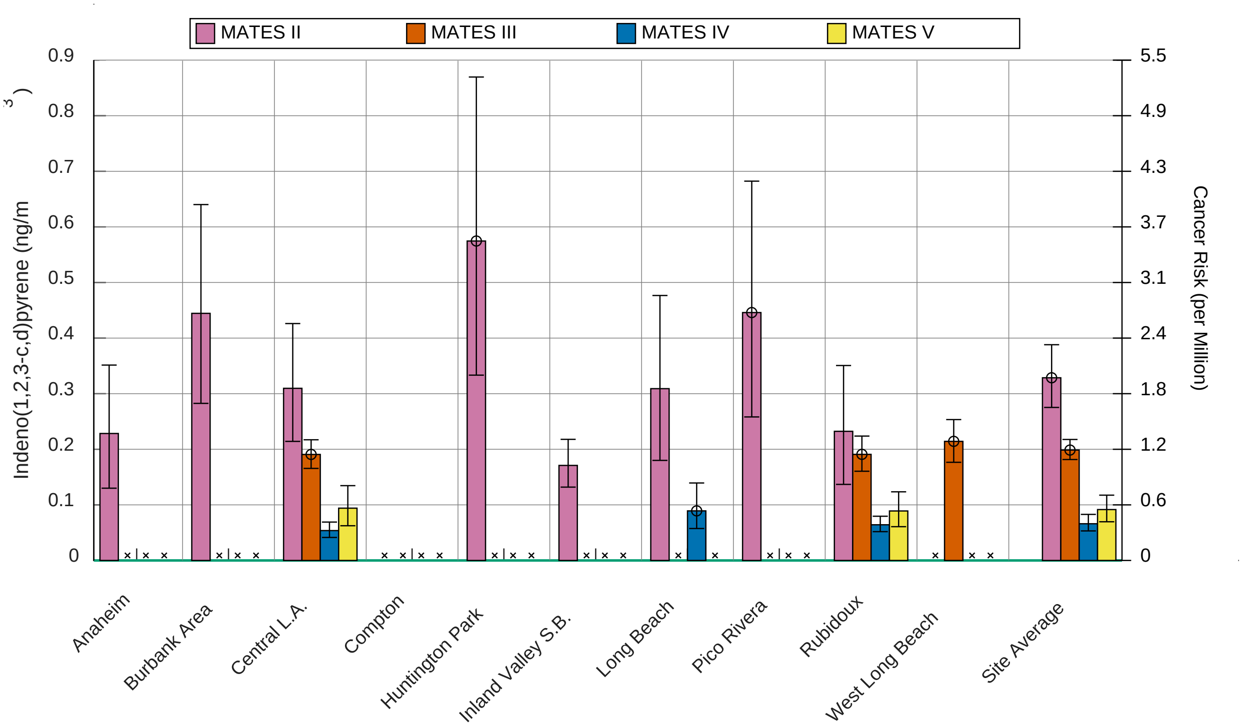


Figure 2-44 Average Concentrations of Indeno(1,2,3-c,d)pyrene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days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

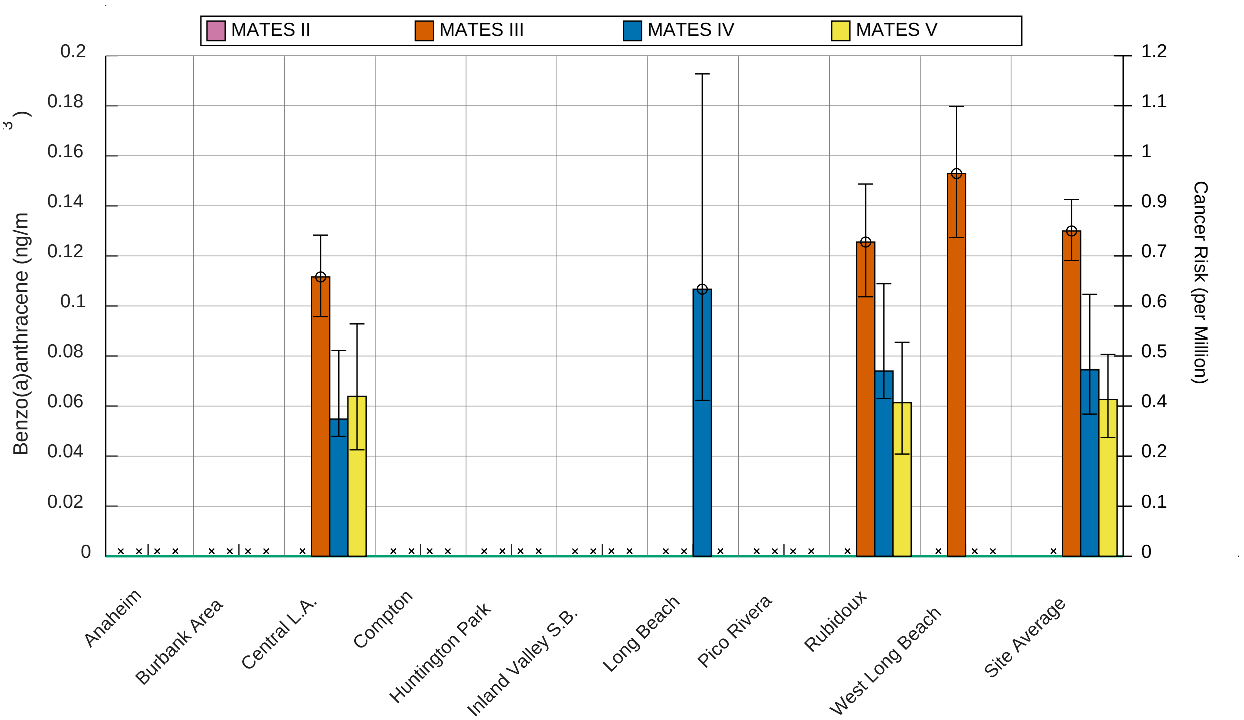


Figure 2- 45 Average Concentrations of Benzo(a)anthracene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in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

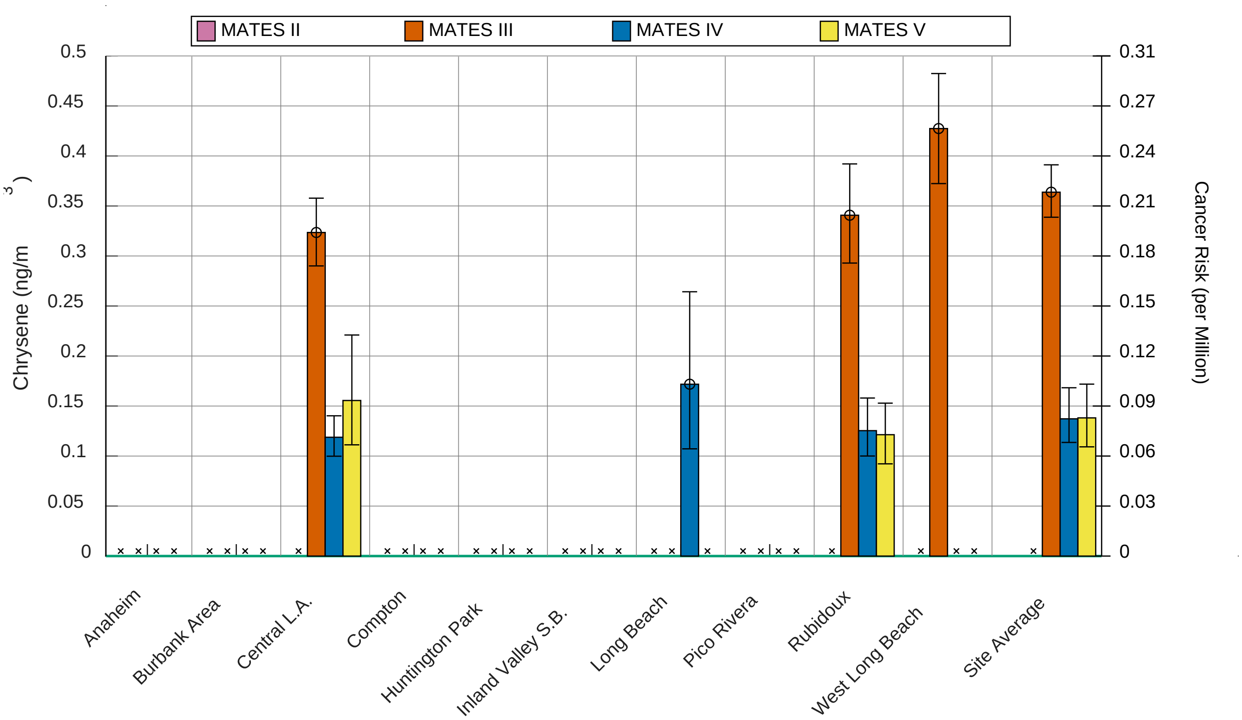


Figure 2-46 Average Concentrations of Chrysene. "x" in the place of a bar indicates that there are no data for a given station/MATES iteration. "o" at the top of a bar or in the location of a missing bar indicates that valid measurements do not exist for at least 75% of the sampling days in all quarters.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

---

[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.

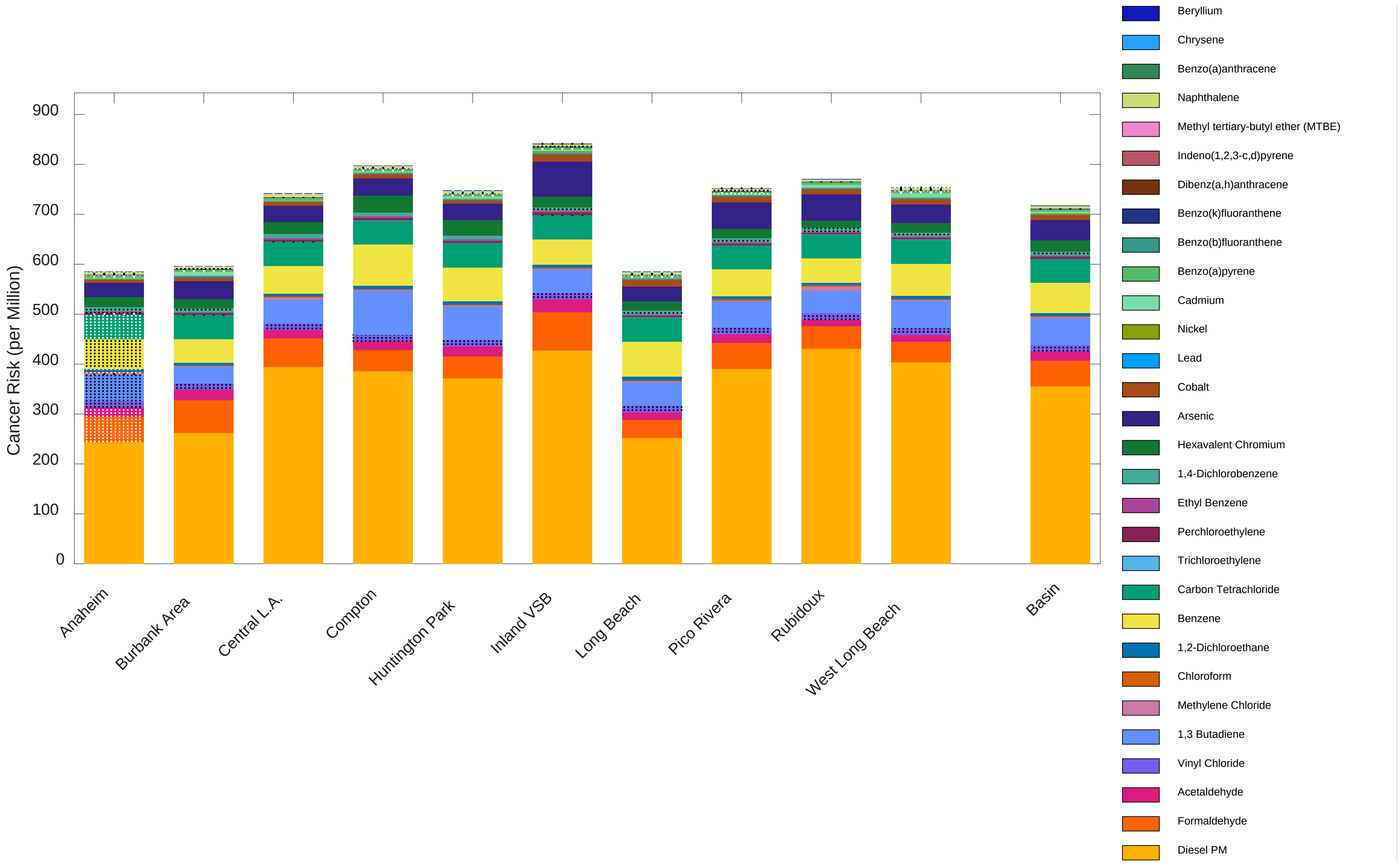


Figure 2-47 Bar charts of the cumulative cancer risks by station for MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark bar segments that are more uncertain due to either substitution for data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

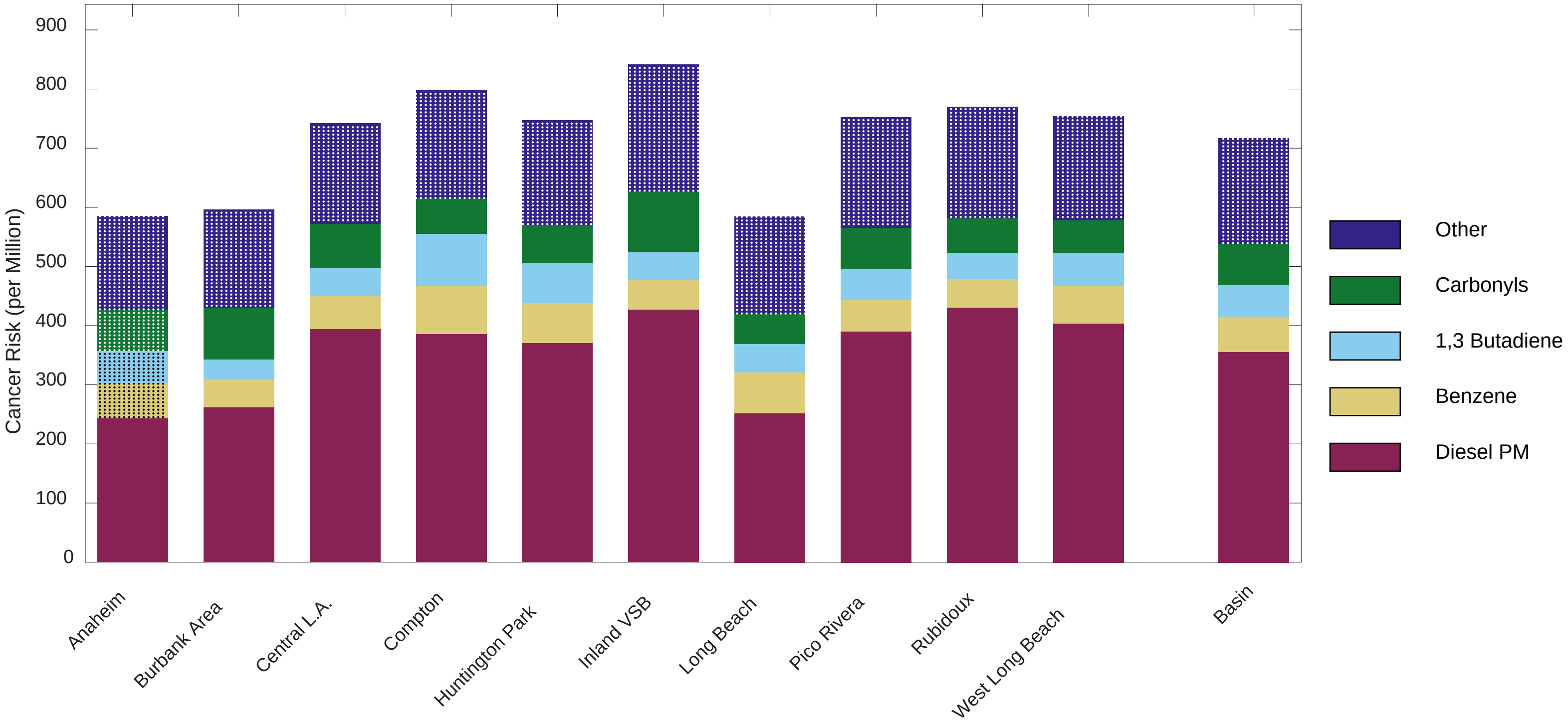


Figure 2-48 Bar charts of the cumulative cancer risks by station for MATES V with grouped analytes. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark bar segments that are more uncertain due to either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

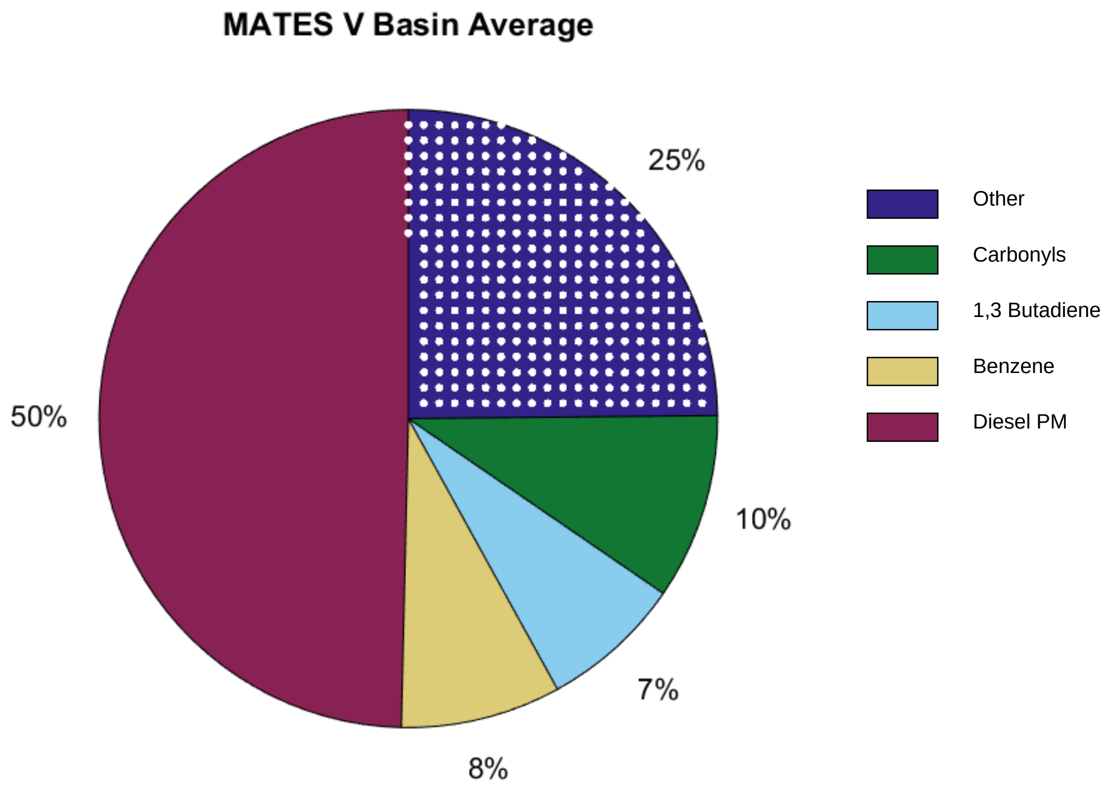


Figure 2-49 Pie charts of the basin-wide cumulative cancer risks for MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark segments that are more uncertain due to either substitution for data that 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.

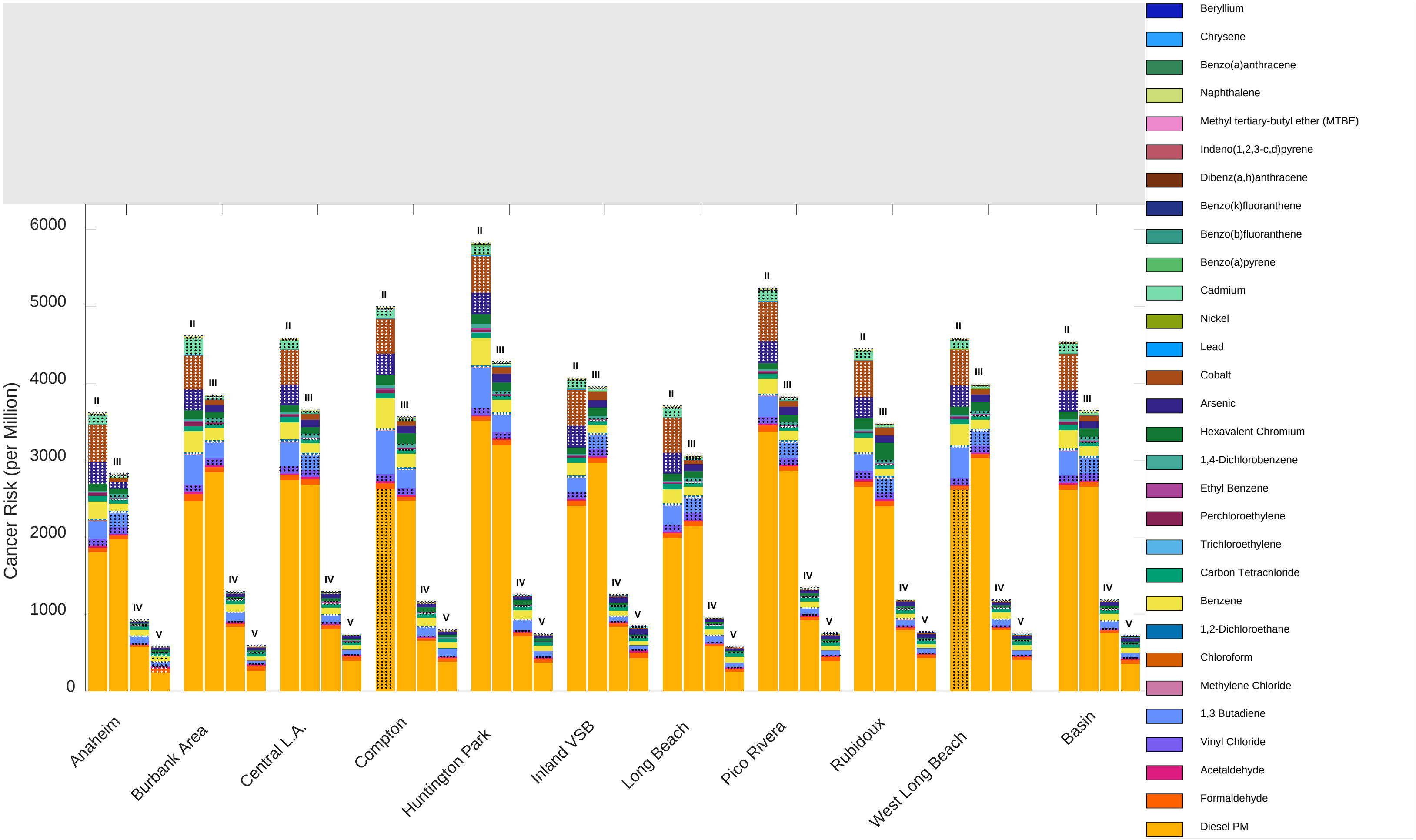


Figure 2-50 Cancer risk trends across MATES II through MATES V at all stations. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Bromomethane was also excluded because it was only measured in MATES 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.

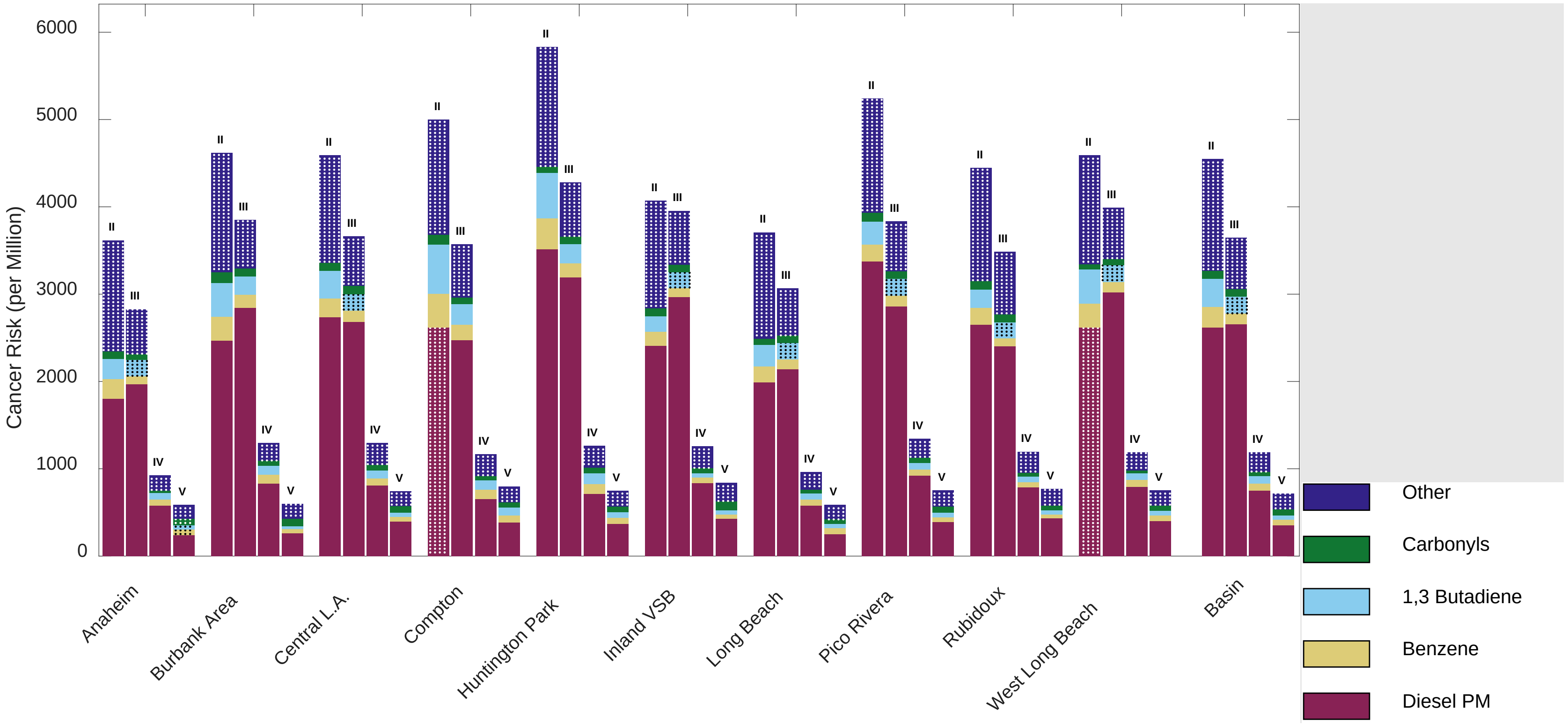


Figure 2-51 Cancer risk trends across MATES II through MATES V at all stations with analytes grouped. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Dots are used to mark bar segments that are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

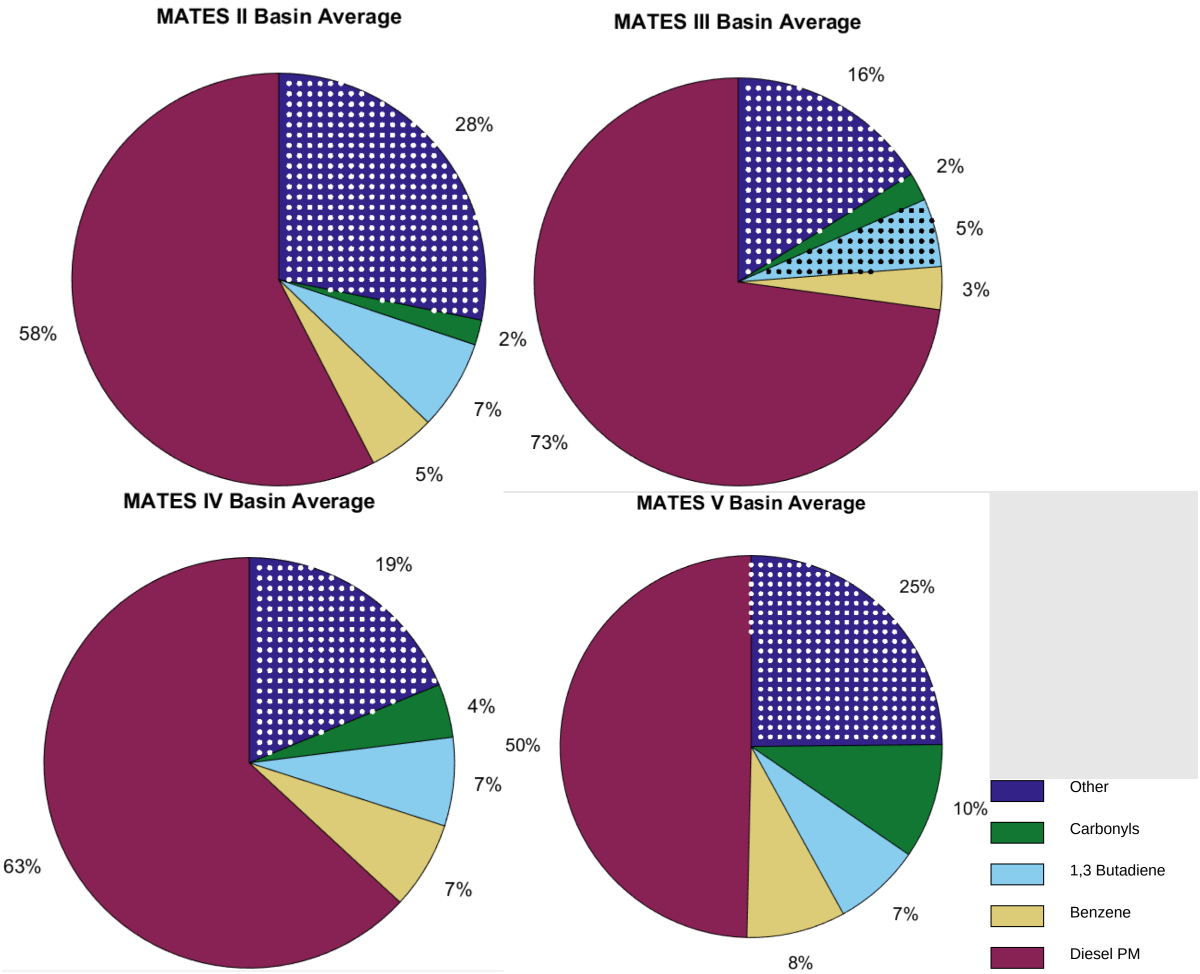


Figure 2-52 Pie charts of the basin-wide cumulative cancer risks for MATES II through MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Dots are used to mark bar segments that are more uncertain 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

---

[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.

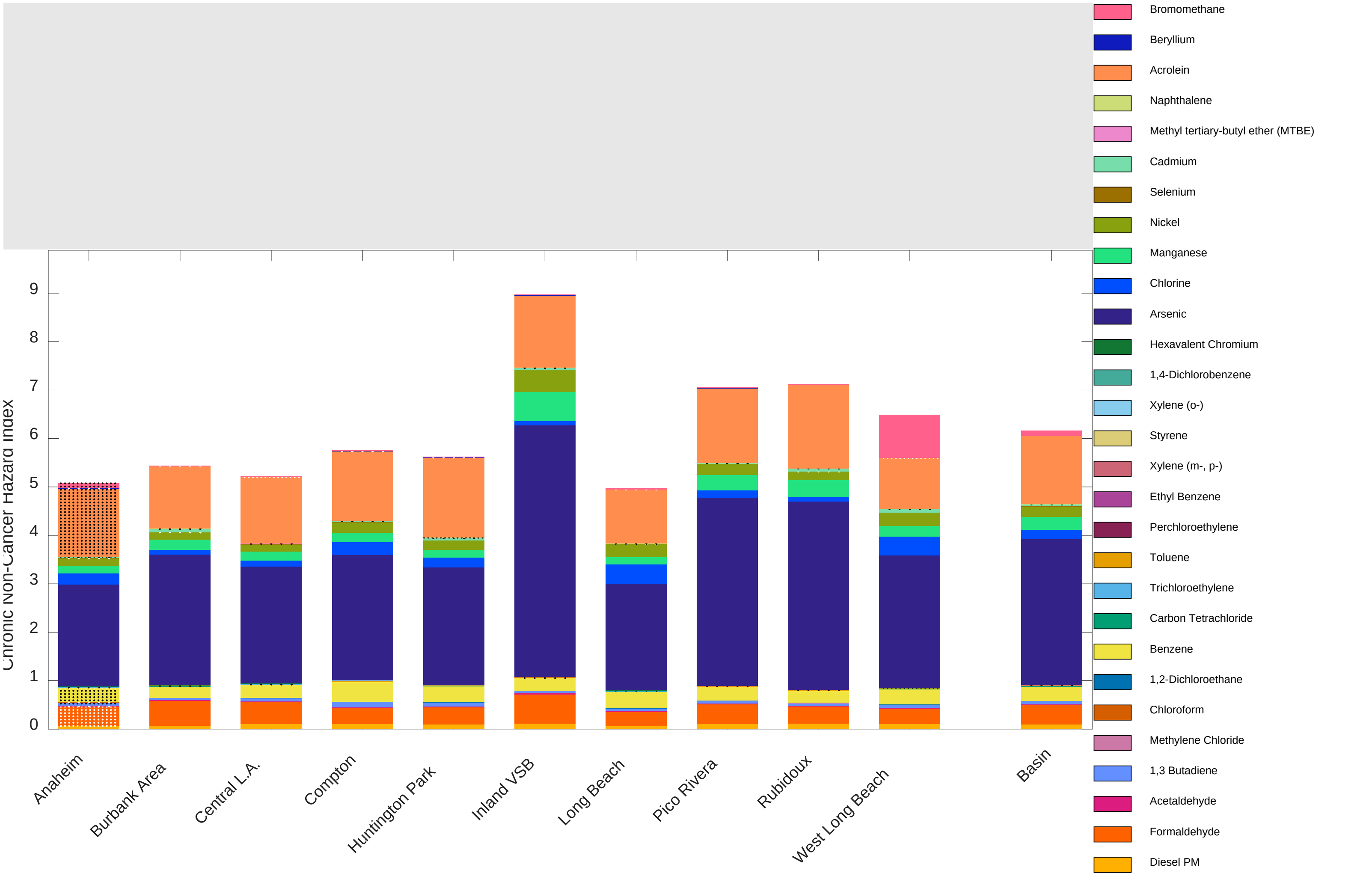


Figure 2-53 Bar charts of the cumulative chronic non-cancer hazard indices by station for MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark bar segments that are more uncertain due to either substitution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

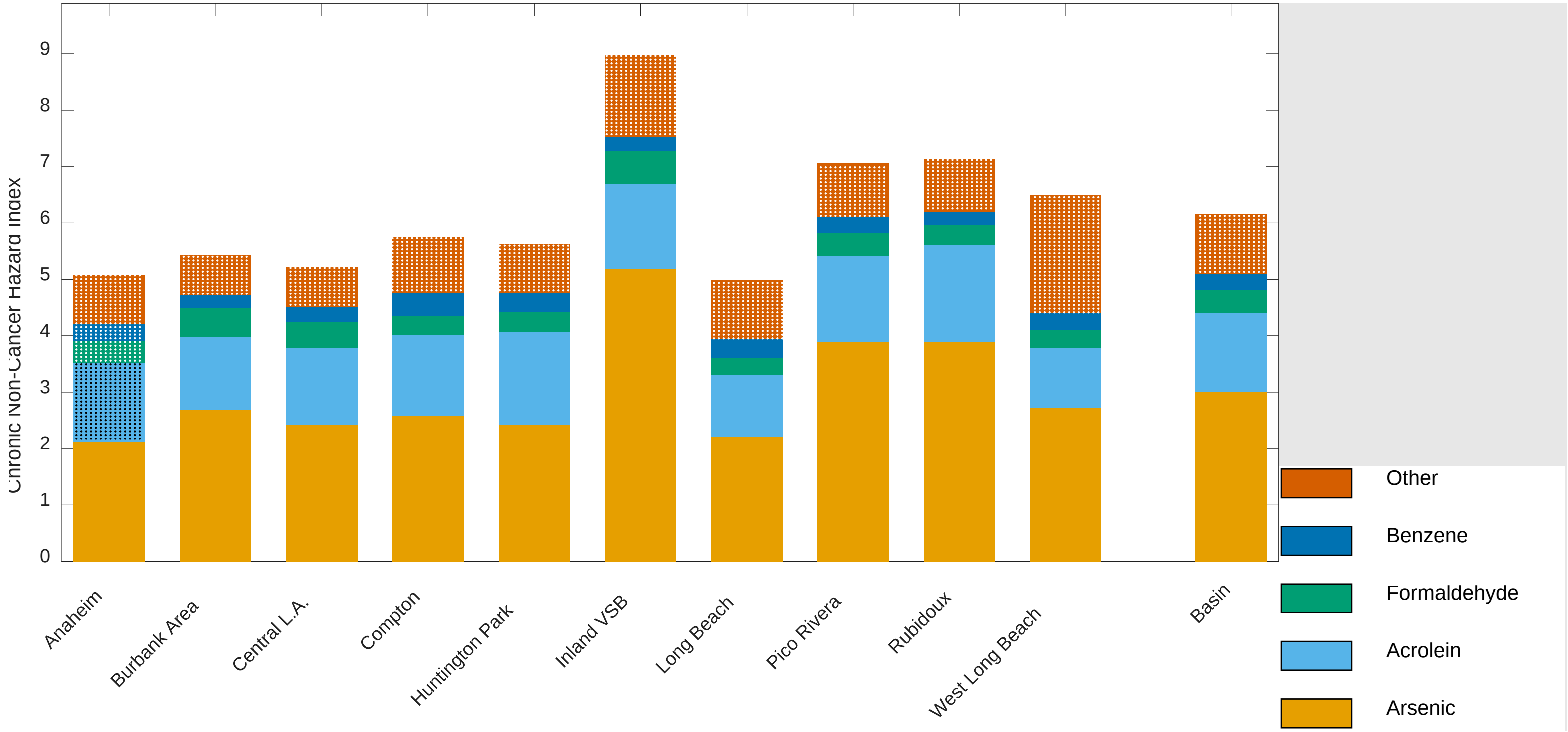


Figure 2-54 Bar charts of the cumulative chronic non-cancer hazard indices by station for MATES V with grouped analytes. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark bar segments that are more uncertain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

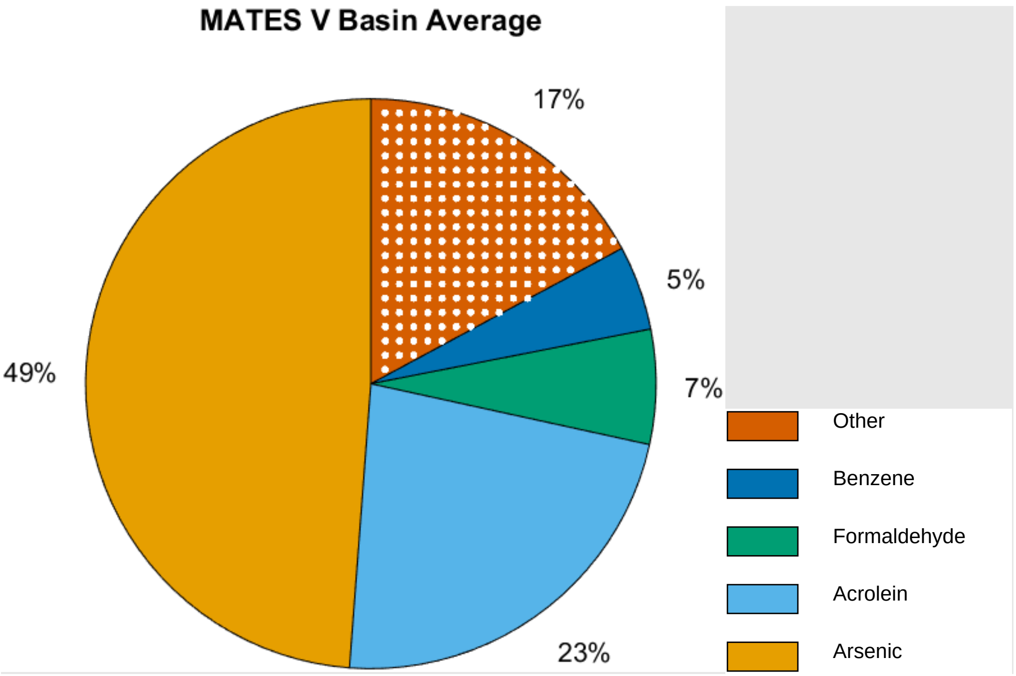


Figure 2-55 Relative contributions to the basin-wide chronic HI at the MATES V monitoring sites. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below detection limit for each station. Dots are used to mark segments that are more uncertain due to either substitution 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.

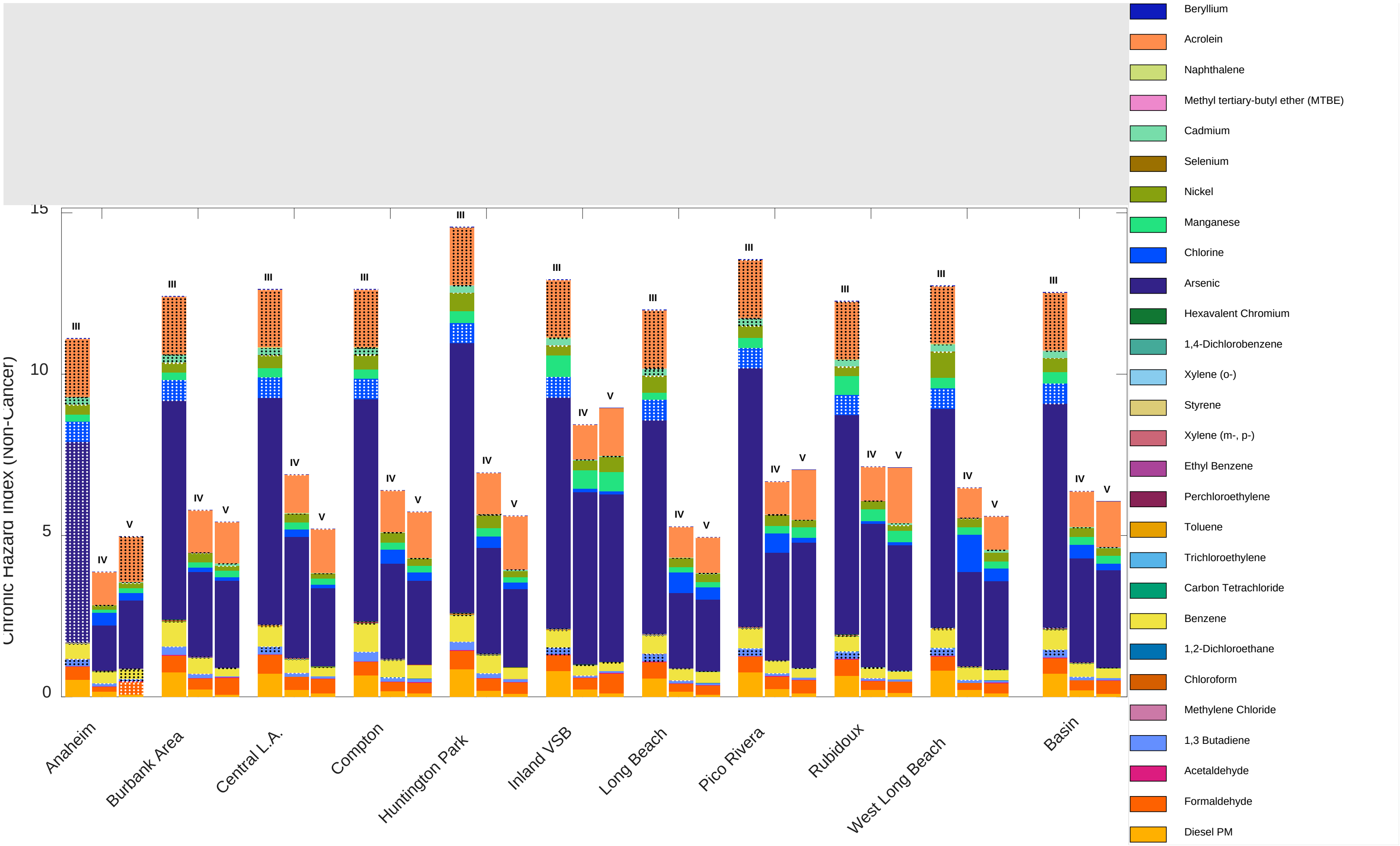


Figure 2-56 Chronic HI trends across MATES III through MATES V at all stations. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Bromomethane was also excluded because it was only measured in MATES 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.

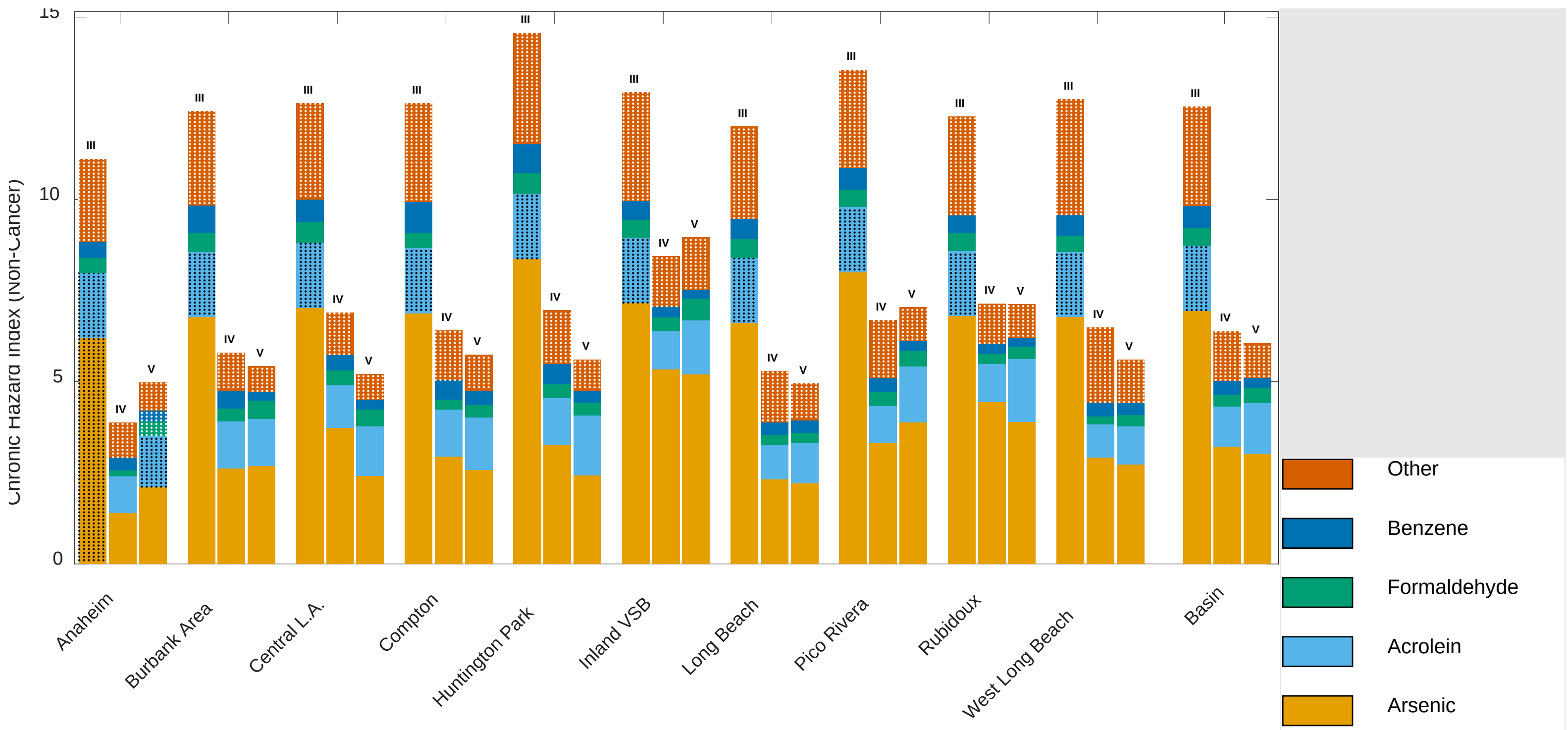


Figure 2-57 Chronic HI trends across MATES III through MATES V at all stations with analytes grouped. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Bromomethane was also excluded because it was 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.

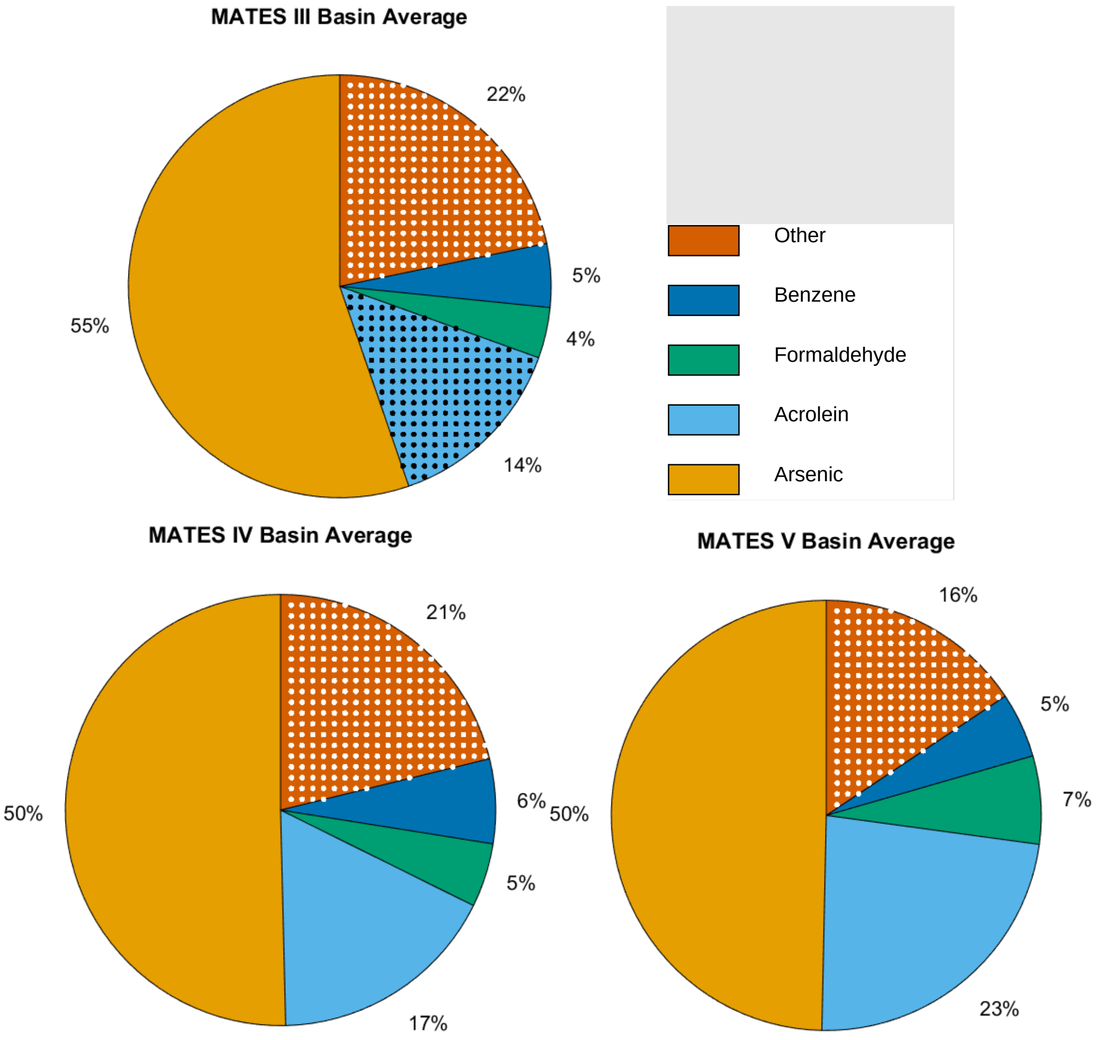


Figure 2-58 Pie charts of the basin-wide cumulative chronic non-cancer health impacts for MATES III through MATES V. 1,2 Dibromoethane is excluded because of high uncertainty due to all measurements being below the detection limit for each station for all MATES projects. Bromomethane was also excluded 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

---

[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.

---

[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

---

[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).

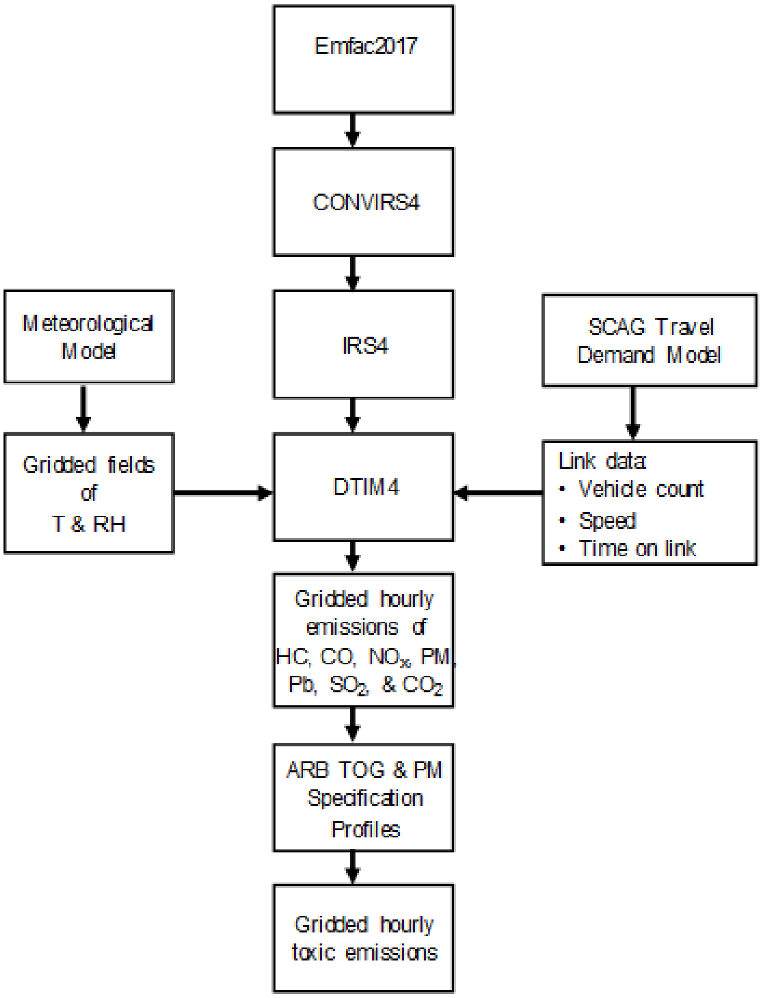


Figure 3-1. Flow Diagram for On-Road Emissions Processing.

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

---

[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

---

[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		

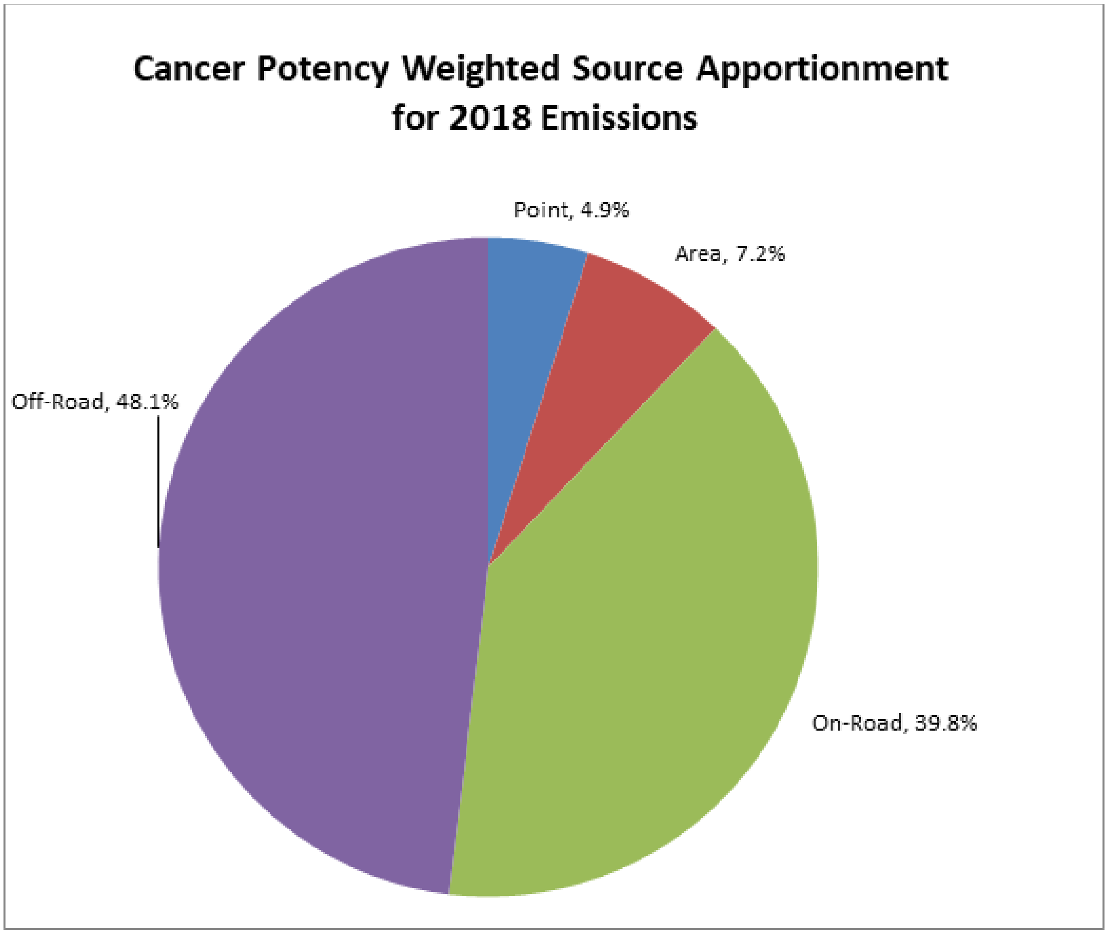


Figure 3-2. Cancer Potency Weighted Source Apportionment for 2018 Emissions.

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

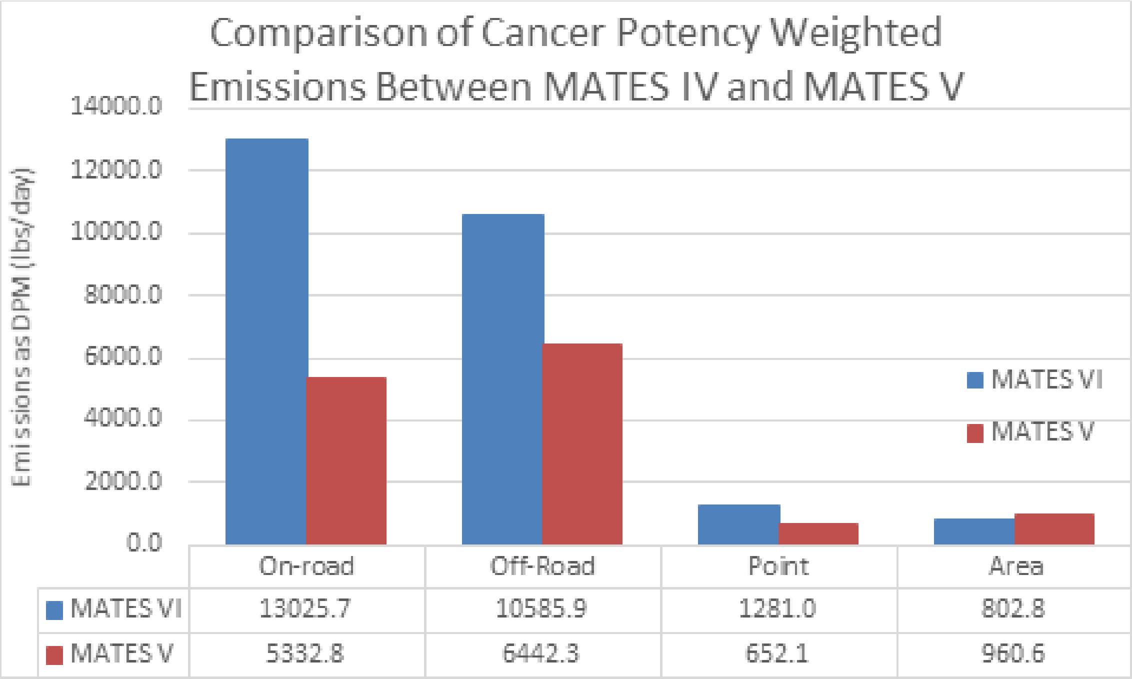
---

[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

---

[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.

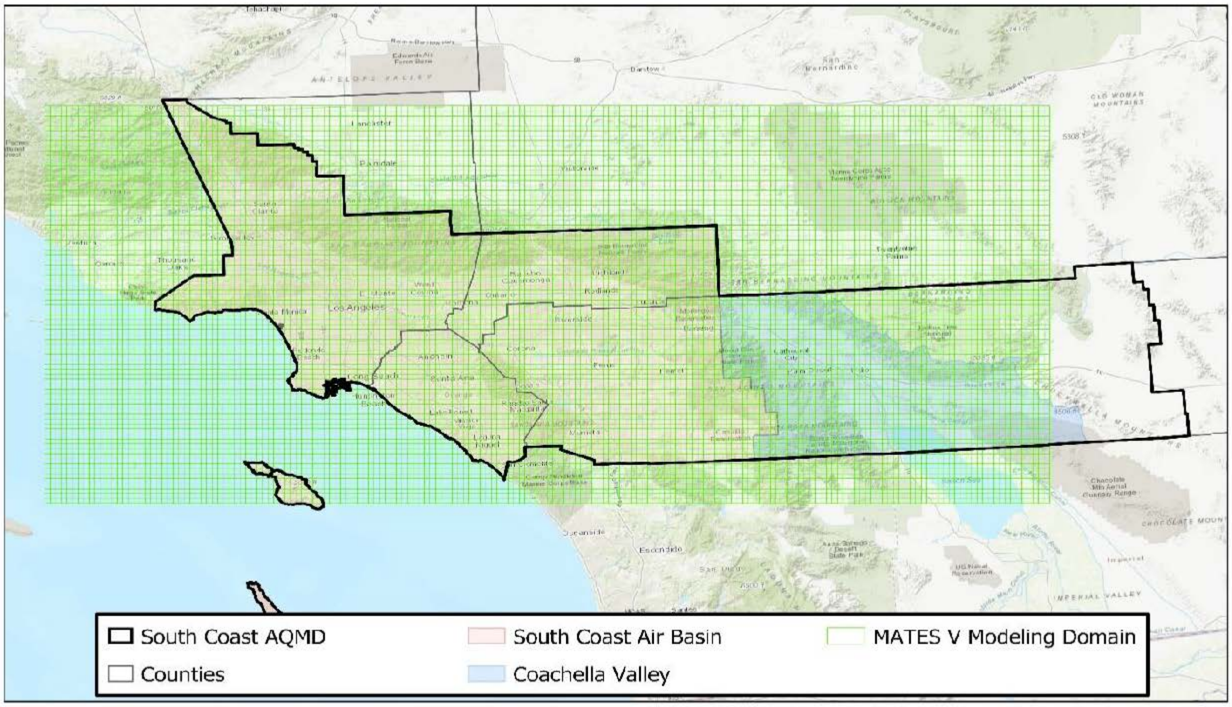


Figure 4-1.
MATES V Modeling Domain

---

[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

---

[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.

---

[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

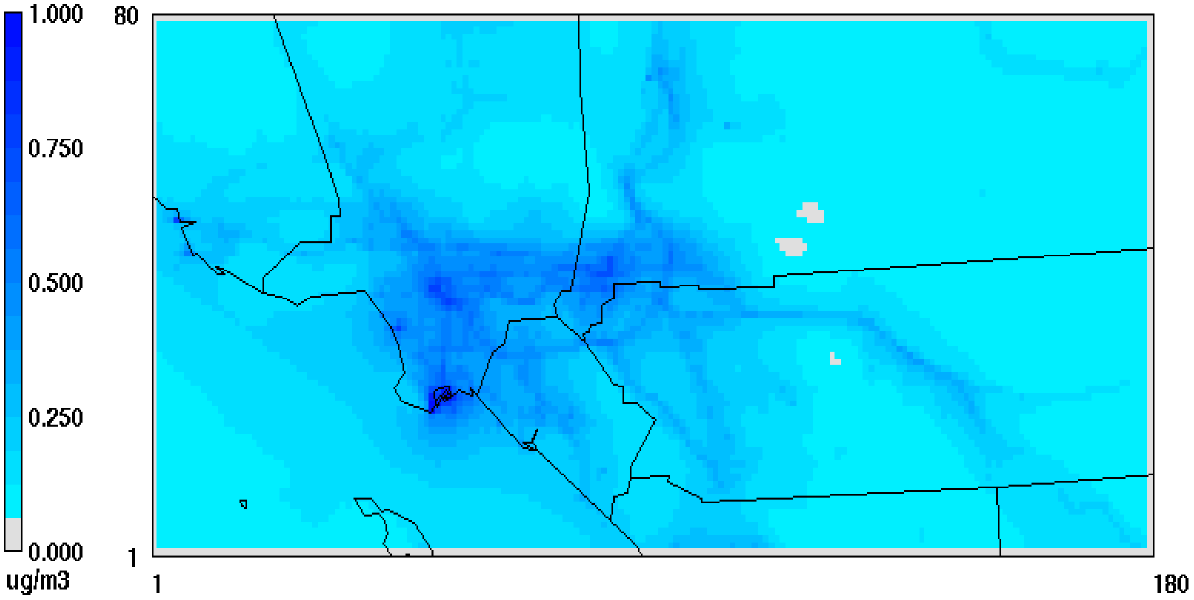


Figure 4-2
Annual Average Concentration Pattern for Diesel PM

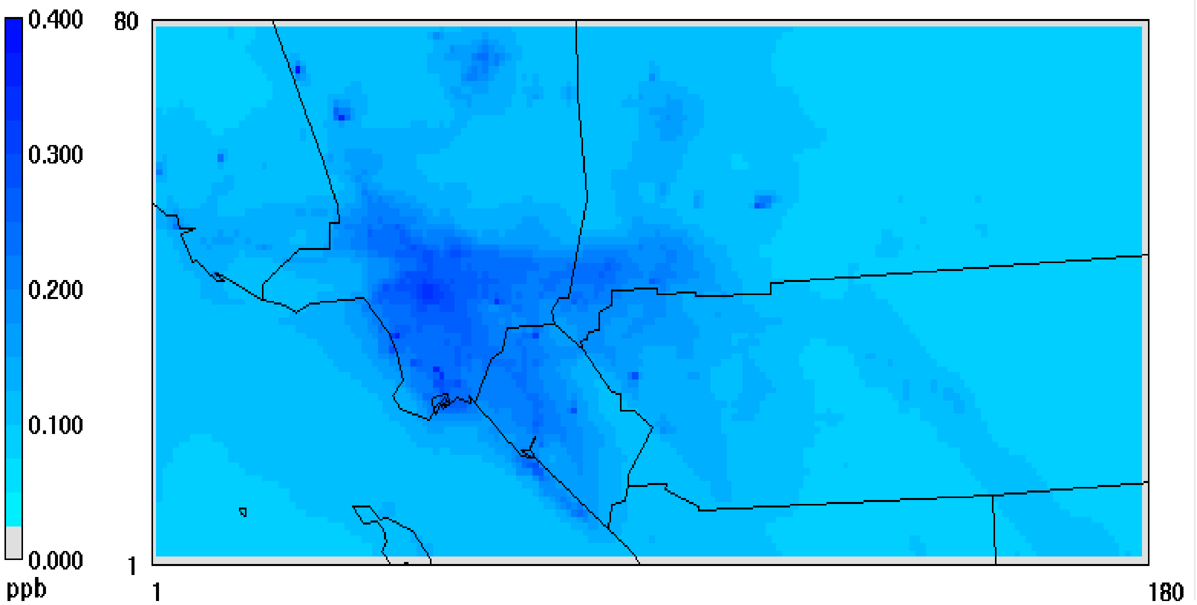


Figure 4-3
Annual Average Concentration Pattern for Benzene

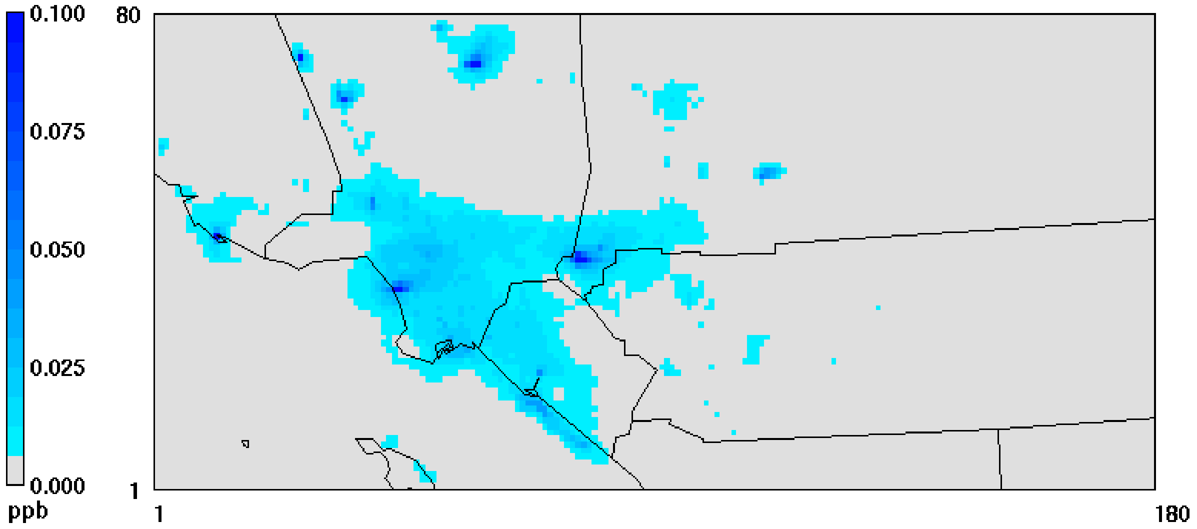


Figure 4-4
Annual Average Concentration Pattern for 1,3-Butadiene

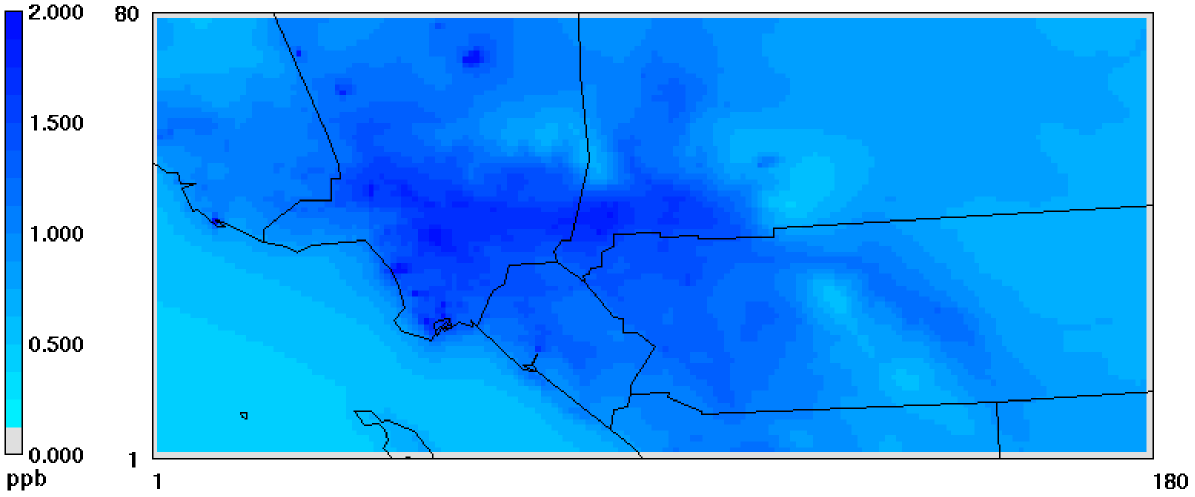


Figure 4-5
Annual Average Concentration Pattern for Total Formaldehyde

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 $\mu g/m^3$. The modeled average concentration corresponding to the average across the same 10 sites is 0.51 $\mu g/m^3$. 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.

---

[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

---

[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%.

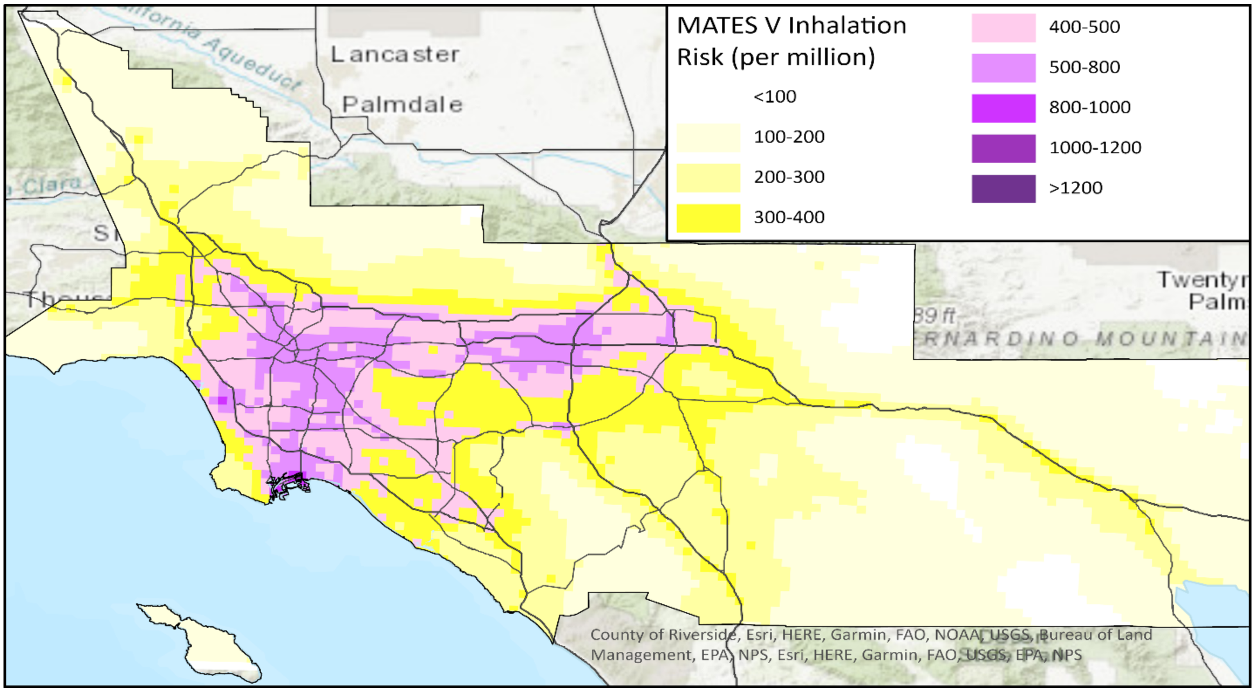


Figure 4-6
MATES V CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk

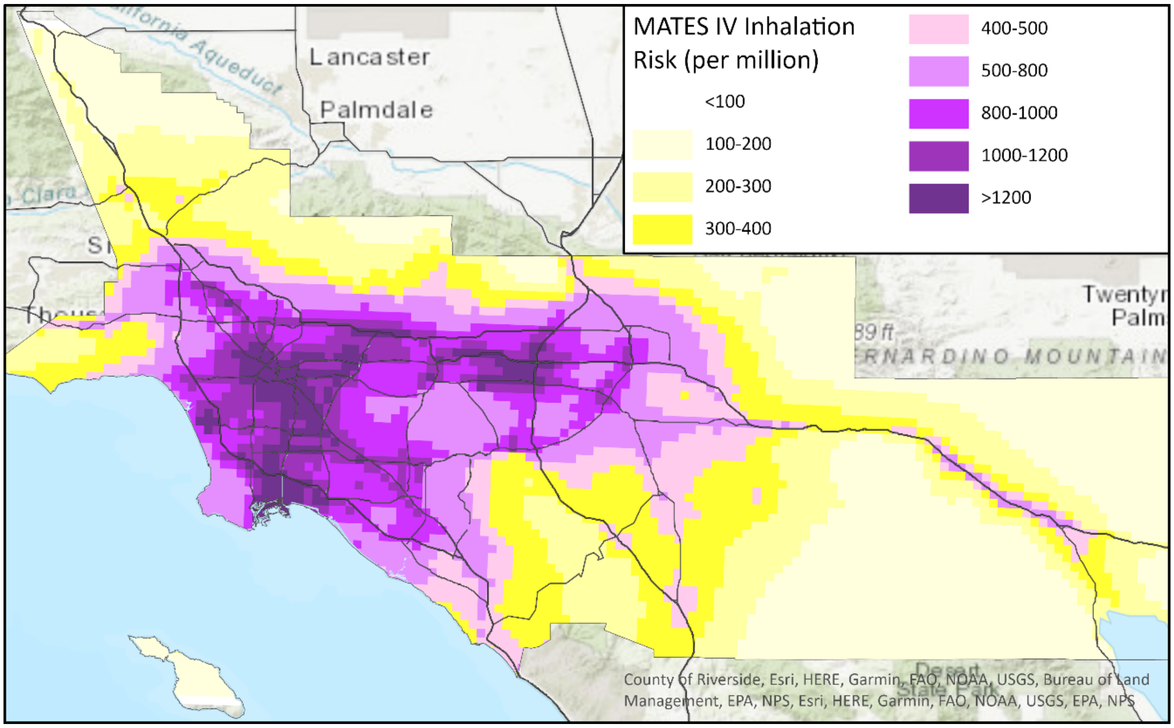


Figure 4-7
MATES IV CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk

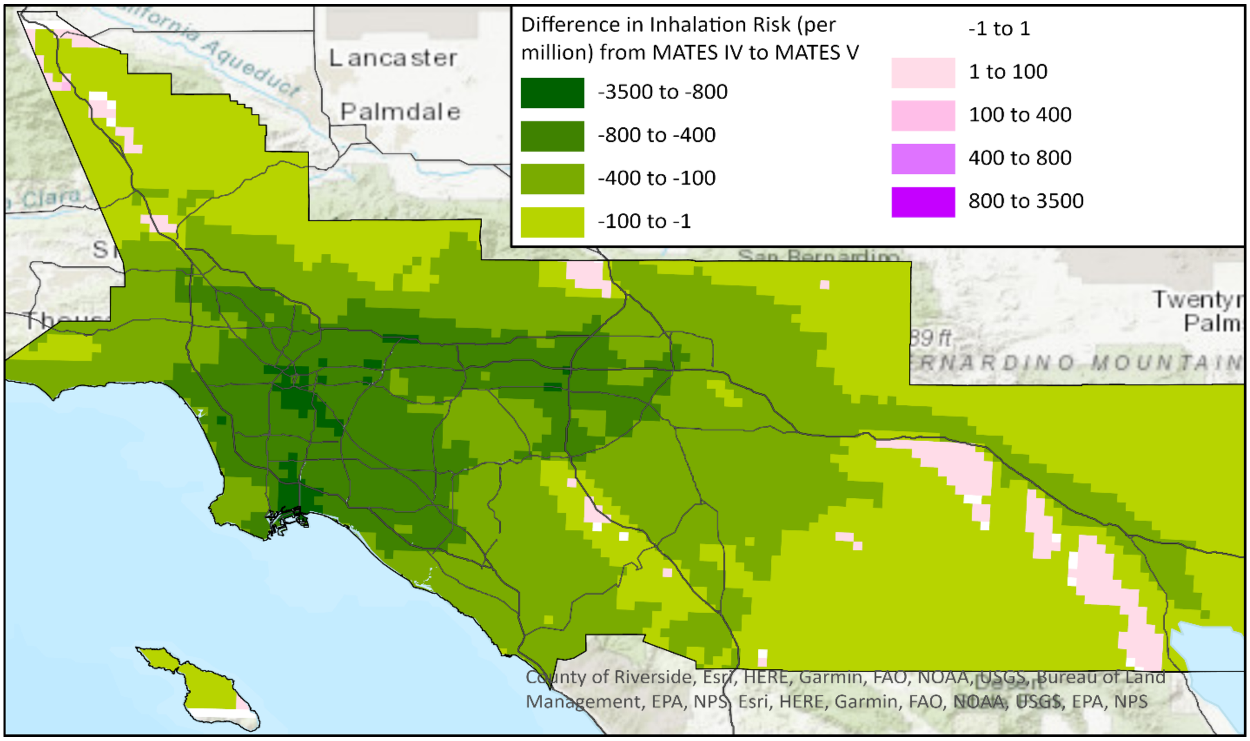


Figure 4-8
Changes in CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk (per million) from MATES IV to MATES V Period

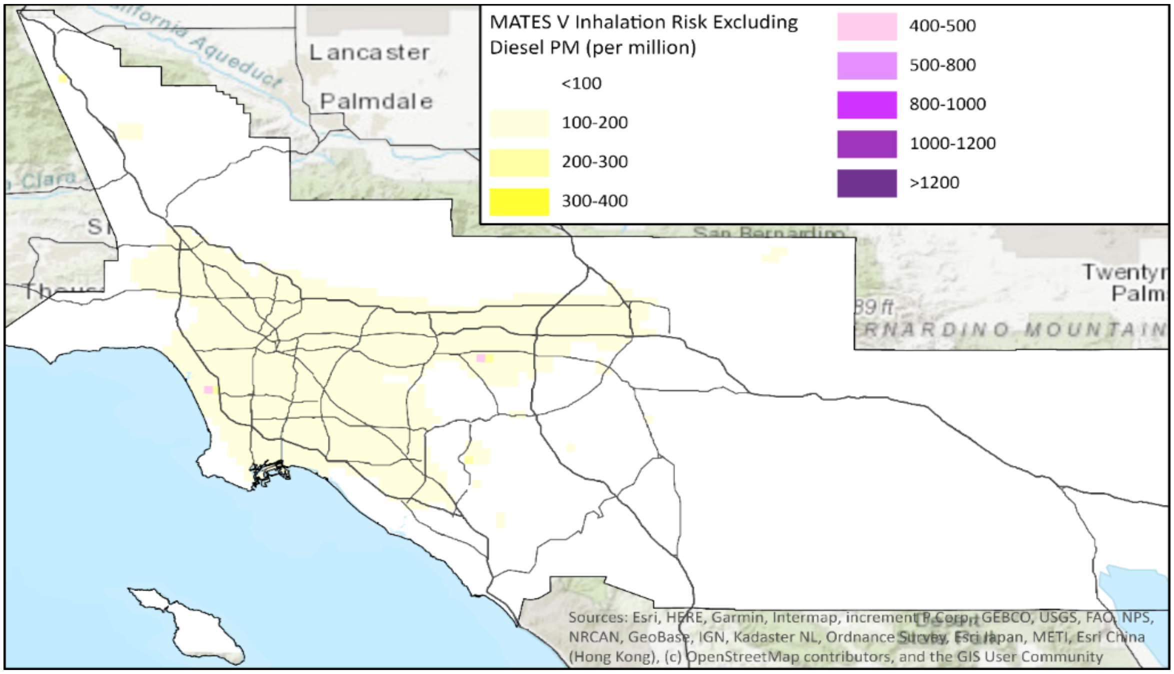


Figure 4-9
MATES V Simulated Inhalation Air Toxics Cancer Risk excluding Diesel PM

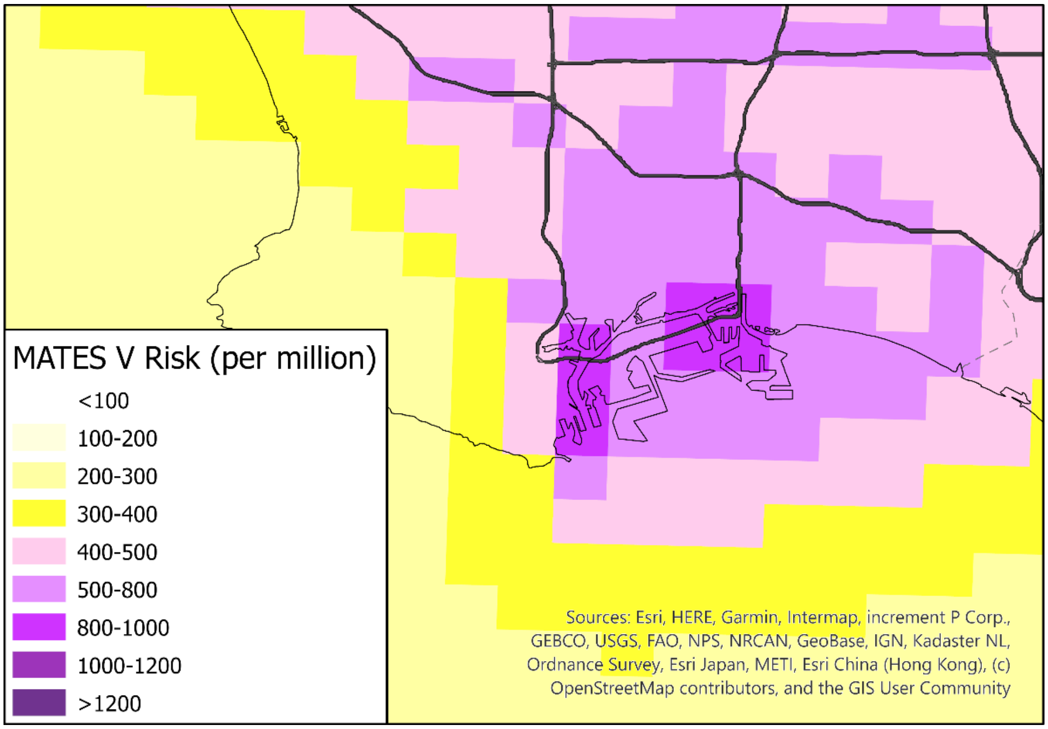


Figure 4-10
Ports Area MATES V Simulated Inhalation Air Toxics Cancer Risk

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,

---

[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.

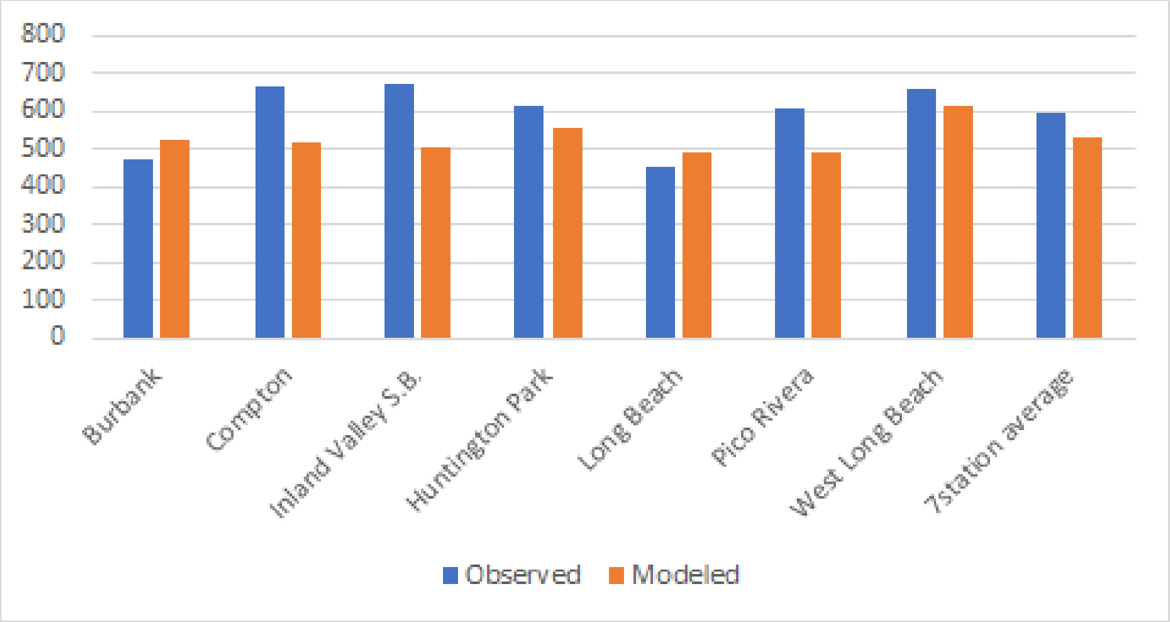


Figure 4-11
MATES V Modeled vs. Measured Inhalation Air Toxics Cancer Risk (Per Million)

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.

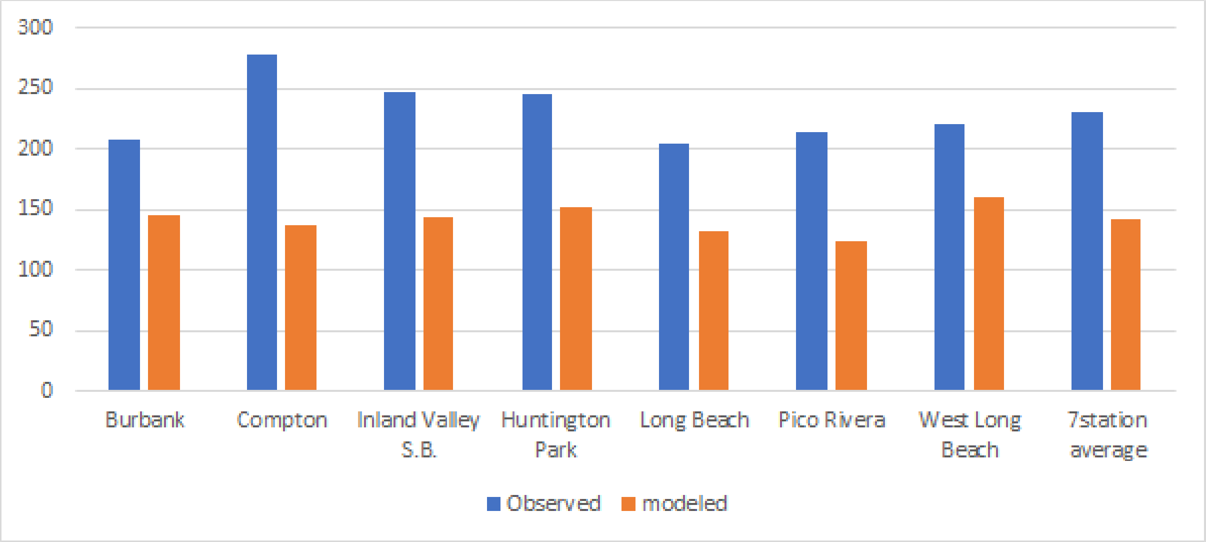


Figure 4-12

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.

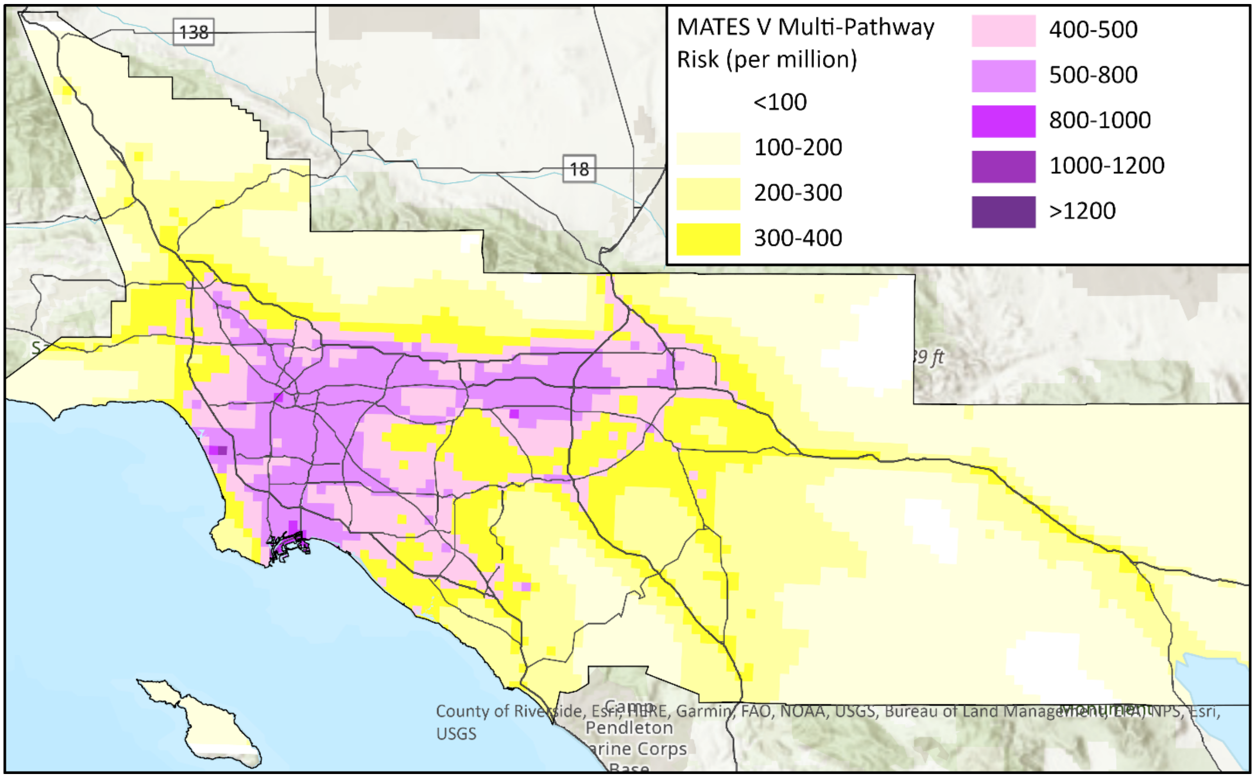


Figure 4-13
MATES V CAMx RTRAC Simulated Multiple-Pathway Air Toxics Cancer Risk

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.

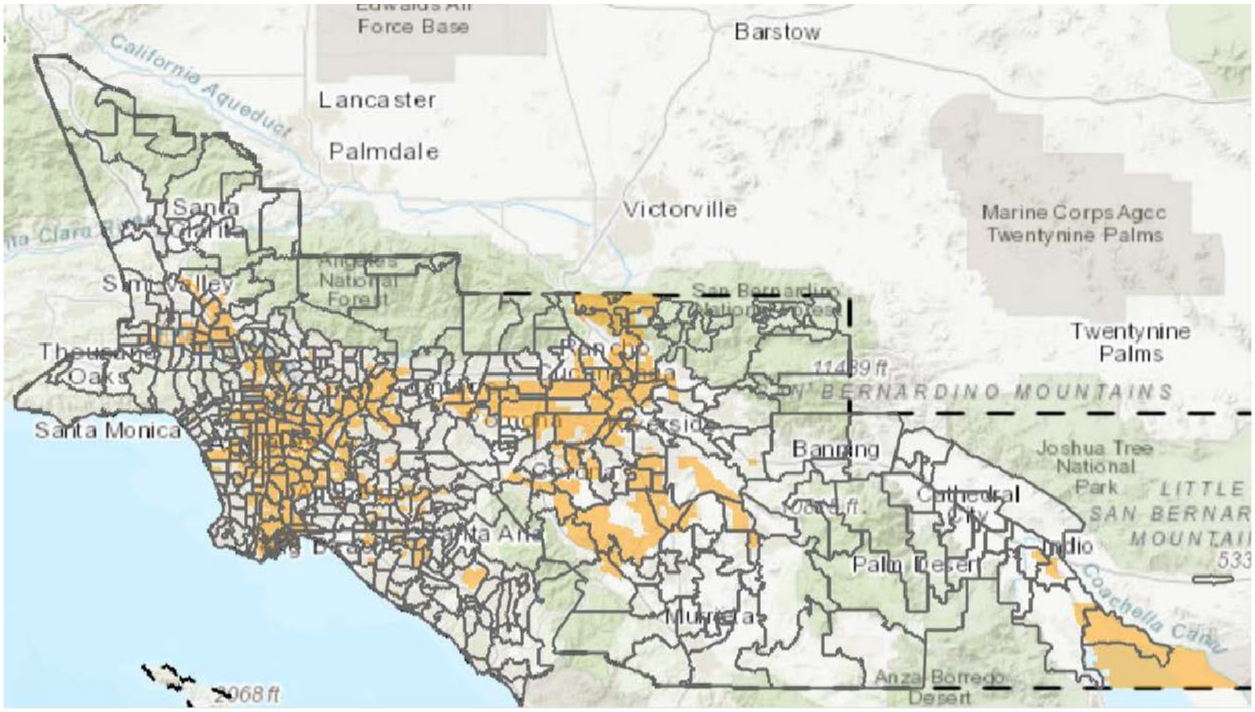


Figure 4-15: SB535 Communities

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

---

[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.

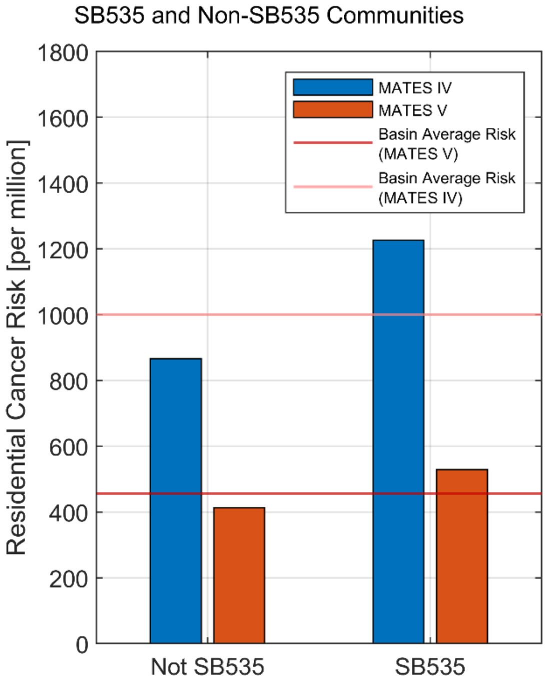


Figure 4-16: Population weighted average Residential Cancer Risk in SB535 and Non-SB535 Communities.

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

---

[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.

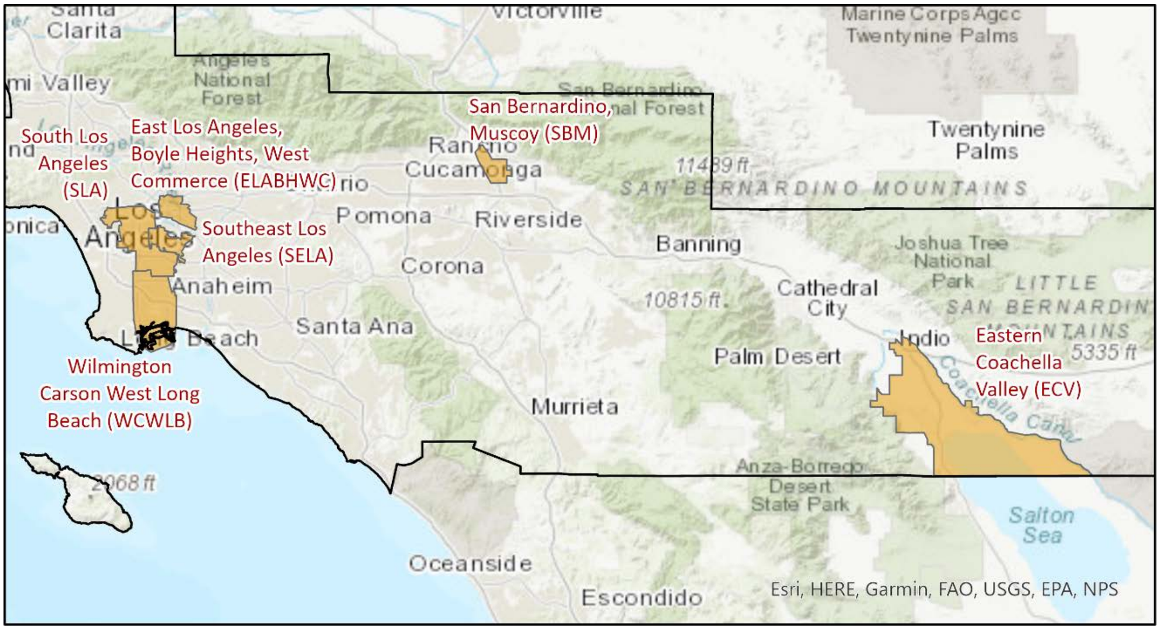


Figure 4-17: AB 617 Designated Communities in the South Coast AQMD

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

---

[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.

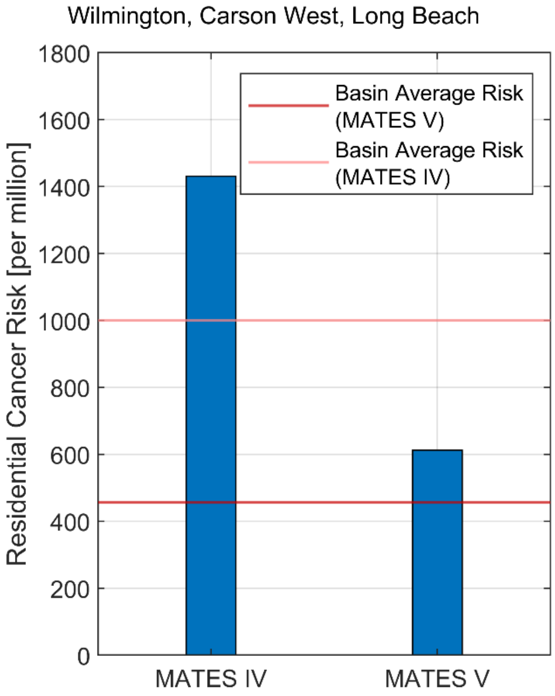


Figure 4-18: Population weighted average Residential Cancer Risk in Wilmington, Carson, West Long Beach.

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.

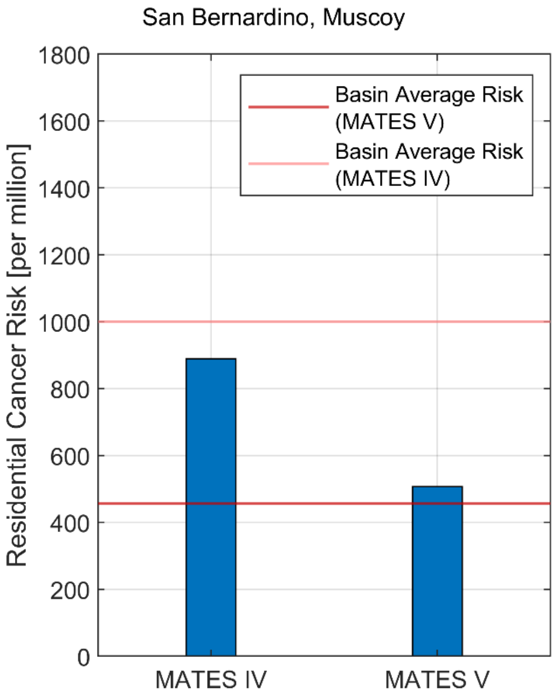


Figure 4-19: Population weighted average Residential Cancer Risk in San Bernardino, Muscoy.

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.

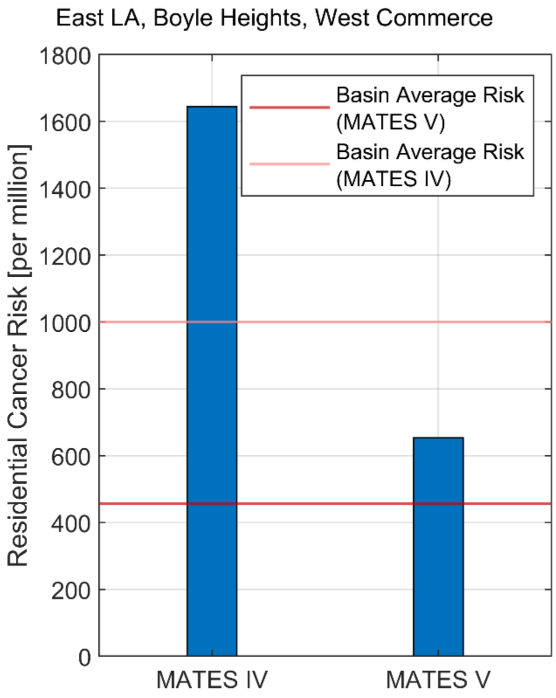


Figure 4-20: Population weighted average Residential Cancer Risk in East LA, Boyle Heights, West Commerce.

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.

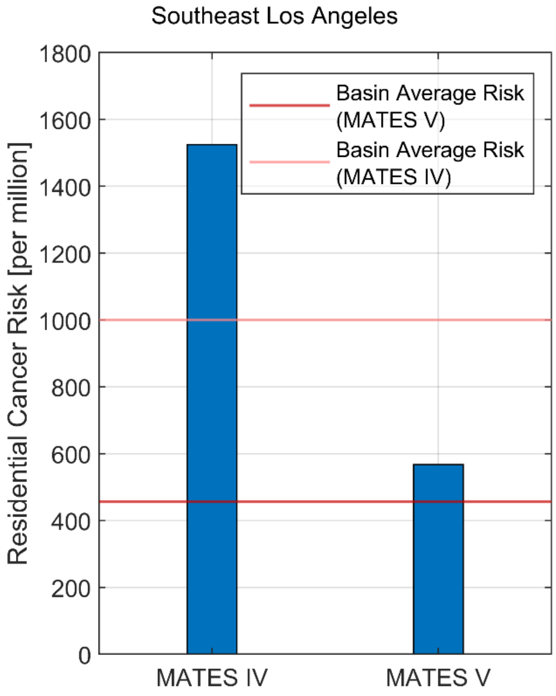


Figure 4-21: Population weighted average Residential Cancer Risk in Southeast Los Angeles.

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.

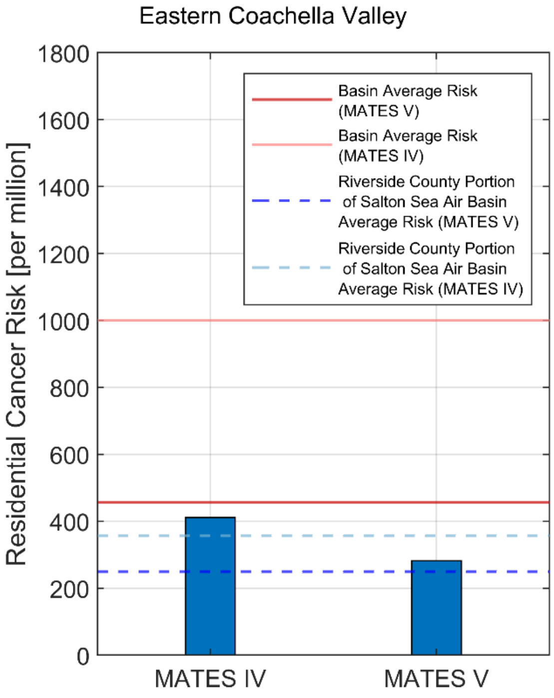


Figure 4-22: Population weighted average Residential Cancer Risk in Eastern Coachella Valley.

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.

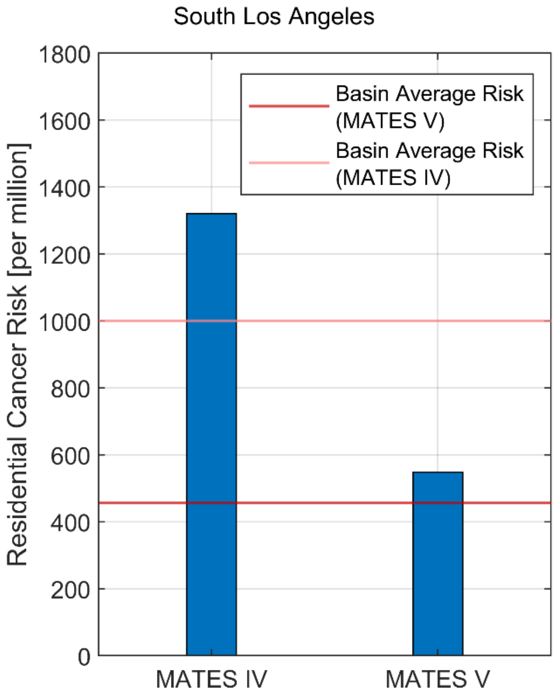


Figure 4-23: Population weighted average Residential Cancer Risk in South Los Angeles.

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.

---

[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,

---

[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.

Pico Rivera, and Rubidoux, and West Long Beach. Additional details about the monitoring sites, 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]

---

[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.

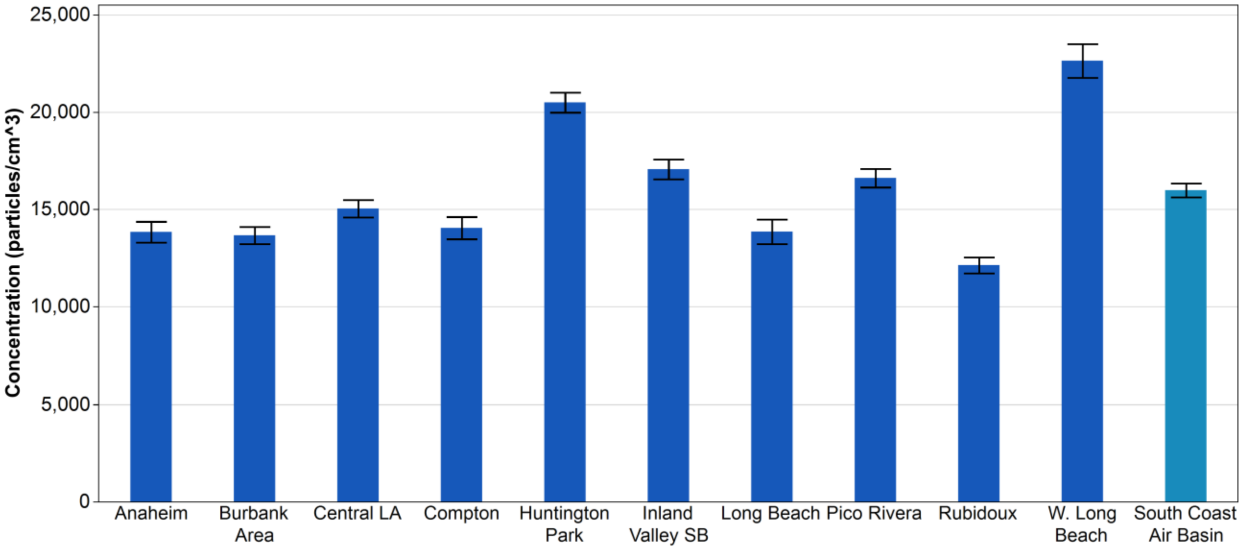


Figure 5-1. Ultrafine particle concentration mean and 95% confidence interval for each site and the South Coast Air Basin (10 site average)

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.

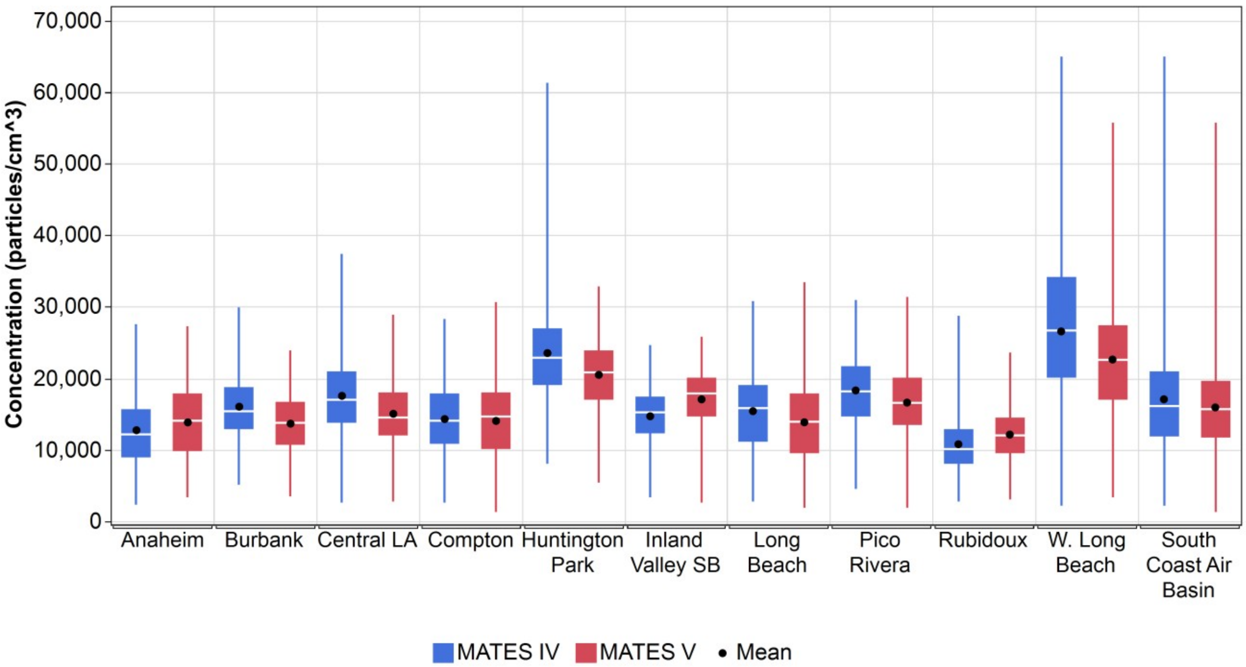


Figure 5-2. Box plots showing the daily average minimum, first quartile, median, third quartile, and maximum values at each site and SCAB (10 site average) for both MATES IV and V

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

---

[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

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.

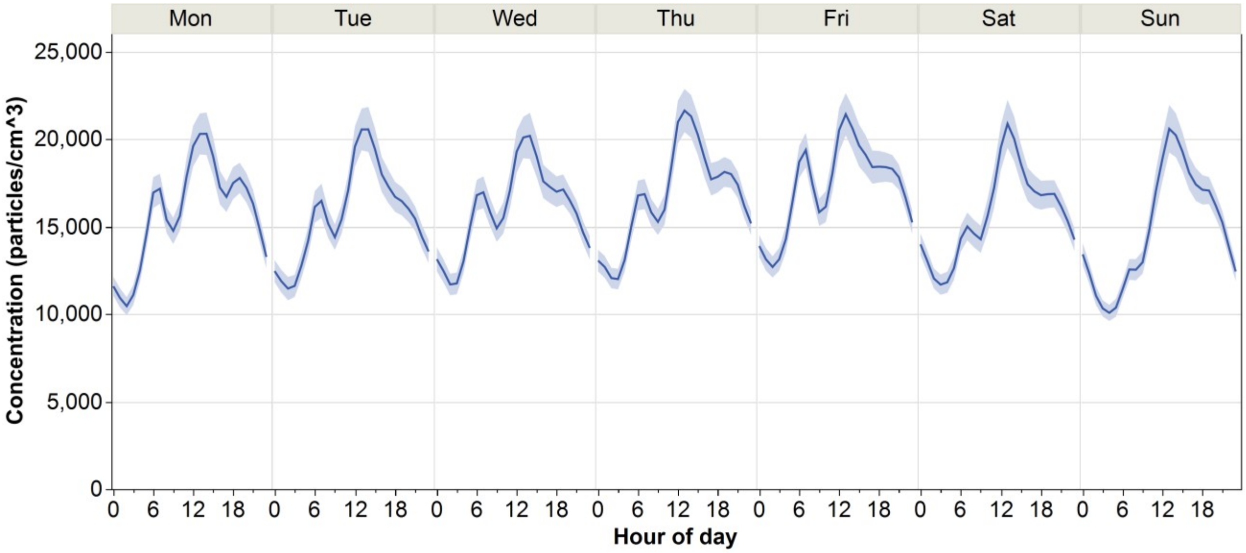


Figure 5-3. Diurnal profiles ultrafine particle concentration by day of week in the South Coast Air Basin. Error bands represent 95% confidence intervals. The hour of day times are shown for Pacific Standard Time (PST) and not adjusted for daylight savings time

---

[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.

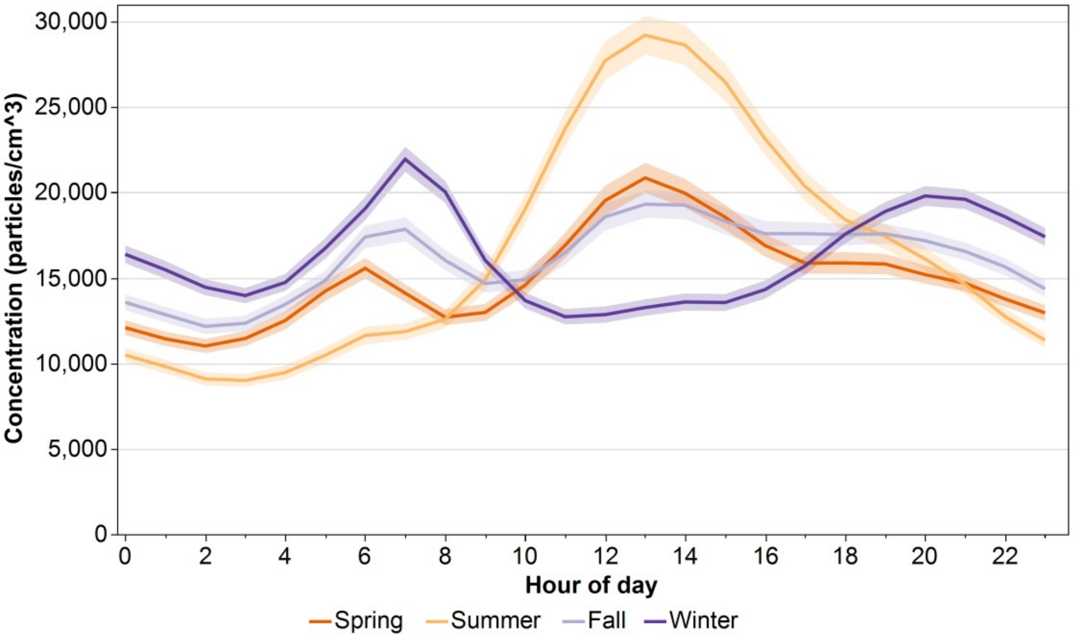


Figure 5-4. Seasonal diurnal profiles of ultrafine particle number concentration in the South Coast Air Basin (10 site average). Error bands represent 95% confidence intervals

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

---

[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.

secondary formation of UFP through photochemical reactions. In these months, the inversion layer 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).

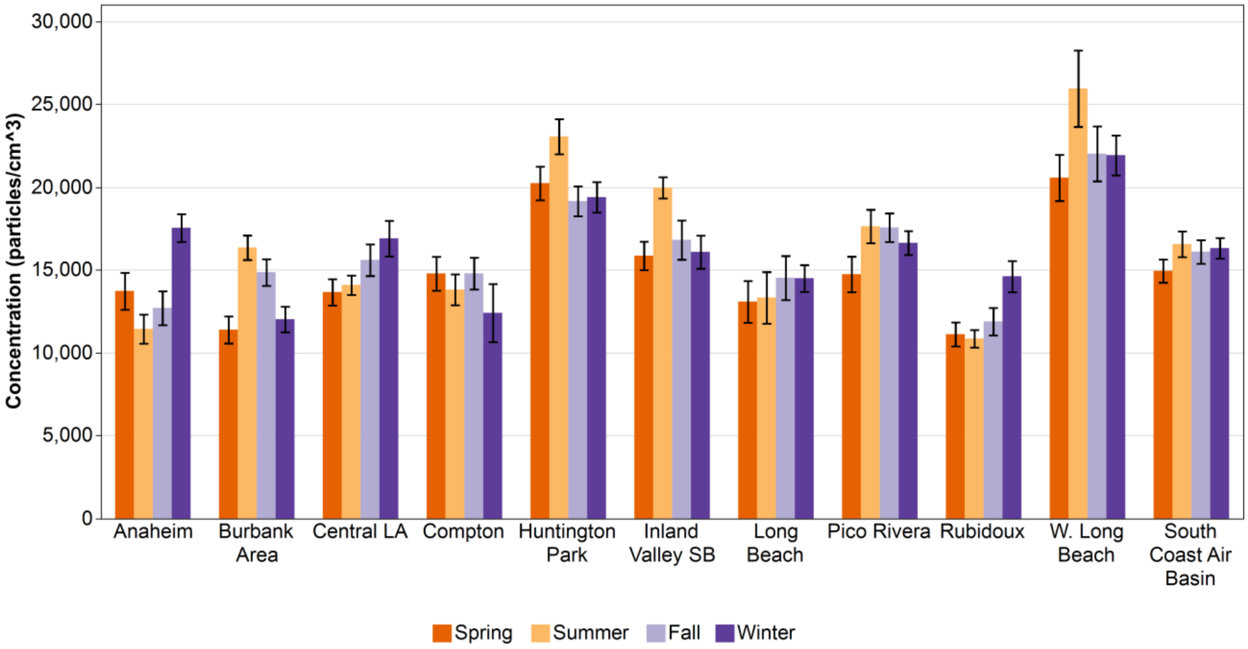


Figure 5-5. Average seasonal particle number concentration for each site and in the South Coast Air Basin (10 site average). Error bars represent 95% confidence intervals

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

---

[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

summer months. In the wintertime, emissions from primary sources dominate the UFP concentrations due to stagnant atmospheric conditions. In addition, the coastal region experiences 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

---

[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

---

[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.

impacts of diesel emissions, often result in reduction of soot levels.[35]

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

---

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

[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.

concentration across the 10 sites in the SCAB is 22% lower than what was measured during MATES IV.

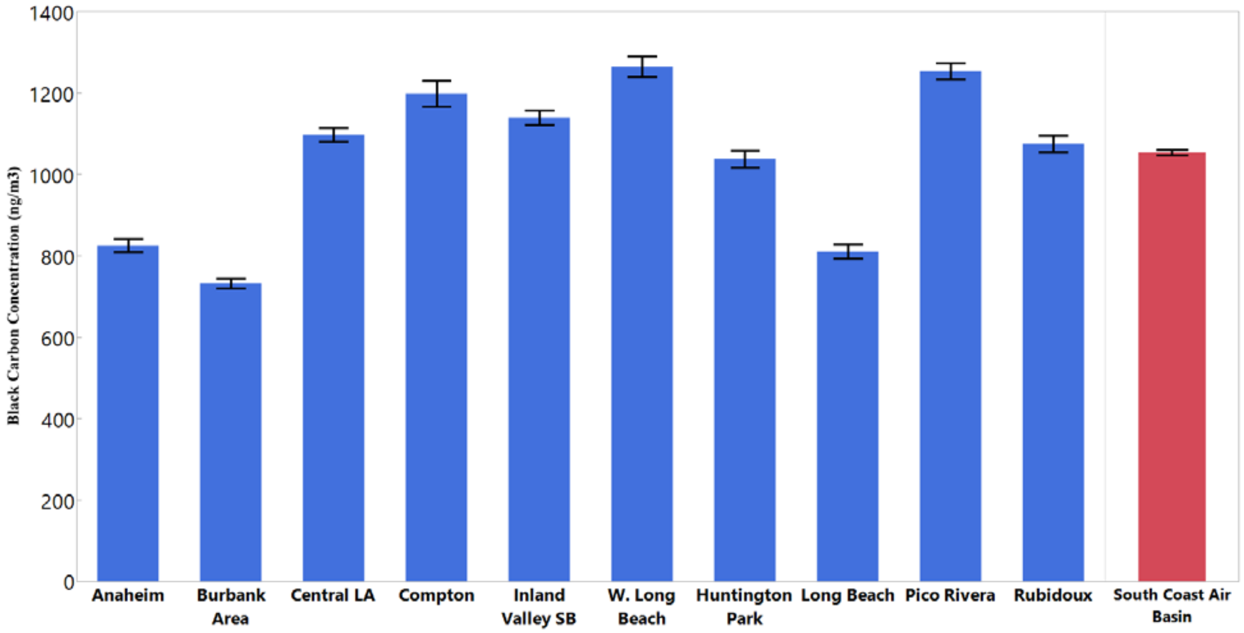


Figure 5-6. Black Carbon concentration average and 95% confidence interval for each site and the South Coast Air Basin (10 site average)

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.

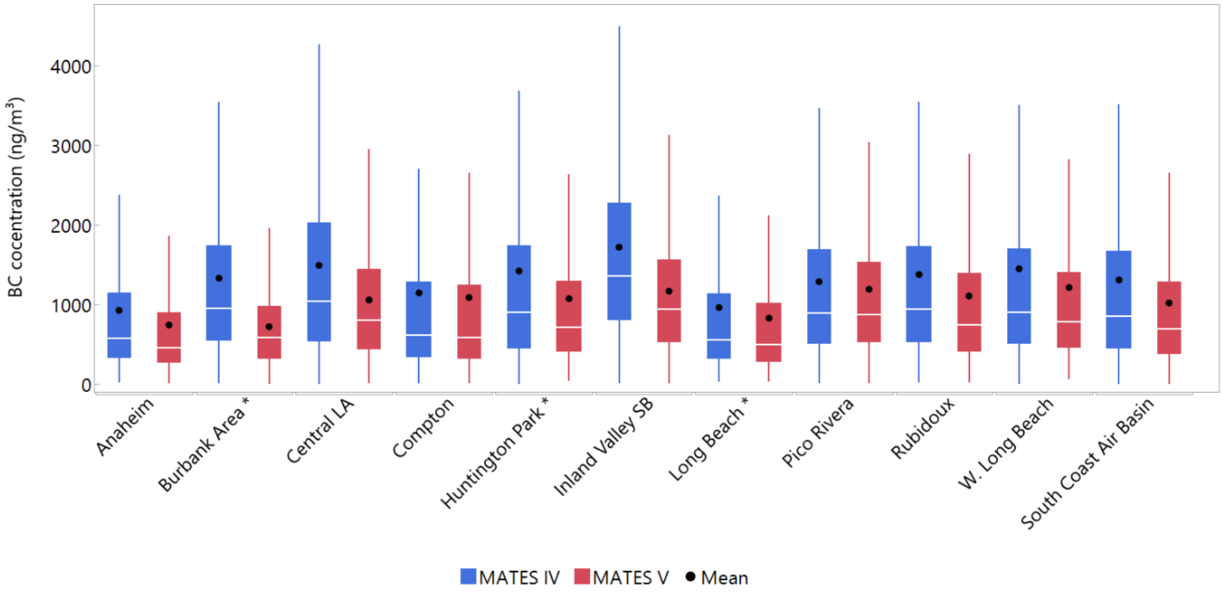


Figure 5-7. A comparison between the spatial distribution of BC levels during MATES IV and MATES V. *Refers to sites that have been relocated between the two study periods.

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).

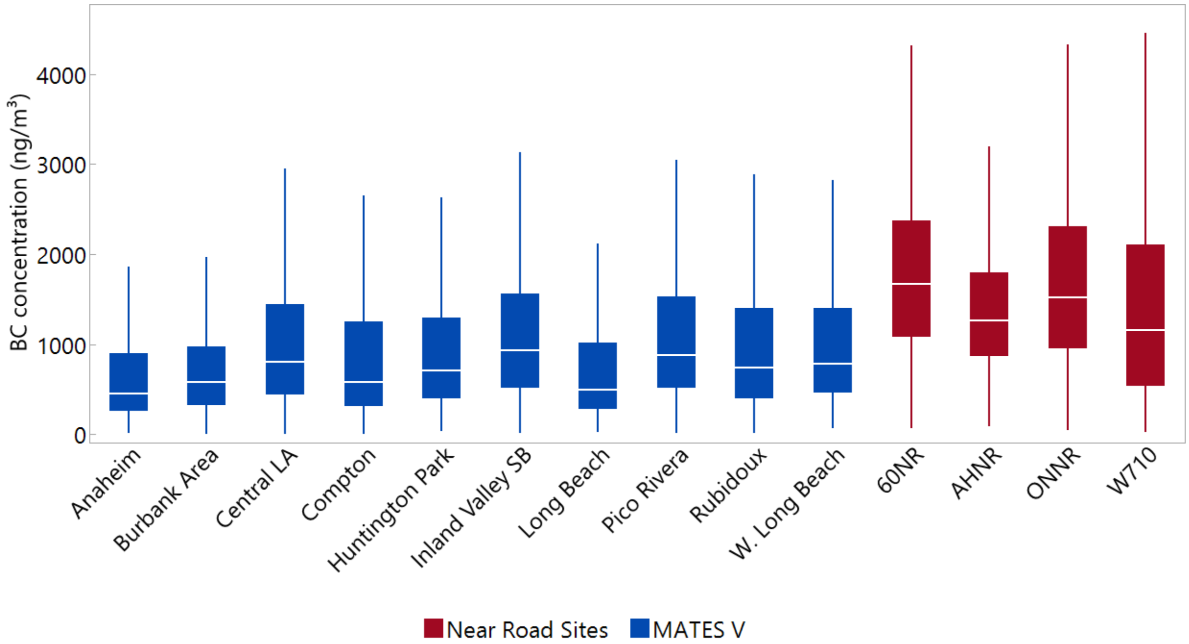


Figure 5-8. Boxplot comparison of BC concentrations between MATES V sites (blue) and near- road sites (red).

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.

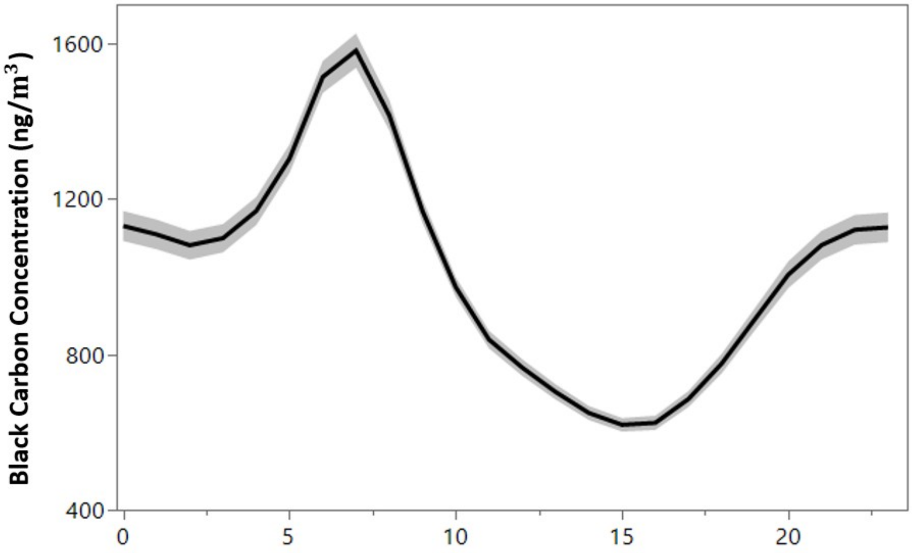


Figure 5-9. Diurnal variation of black carbon concentrations in the South Coast Air Basin during MATES V. Shaded area represents the 95% confidence level of the measurement.

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.

---

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

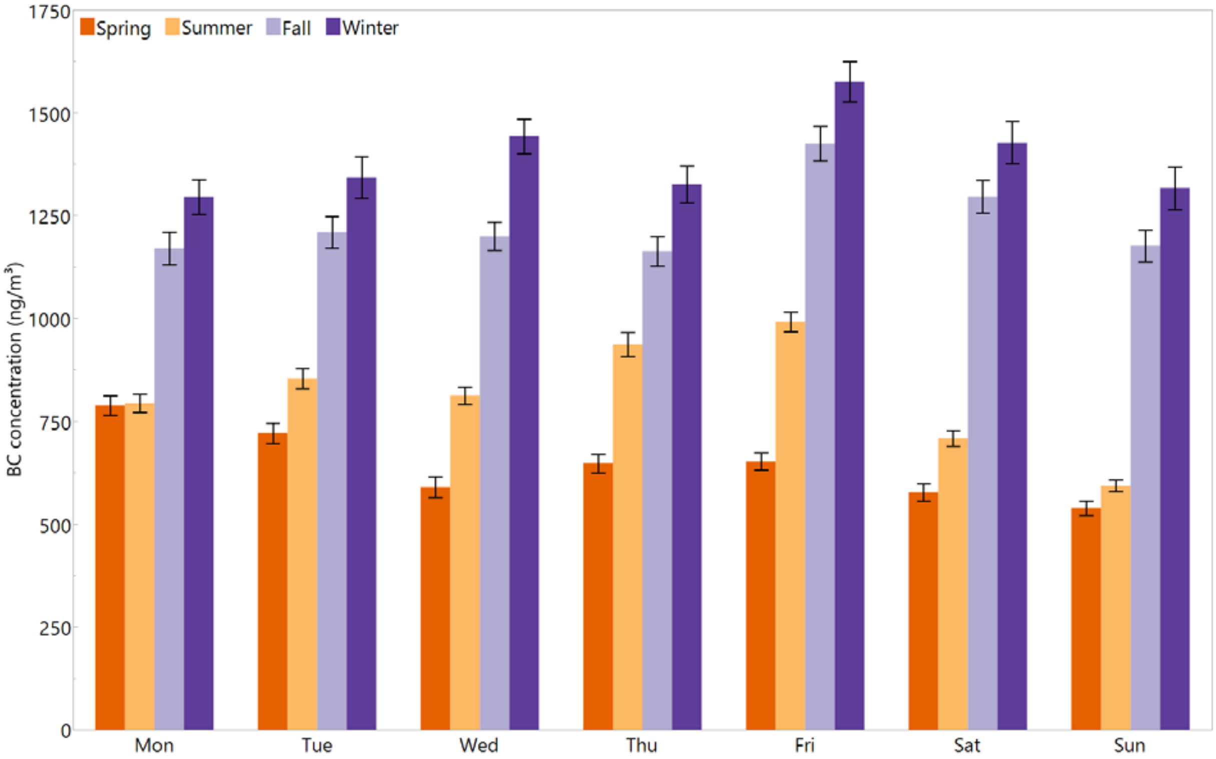


Figure 5-10. Seasonal day-of-week comparison of BC concentrations in the South Coast Air Basin during MATES V.

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.

MATES V

Multiple Air Toxics Exposure Study in the South Coast AQMD

FINAL APPENDICES
AUGUST 2021

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

Multiple Air Toxics Exposure Study V

MATES V

DRAFT FINAL APPENDICES

August 2021

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

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
GOVERNING BOARD

AUTHORS AND CONTRIBUTORS

South Coast Air Quality Management District

Executive Officer
Wayne Nastri

Chief Operating Officer
Jill Whynot

Deputy Executive Officer
Planning, Rule Development & Area Sources
Sarah Rees, PhD

Assistant Deputy Executive Officer
Planning, Rule Development & Area Sources
Susan Nakamura

Assistant Deputy Executive Officer
Planning, Rule Development & Area Sources
Ian MacMillan

Health Effects Officer
Planning, Rule Development & Area Sources
Jo Kay Ghosh, PhD, MPH

Deputy Executive Officer
Science and Technology Advancement
Matt Miyasato, PhD

Assistant Deputy Executive Officer
Science and Technology Advancement
Jason Low, PhD

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
Fred Lurmann, MS	Sonoma Technology, Inc.
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

MATES V List of Appendices

APPENDIX I

MATES V

DRAFT FINAL REPORT

Cancer Potency Factors and Chronic RELs

Appendix I

Cancer Potency Factors and Chronic RELs

The estimated concentration of a substance is combined with the cancer potency factors and Reference Exposure Levels (RELs) to estimate the potential for health effects. The calculations used in MATES 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 equations below show the cancer risk and chronic hazard index calculations.

$$\begin{aligned} &Potential\ Cancer\ Risk \\ &\quad = Concentration * Cancer\ Potency\ Factor * Cancer\ Multi\ pathway\ Factor \\ &\quad * Molecular\ Weight\ Adjustment\ Factor * Exposure\ Duration \end{aligned}$$

$$\begin{aligned} &Hazard\ Index \\ &= \frac{Concentration * Chronic\ Multi\ pathway\ Factor * Molecular\ Weight\ Adjustment\ Factor}{Chronic\ Inhalation\ REL} \end{aligned}$$

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 (California Office of Environmental Health Hazard Assessment, 2015). 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 (South Coast Air Quality Management District, 2017). The multi-pathway adjustment factors used in MATES V are shown in Table I-1.

For chronic non-cancer hazard index calculations, the annual average concentrations 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 the levels of that pollutant (or group of pollutants) are unlikely to cause chronic non-cancer risk health effects for any of the target organs. A hazard index greater than one does not mean that adverse health effects will occur, but rather that the risk of chronic non-cancer health effects increases with increasing levels of the pollutant.

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

Table I-1. OEHHA Cancer Potency Factors, Chronic RELs, and Multipathway Adjustment Factors for species analyzed in MATES V.

Species	**CAS/CARB Emittant ID**	**Inhalation Cancer Potency Factor (mg/kg-d)$^{-1}$**	**Multipathway Adjustment Factor for Cancer Risk**	**Chronic Inhalation REL (ug/m^3)**	**Multipathway Adjustment Factor for Chronic Non-Cancer Health Impacts**
Acetaldehyde	75-07-0	0.01		140	
Acrolein	107-02-8			0.35	
Arsenic	7440-38-2	12	9.71	0.015	88.03
Benzene	71-43-2	0.1		3	
Benzo(a)anthracene	56-55-3	0.39	23.12		
Benzo(a)pyrene	50-32-8	3.9	23.12		
Benzo(b)fluoranthene	205-99-2	0.39	23.12		
Benzo(k)fluoranthene	207-08-9	0.39	23.12		
Beryllium	7440-41-7	8.4		0.007	
Bromomethane	74-83-9			5	
1,3 Butadiene	106-99-0	0.6		2	
Cadmium	7440-43-9	15		0.02	1.98
Carbon Tetrachloride	56-23-5	0.15		40	
Chlorine	7782-50-5			0.2	
Chloroform	67-66-3	0.019		300	
Chrysene	218-01-9	0.039	23.12		
Cobalt	7440-48-4	27			
Dibenz(a,h)anthracene	53-70-3	4.1	7.99		
1,2-Dibromoethane	106-93-4	0.25		0.8	
1,4-Dichlorobenzene	106-46-7	0.04		800	
1,2-Dichloroethane	107-06-2	0.072		400	
Diesel Exhaust	9901	1.1		5	

Species	**CAS/CARB Emittant ID**	**Inhalation Cancer Potency Factor $(mg/kg\text{-}d)^{-1}$**	**Multipathway Adjustment Factor for Cancer Risk**	**Chronic Inhalation REL (ug/m^3)**	**Multipathway Adjustment Factor for Chronic Non-Cancer Health Impacts**
Ethyl Benzene	100-41-4	0.0087		2000	
Formaldehyde	50-00-0	0.021		9	
Hexavalent Chromium	18540-29-9	510	1.6	0.2	2.44
Indeno(1,2,3-c,d)pyrene	193-39-5	0.39	23.12		
Lead	7439-92-1	0.042	11.41		
Manganese	7439-96-5			0.09	
Methylene Chloride	75-09-2	0.0035		400	
Methyl tertiary-butyl ether (MTBE)	1634-04-4	0.0018		8000	
Naphthalene	91-20-3	0.12		9	
Nickel	7440-02-0	0.91		0.014	
Perchloroethylene	127-18-4	0.021		35	
Selenium	7782-49-2			20	195.58
Styrene	100-42-5			900	
Toluene	108-88-3			420	
Trichloroethylene	79-01-6	0.007		600	
Vinyl Chloride	75-01-4	0.27			
Xylene (m-, p-)	1330-20-7			700	

Table I-2. Species analyzed in MATES V that do not have OEHHA Risk Assessment Health Values for Cancer Potency or Chronic Non-cancer REL.

Species	**CAS/CARB Emittant ID**
Acenaphthene	83-32-9
Acenaphthylene	208-96-8
Acetone	67-64-1
Aluminum	7429-90-5
Ammonium Ion	14798-03-9
Anthracene	120-12-7
Antimony	7440-36-0
Barium	7440-39-3
Benzaldehyde	100-52-7
Benzo(e)pyrene	192-97-2
Benzo(g,h,i)perylene	191-24-2
Calcium	7440-70-2
Cesium	7440-46-2
Chloride	16887-00-6
Chromium	7440-47-3
Copper	7440-50-8
Coronene	191-07-1
Cyclopenta(c,d)pyrene	27208-37-3
1,2-Dichlorobenzene	95-50-1
1,2-Dichloropropane	78-87-5
EC1	
EC2	
EC3	
Elemental Carbon	
Fluoranthene	206-44-0

Species	**CAS/CARB Emittant ID**
Fluorene	86-73-7
9-Fluorenone	486-25-9
Galactosan	644-76-8
Iron	7439-89-6
Levoglucosan	498-07-7
Magnesium	7439-95-4
Mannosan	14168-65-1
Methyl Ethyl Ketone	78-93-3
Molybdenum	7439-98-7
Nitrate	14797-55-8
OC1	
OC2	
OC3	
OC4	
Organic Carbon	
PM2.5 Mass	88101
Perylene	198-55-0
Phenanthrene	85-01-8
Phosphorus	7723-14-0
Potassium	7440-09-7
Potassium Ion	24203-36-9
Propionaldehyde	123-38-6
Pyrene	129-00-0
Retene	483-65-8
Rubidium	7440-17-7
Samarium	7440-19-9

Species	CAS/CARB Emittant ID
Sodium	7440-23-5
Strontium	7440-24-6
Sulfate	14808-79-8
Sulfur	7704-34-9
Thallium	7440-28-0
Tin	7440-31-5
Titanium	7440-32-6
Total Carbon	
Uranium	7440-61-1
Vanadium	7440-62-2
Yttrium	7440-65-5

References

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

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

APPENDIX II

MATES V

DRAFT FINAL REPORT

MATES V Technical Advisory Group Roster

Appendix II

MATES V Technical Advisory Group Roster

NAME	REPRESENTING	EMAIL
Michael Benjamin	CARB	mbenjami@arb.ca.gov
Judy C. Chow, ScD	DRI	Judy.Chow@dri.edu
Maria Costantini, PhD	HEI	mconstantini@healtheffects.org
Kenneth Davidson, MEM, BA	USEPA	davidson.ken@epa.gov
Rob Farber, PhD	Consultant	farberrj@yahoo.com
Dennis Fitz, MS	UCR	dfitz@cert.ucr.edu
Ramine Cromartie	WSPA	rcromartie@wspa.org
Scott Fruin, DEnv	USC	saffron@fastmail.com
Scott Herndon	Aerodyne	herndon@aerodyne.com
Uduak-Joe Ntuk	CalGEM	Uduak-Joe.Ntuk@conservation.ca.gov
Michael Kleinman, PhD	UCI	mtkleinm@uci.edu
Robert Krieger	CARB	rkrieger@arb.ca.gov
Fred Lurmann, MS	Sonoma Tech	fred@sonomatech.com
Julia May	CBE	jmay@sbcglobal.net
Eduardo (Jay) Olaguer	HARC	eolaguer@HARCresearch.org
John D. Budroe, PhD	OEHHA	john.budroe@oehha.ca.gov
Constantinos Sioutas, ScD	USC	sioutas@usc.edu
Jochen Stutz	UCLA	jochen@atmos.ucla.edu
Yifang Zhu, PhD	UCLA	yifang@ucla.edu

Updated April 2021
Previous Members:
Andrea Hricko – USC
Andrew Salmon – OEEHA
Bridget McCann – WSPA
Diane Bailey – NRDC
John Froines – USC
Michael Flagg – USEPA

APPENDIX III

MATES V

DRAFT FINAL REPORT

Monitoring and Laboratory Analysis Protocol

DISCLAIMER

Any or all reference made in this Appendix to a specific product or brand name does not constitute an endorsement of that product or brand by the South Coast Air Quality Management District.

Appendix III

Monitoring and Laboratory Analysis Protocol

III.1. INTRODUCTION

III.1.1 Background

In 1986, the South Coast Air Quality Management District (South Coast AQMD) performed a study of ambient air toxics impacts in the South Coast Air Basin. Although this study involved only limited measurements, it was an important beginning of the Multiple Air Toxics Exposure Study (MATES). In 1998, the South Coast AQMD conducted a follow up to that initial study, but included an intensive ambient air toxics monitoring program, which became MATES II. The objective of MATES II was to establish a baseline of existing air toxics ambient emissions, exposure and risk level data and an assessment of model accuracy. Sampling for MATES II was performed over a one-year period at ten sites throughout the South Coast Air Basin (Basin). The MATES II Final Report was approved by the South Coast AQMD Board in March 2000.

As a follow up study to MATES II, MATES III was conducted from April 2004 through March 2006. The initial scope of the study was for one year, however, sampling continued for a second year due to concerns of the impact of heavy rains on data collected during the first year. The MATES III Final Report was published in September 2008.

From July 2012 through July 2013, MATES IV monitoring was performed to build upon prior ambient toxics data sets, to evaluate spatial and temporal trends and better understand current risk associated with air toxics in the Basin. Black carbon (BC) and ultrafine particle (UFP) measurements were included in this study. The MATES IV report was released in May 2015[1].

For MATES V, sampling was conducted for a year from May 2018 through April 2019. In addition to continued monitoring efforts for air toxics measured in previous MATES, this study incorporated measurements for biomass burning indicators (sugars) and bromomethane (methyl bromide).

---

[1] South Coast Air Quality Management District (2015). *MATES IV*. https://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-iv

III.2. MONITORING EQUIPMENT

III.2.1 Introduction

For the purposes of this appendix, the descriptions and operational and maintenance procedures of the following equipment are stated.

Table III-2-1. MATES V Samplers

Sampler Type	**Vendor and Model Number**
Volatile Organic Compounds (VOCs)	Xontech 910A/ 912
Carbonyls	ATEC 8000
Metals, Hexavalent Chromium (Cr^{+6})	Xontech 924
$PM_{2.5}$ Speciation	Met One Instruments SASS
Black Carbon (BC)	Teledyne API 602 (Aethalometer)
Ultrafine Particles (UFPs)	Teledyne TSI 651 (CPC)
Polycyclic Aromatic Hydrocarbons (PAHs)	TISCH Polyurethane Foam (PUF+)

The siting, acceptance testing, and calibration functions for each type of equipment identified above are defined below.

III.2.2 Equipment Characteristics

III.2.2.1 Siting

A) Monitoring site selection criteria was the same for all fixed sites. Site uniformity was achieved to the greatest degree possible. Descriptions were prepared for all sampling sites and can be found in the South Coast AQMD Annual Network Plan[2]. The description includes, at a minimum, the type of ground surface, the direction, distance, and approximate height to any airflow obstruction, and the direction and distance to any local pollutant sources.

B) The sampler platform was located in an area with unobstructed airflow, especially in the direction of any known sources of the sampled compounds. This is critical since turbulence and eddies from obstructions will cause non-representative results. The distance between an obstruction and the sampler is not to be closer than two times the height of the obstruction.

---

[2] South Coast Air Quality Management District (Current). *Monitoring Network Plan*. http://www.aqmd.gov/home/air-quality/clean-air-plans/monitoring-network-plan

C) Locations significantly influenced by nearby pollutant sources, activities potentially impacting air quality, or where reactive surfaces may cause chemical changes in the air sampled were avoided. Micro-meteorological influences caused by nearby hills, bodies of water, valley drainage flow patterns, etc. were considered when selecting a monitoring site.

D) The recommended intake probe height for criteria pollutants is 3 to 15 meters above ground level as near breathing height as possible with the additional criteria that a site is not placed where a building is an obstruction or where equipment is easily vandalized.

E) The probe extends at least two meters away from the supporting structure. If the probe is located on a building, it is mounted on the prevailing windward side of the building.

III.2.2.2 Acceptance Testing

Acceptance testing was performed on all instrumentation and sampling equipment approximately one month after receipt. After acceptance testing was completed and instruments were found to meet acceptance criteria, they were deployed in the field and ambient sampling commenced. Acceptance testing was conducted according to the following steps:

A) All instruments were carefully unpacked from their shipping containers and checked for completeness, broken parts, and correct subunits.

B) The units were assembled according to manufacturer guidelines and prepared for start-up.

C) The flowrate/flow meter portion of the pneumatic system, if any, was checked using the most appropriate calibration-transfer standard to verify the operating flow/flowrate.

D) Timer accuracy was evaluated by comparing it to an elapsed-timer standard. All timers must hold their accuracy to ±5 minutes over a 24-hour period.

E) Any deficiency was corrected and addressed following the manufacturer's recommendations and procedures as stated in operations manuals.

III.2.2.3 Calibration

At each sampling site, final dynamic calibrations were performed on each analyzer and sampler prior to the start of the program. At the end of the sampling period, an "As Is" calibration was performed on each analyzer to ascertain the amount of analyzer drift.

III.2.2.4 Sample Pickup

The sampling media were prepared in the South Coast AQMD laboratory and retrieved by Air Quality Instrument Specialists (operators). Filters and carbonyl cartridges were transported at <4°C in coolers with blue ice and the canisters were capped during transportation. Once the filters and carbonyl cartridges were used to collect samples, they were refrigerated at <4 °C until returned to the South Coast AQMD Laboratory.

III.2.2.5 Troubleshooting

The routine maintenance and quality control checks were based on U.S. EPA *Quality Assurance Project Plan for the Air Toxics Monitoring Network* [3] and U.S. Environmental Protection Agency (EPA) *National Air Toxics Trends Stations Technical Assistance Document* (NATTS TAD)[4]. For the instruments that were not included in the NATTS program, a maintenance guide based on the equipment manufacturers suggested operating procedures was the basis for maintenance activity including frequency and quality control checks for each instrument. If an instrument drifted out of the criteria, or if there was a component failure, the operator immediately contacted the South Coast AQMD STA/AM Support and Repair Section to schedule a repair.

III.2.2.6 Repair

The potential failure of instrument and equipment components such as pumps and flow controllers were addressed by South Coast AQMD maintaining an inventory of staff replaceable spare parts.

III.2.3 SAMPLING EQUIPMENT

III.2.3.1 Xontech 910A and 912

III.2.3.1.1 Xontech 910A - Description

The Xontech 910A air sampler is designed to take air samples at a constant flow rate for a known sampling period. It is durable, serviceable and accurate within NATTS program criteria, making it useful for sampling a wide variety of gases.

Specifically, the 910A sampler takes air from the sample inlet and injects it into a canister at a constant flow rate for the preset duration. Excess air is exhausted through a bypass exhaust. The constant flow rate and elapsed time allow the operator to calculate the integrated air sample volume. Airflow to the canister is uniformly maintained by a mass flow controller that fills each canister with a representative sample volume and sufficient pressure for analysis. The Xontech 910A is operated according to the guidelines documented in the South Coast AQMD SOP00080 *Standard Operating Procedure for Xontech 910 Canister Sampler/912 Multi-Channel Controller*.

---

[3] U.S. EPA. (2001). *Quality Assurance Project Plan for the Air Toxics Monitoring Network.* https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=200120XJ.PDF

[4] U.S. EPA (2016). *Technical Assistant Document For The National Air Toxics Trends Stations Program.* www3.epa.gov/ttn/amtic/files/ambient/airtox/NATTS%20TAD%20Revision%203_FINAL%20October%202016.pdf

III.2.3.1.2 Xontech 912 - Description

The Xontech 912 adapter may be added to the Xontech 910A to enhance sampling capability over a reduced duration. It cannot operate independent of the 910A. It is designed to route gas samples to a maximum of 16 canisters. An internal time base can be used to step a rotary valve from canister to canister at a user-selected rate. The 912 also accepts timing signals from the model 910A. The Xontech 912 adapter was operated according to the procedures in the South Coast AQMD SOP00080, *Xontech 910 Canister Sampler/912 Multi-Channel Controller.*

III.2.3.1.3 Cleanliness Check

To ensure data quality objectives are met, sampling units are checked for contamination and bias following the South Coast AQMD Standard Operating Procedure for *Time-Integrated And Instantaneous Canister Sampling*, SOP 00199. To perform a system bias check, zero air was passed through the sample manifold to fill one, 3-hour canister. Additionally, the 24-hour sampler was tested by increasing its sample flow to fill a canister in approximately 6 hours. A field blank canister was filled at the site by flowing zero air into an evacuated cylinder. A difference of less than 1 part per billion (ppb) per compound between the field blank and the bias test samples is the acceptance criteria for this test and indicates that the system is not contaminated (non-biasing). A value greater than 1 ppb per compound required investigation and corrective action. A system bias check was repeated until all biases were demonstrated to be eliminated. The District's Ambient Monitoring Support Group performed system repairs. This group assembled, leak checked, disassembled, and cleaned the sample manifold, and the Auditing Group calibrated the mass flow controller (MFC) for flow.

III.2.3.1.4 Canister Sample Pickup

Field operators retrieved verified clean silica lined stainless steel canisters from the South Coast AQMD Laboratory. Evacuated canisters were transported by vehicle to the respective air monitoring stations. Each canister had an informational tag attached (Appendix III-E). This tag contains the following information: sample site, operator initials, and sample date. The air monitoring station operator recorded sampling information on this tag once the canister was set up for sampling. Once the canister was filled and disconnected from the 910A or 912 sampler, and prior to returning the sampled canister to the Laboratory, the canister number, start vacuum, end pressure (psig), and elapsed time was recorded on the MATES V sample log (Appendix III-D). The times on the QC chart was also checked and adjusted. This value was required to be within ± 10 minutes of actual Local Standard Time.

III.2.3.2 ATEC 8000

III.2.3.2.1 Description

The ATEC Model 8000 sampler is designed for the unattended collection of ambient air samples used in the determination of carbonyl compounds (aldehydes and ketones) in ambient air using acidified DNPH cartridges, according to EPA Compendium Method TO-11A. The ATEC 8000 has eight ports; each port can be programmed to collect samples over a specific time period.

Flow rates are regulated using mass flow controllers (MFC). Optional channels can be configured for collocated sampling. A touch screen display provides information on the samples, including sampling date, start time, stop time, average flowrate, minimum flowrate, maximum flowrate, total volume sampled, sampling time duration, and error status.

III.2.3.2.2 Operation

To setup for sampling, the operator attaches the DNPH cartridges to the ATEC sampler and programs the instrument for collection of samples by selecting the channels/ports used and entering sampling parameters (flow rate, start time, stop time) and identification labels. Leak checks are performed prior to sampling to verify cartridge connections are leak free prior to sampling. Detailed operational procedures are available in the South Coast AQMD SOP 00119, *ATEC Model 8000 Automated Sampler.*

III.2.3.3 Xontech 924

III.2.3.3.1 Description

The Model 924 Toxic Air Samplers are designed to collect ambient air particulate samples on a variety of filter materials and sorbent media in unattended field use. Samples collected using this sampler were brought to the South Coast AQMD headquarters for Laboratory analysis. The sampler controls the sampling time and flowrate through each sampling head using a microprocessor and mass flow controller (MFC). Sampler design is modular to facilitate installation of individual sampling channels. Each sampler accommodates eight sampling channels for two types of sample collection media: one that accepts 37- or 47-millimeter filters and another that accepts sorbent tubes.

The sampler consists of three modules, each contained in a separate enclosure. The heart of the system is the control module. This module contains the microprocessor, controller, mass-flow controllers, and front panel, displays, printer, and keypad. The difference between the Model 920 and 924 is that the electronics have been upgraded in the 924 to reflect the increase in microprocessor functionality presently available that was not available in the circa 1995 Model 920. The sampling module is equipped with isolation valves that protect the sampling media from passive sampling before or after sampling or sample loss after sampling. The sampling inlet height is 1.2 meters above ground level. The third element of the sampler is the pump module. It contains the vacuum pump that provides capacity for simultaneous operation of three, 30 liters per minute (lpm) and 200 cubic centimeters per minute (ccm) sampling channels.

III.2.3.3.2 Operation

To use the sampler, the operator inserts the sample filter cassette or sorbent tube into the sampling head and keys in the filter or sorbent head number. Start and stop times, and flow rates are pre-programmed or can be manually input. Following the sampling period, a report is automatically printed which is removed from the printer and submitted to the Laboratory with the filter for analysis.

Operational specifications are discussed in South Coast AQMD SOP 00094, *RM Environmental Systems Inc. (RMESI) 924 Toxics Sampler*.

III.2.3.4 MET One SASS

III.2.3.4.1 Description

The MET One Speciation Air Sampling System (SASS) accommodates up to five sampling canisters which can hold multiple 47-millimeter filters to capture PM2.5 particles. The PM2.5 separation is produced by a sharp cut cyclone (SCC) that removes both solid and liquid coarse particles. Particle penetration through the SCC mimics the PM2.5 cutoff curve of the WINS impactor as defined by the U.S. Environmental Protection Agency. All routine maintenance can be done in the field. Filter containers are transported to the Laboratory for inspection, cleaning and unloading/loading of sampling substrates. Every element of the sampler contacted by the sampled air stream ahead of the filter, including the inlet can be cleaned with each sample change. The SASS was designed with individual sharp cut cyclone inlets. Particles larger than 2.5 micron aerodynamic diameter are removed by the cyclonic inlet mounted with each filter container. The filter containers are equipped with a diffusion denuder ahead of the filter to remove selected gaseous compounds. Additional sampler description and operation is available in the South Coast AQMD Standard Operating Procedure, SOP00086 for the *Collection of PM2.5 Air Samples with the Met One Instruments Speciation Air Sampling Systems (SASS) SOP00086*.

III.2.3.4.2 Module and Media Description

The integrated SASS canister contains the following components: a sharp cut cyclone, a denuder to remove nitric acid or ammonia gases, a 47 mm front filter for particle capture, a 47 mm tandem or backup filter as needed, and a cover to protect the components.

Several types of filter media are needed for assaying the different chemical constituents of ambient air particles. The chosen filter media are suitable for the type of analysis intended. For example, Teflon filters were used for gravimetric mass and trace metal determinations. Quartz fiber filters were used for elemental and organic carbon analysis as well as anions and cations analysis.

III.2.3.5 Black Carbon Measurements Using an Aethalometer

The term soot often refers to impure carbon particles resulting from the incomplete combustion of fossil fuels and various types of biomass burning. Soot is a key component of atmospheric aerosols because of its strong ability to absorb solar radiation, causing a warming effect on global and regional climate. Soot is also of interest because of its potential adverse health effects.

Various analytical methods have been developed to quantify the concentration of atmospheric soot. Depending on the measurement method used, the non-Organic Carbon fraction of soot is referred to as Black Carbon (BC) or Elemental Carbon (EC). While BC is an "optical term" that is used to denote strong light-absorbing carbon, EC is a "chemical term" that refers to thermal-refractory carbon with a graphite-like structure. Thus, BC and EC are two methodologically defined species that are typically measured using optical (summarized here and described in greater detail in Appendix VI) and thermal-optical methods (described in section III.2.3 of this Appendix), respectively.

The Aethalometer® (developed by Magee Scientific, Berkeley, CA) is an instrument that uses optical analysis to determine the mass concentration of BC particles collected from an air stream passing through a filter. Aethalometers are the most common instruments used to measure BC in real time. The operation of the Aethalometer is described in detail in the South Coast AQMD's *Standard Operating Procedure For the Operation, Maintenance, and Calibration of the Aethalometer – Teledyne "Dual Spot" Model 633 (Magee/Aerosol AE33)*, SOP00142. During sampling, the gas stream (frequently ambient air) briefly passes through a filter material which traps the suspended particulates, creating a deposit of increasing density. A light beam projected through the deposit is attenuated by those particles which are absorbing ('black') rather than scattering ('white'). Measurements are made at successive regular time intervals. The increase in attenuation from one measurement to the next is proportional to the increase in the density of optically absorbing material on the filter. This, in turn, is proportional to the concentration of the material in the sampled air stream. The sample is collected as a spot on a roll of filter tape. When the density of the deposit spot reaches a pre-set limit, the tape advances to a fresh spot and the measurements continue. Measurement of the sample gas flow rate and knowledge of the instrument's optical and mechanical characteristics permit a calculation of the average concentration of absorbing particles in the gas stream during the sampling period. Aethalometers may operate on time-base periods as rapid as 1 second, providing quasi-real-time data. One minute to one-hour averages are commonly used in most field applications. Comparison of aethalometer data with other physical and chemical analyses allows the output to be expressed as a concentration of BC. A more detailed description of the Magee Scientific Aethalometer along with monitoring results can be found in Appendix VI.

III.2.3.6 Ultrafine Particle (UFP) Measurements

Ultrafine Particles (UFPs) are typically defined as particles with an aerodynamic diameter less than 100 nm. UFPs are emitted from both natural and anthropogenic sources, although in most urban environments vehicular fossil fuel combustion constitutes the major contributing source. The terms UFPs and nanoparticles (NP; diameter < 0.05 µm) are sometimes used interchangeably, and the definitions of each generally vary with the study or application. While fine particulate matter ($PM_{2.5}$) dominates the mass distribution of atmospheric particles, UFPs account for about 90% of the total particle number. For this reason, their concentration is usually expressed in terms of total particle count (i.e. # per cubic centimeter of sampled air, or $\#/cm^3$), even though a small fraction of the particles being counted may be above 100 nm.

Condensation Particle Counters (CPCs) are instruments that provide the total number concentration of particles above a lower size limit (~3-20 nm, depending on make and model) in real-time. By mean of CPCs, UFPs are grown through condensation in a controlled super-saturation environment to larger sizes and then measured/counted using a photodetector. Although CPCs are the most widely used instruments in most applications, they do not provide any information on the original size of the particles counted.

The CPC used to measure the ambient number concentration of UFPs at the ten fixed MATES V sites is commercialized by Teledyne Advanced Pollution Instrumentation PI (Teledyne API, San Diego, CA). This particular model (651) was specifically designed for network operation and its performance was evaluated by South Coast AQMD Staff prior to the beginning of MATES IV. The Teledyne 651 CPC utilizes a patented laminar-flow, water-based condensation growth technique. Particles which are too small (nanometer scale) to scatter enough light to be detected by conventional optics are grown to a larger size by condensing water on them. An air sample is continuously drawn through the CPC inlet via an external pump and a portion of the flow is sent to the exhaust as bypass flow. The aerosol sample is pulled through a cool region saturated with water vapor and its temperature is equilibrated. The sample then passes to a growth section where wetted walls are heated to produce an elevated vapor pressure resulting in a thermodynamic "supersaturation" condition. The small cool particles in the flow stream act as nuclei for condensation and grow into micron sized droplets. The droplets are passed through a laser beam and create a large light pulse. Every particle pulse event is detected and counted. In this technique, particle concentration is measured by counting every particle in the air stream. The CPC model 651 is able to detect particles as small as 7 nm in diameter and is operated with an upper size cutoff of approximately 600 nm. The detection range is between 0 and 1,000,000 #/cm^3. The instrument is operated according to South Coast AQMD’s SOP00143, *Operation, Maintenance, and Calibration of Teledyne’s Ultrafine Particle Monitor Model 651.*

III.2.3.7 Polycyclic Aromatic Hydrocarbons (PAH)

Polycyclic Aromatic Hydrocarbons (PAHs) are collected using TISCH Environmental Polyurethane Foam (PUF+) samplers designed to hold a circular 4-inch diameter quartz fiber filter and a 2.5 inch diameter by 5 inch long cylindrical glass cartridge containing a 3 inch PUF sorbent trap and granular solid sorbent material. The South Coast AQMD Laboratory staff prepared sample collection canisters using sampling media supplied by ERG, deconstructed the samples post-sampling, and mailed samples back to ERG for analysis. The South Coast AQMD Instrument Technicians setup the PUF instrument for sample collection, retrieved the canisters after sampling, and returned PUF samples to the South Coast AQMD Laboratory for deconstruction. Chain of Custody was maintained beginning from receipt of sampling media from ERG until the samples were shipped to ERG for analysis. South Coast AQMD staff was responsible for calibrating, calculating and reporting of the total air volume of each sample. This included calibration of the sampling instrument flow rate. The TISCH sampler was operated and maintained according to SOP00114, Standard Operating Procedure for TISCH PUF+ POLY-URETHANE FOAM (PUF) SAMPLER. A short method description is given in Appendix III-K.

III.3. LABORATORY PROCEDURES

III.3.1 Introduction

In 2008 the National Air Toxics Trends Stations (NATTS) program was implemented in the South Coast Air Basin. Some of the existing sampling instruments for NATTS, additional U.S. EPA programs, and South Coast AQMD programs, were utilized in MATES V. Hence, many of the procedures and protocols for the MATES V program were based on the South Coast AQMD

Quality Management Plan for Environmental Measurement Programs (2016), the South Coast AQMD *Quality Assurance Project Plan (QAPP) for PM2.5 Speciation Program* (2013), and the EPA NATTS TAD[5]. However, MATES V also utilizes several analytical methods not performed under the federal programs and the procedures included herein are based upon manufacturer's measurement and quality control procedures that are intended to ensure that the data quality is suitable for the intended purposes of MATES V.

The South Coast AQMD utilized Air Quality Instrument Specialists to collect, retrieve, and deliver samples to the Laboratory. The Laboratory sample custodians handled sample logging within the South Coast AQMD Laboratory. Procedures for proper sampling and initial chain-of-custody are outlined in the South Coast AQMD standard operating procedures (SOPs).

III.3.2 SAMPLE HANDLING

All sampling media were handled according to Laboratory standard practices for toxics analysis and particulate matter network programs, as applicable. Operators completed the sampling information and chain-of-custody forms[6], and delivered samples to the Laboratory for receipt by sample custodians. .

III.3.2.1 Canister Cleaning

The South Coast AQMD Laboratory has a canister cleaning oven system operated according to SOP00091 *"Canister Cleaning System (CCS) Ovens 3 & 4 Toxics."* These systems use humidified nitrogen to flush and clean canisters in a heated oven to less than 5 ppb total non-methane organic carbon (TNMOC). The canisters are held at 80ºC and are flushed a minimum of seven times over a 2 ½ -hour period. Canisters are removed from the canister cleaning oven and batch analyzed for residual hydrocarbons. Data collected in performance of SOP00091 demonstrates the cleaning procedures satisfy cleanliness requirements and long-term experience has proven that the canister-cleaning oven system is sufficient to provide clean canisters meeting federal PAMS and NATTS cleanliness requirements. Any hydrocarbons and TNMOC above the threshold concentrations in one or more canisters trigger investigation and corrective action. All canisters (8) in the batch are re-cleaned and tested again to assure they meet cleanliness requirements. The cleaning date and operator are noted on the canister tag and in an electronic database that serves as the primary chain-of-custody.

III.3.2.2 Field Canister Use

Canisters are transported by Instrument Specialists to the site and are installed in accordance with the South Coast AQMD Standard Operating Procedure for *Xontech 910A Canister Sampler/912 Multi-Channel Controller* (SOP00080).

---

[5] U.S. EPA. (2016). *National Air Toxics Trends Stations Technical Assistance Document.* *https://www3.epa.gov/ttn/amtic/files/ambient/airtox/NATTS%20TAD%20Revision%203_FINAL%20October%202016.pdf*

Once sample collection was completed and the sample time, canister number, and start and stop vacuum were documented in the MATES V Sample Log (Appendix III-D) that accompanied the canister, samples were promptly returned to the Laboratory for receipt, log-in, and distribution to appropriate staff.

III.3.2.3 Sample Distribution within the Laboratory

The Laboratory sample custodians logged received samples and distributed them to the appropriate staff member following established Laboratory procedures.

III.3.3 Analytic Methods – Appendix III-A Compounds

Gaseous compounds listed in Appendix III-A were analyzed using gas chromatography with mass spectrometry (GC/MS) after cryo-focusing. This technique provides for instrument sensitivity sufficient for meeting MATES V measurement criteria. The method generally follows EPA Method TO-15; *Determination of Volatile Organic Compounds (VOCs) in Specially Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS).* Procedures specific to the South Coast AQMD Laboratory are found in South Coast AQMD SOP0008B. A short method description for sampling and analysis of VOCs by GC/MS can be found in Appendix III-J.

Carbonyl measurements were performed according to EPA Method TO-11, *Determination of Formaldehyde in Ambient Air Using Adsorbent Cartridge Followed by High Pressure Liquid Chromatography, with* NATTS sampling and analysis criteria delineated in the NATTS TAD (2016). The California Air Resources Board (CARB) toxic network design method was followed using the Xontech 924 with a carbonyl channel. A potassium-iodide-coated ozone denuder was also used in all carbonyl samplers. Waters® silica gel cartridge impregnated with dinitrophenyl hydrazine was used to sample for carbonyl compounds. A short method description for the carbonyl sampling and analysis can be found in SOP #00094 and in Appendix III-F.

TSP metals samples were collected on cellulose filters using Xontech 924 samplers and were analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) following the procedure found in South Coast AQMD SOP00096 *Standard Operating Procedure for the Determination of Metals in Ambient Particulate Matter by Inductively Coupled Plasma Mass Spectrometry*.

For $PM_{2.5}$ samples, a Teflon filter was used, and Energy Dispersive X-ray Fluorescence (ED-XRF) was used for metals analysis following the procedure found in South Coast AQMD SOP00004 *Standard Operating Procedure for the Analysis of* $PM_{2.5}$ *Filter Samples by Energy Dispersive X-Ray Fluorescence Spectrometry.* A short method description for sampling and analysis of elements by XRF is attached to this document as Appendix III-G.

Hexavalent chromium in ambient air was measured by collecting total suspended particulate matter (TSP) on cellulose filters impregnated with sodium bicarbonate solution using a Xontech 924 Toxic Air Sampler. The samples were analyzed by a Thermo Scientific ICS-5000 ion chromatograph (IC) equipped with a UV-Vis detector following South Coast AQMD SOP00046

The Analysis of Hexavalent Chromium (Cr(VI)) in Ambient Air by Ion Chromatography. The method description for hexavalent chromium sampling and analysis is found in Appendix III-L.

Particulate filter samples for $PM_{2.5}$ were analyzed for metals, ions, total mass, organic carbon (OC), elemental carbon (EC), and total carbon (TC). The procedure for mass and ion determinations follows the methodology used in support of South Coast AQMD (federally recognized) $PM_{2.5}$ Network activity. Analysis for EC, OC and TC of $PM_{2.5}$ filter samples was performed using the Interagency Monitoring of Protected Visual Environments A (IMPROVE A) method. The method evolves carbon from filters by heating and optically monitors carbon as it is evolved from the filter. After catalysts oxidize then reduce the carbon, it is measured by a flame ionization detector. A more detailed description of the IMPROVE A method can be found in Appendix III-I.

Particulate filter samples for $PM_{2.5}$ were analyzed for levoglucosan and other monosaccharide anhydrides. A portion of the quartz fiber filter sample was extracted in acetonitrile, derivatized with a silanizing reagent, and analyzed using a Gas Chromatograph/Mass Spectrometer. A detailed description of the method can be found in Appendix III-M.

The compounds listed in Appendix III-A were sampled on a one-day-in-six sampling schedule synchronized with the national $PM_{2.5}$ network schedule (BC and UFP measurements are real time). These samples were integrated 24-hour samples. South Coast AQMD personnel and contract employees conducted both the sampling and analysis with the exception of polycyclic aromatic hydrocarbons (PAHs), where the analysis was performed by Environmental Research Group, LLC (ERG).

III.3.4 Sampling Schedule

MATES V sampling was conducted on the same schedule as used by the air-monitoring network. The air monitoring network sampling schedule can be found on the U.S. EPA website at; www.epa.gov/tnn/amtic , and follows a six-day monitoring schedule for TSP lead, $PM_{2.5}$ and VOCs. This sampling schedule has several benefits:

1) Data from MATES V can be correlated with ambient data taken on the same day.
2) Additional staff time to service and maintain MATES V sampling equipment and instrumentation was minimized.
3) Sample set-up, retrieval, and delivery time to the Laboratory was minimized.

III.3.5 Quality Control/Quality Assurance

Appendix V contains the objectives, procedures, documentation, and data review techniques that were used by the South Coast AQMD to quality assure that MATES V data that met or exceeded the acceptance criteria for its intended use.

III.4. Data Processing and Reporting

III.4.1 Introduction

MATES V monitoring and analysis of ambient air toxics has generated a large database which is available for future data analysis. The purpose of this chapter is to outline the data handling of this large database. This section will only pertain to laboratory work performed and not to the meteorological, criteria pollutant, or monitor calibration data.

The aim of reporting is to generate a database for electronic transfer to interested parties. The data was reviewed (verified) for errors, to assure that it meets DQOs and for adherence to other QA criteria such that the data represent the most accurate determinations possible, and is both defensible and suitable for MATES V use. The Laboratory made every effort to disseminate the data in a timely fashion to facilitate feedback.

III.4.2 Data Processing

Data was processed, reviewed, and reported routinely during the MATES V monitoring period. AQ Chemists processed data generated from Laboratory instruments using analytical software and uploaded data to the Laboratory Information Management System (LIMS). The data was then reviewed by peer AQ Chemists, followed by Senior AQ Chemist review, and finalized by Principal AQ Chemists.

The continuous BC and UFP data was also processed, reviewed, and reported routinely during the MATES V monitoring period. Air Quality Instrument Specialists processed and reviewed data acquired from DMS using analytical software, followed by Air Quality Specialist review, and finalized by a Program Supervisor.

III.4.3 Database Compilation

Data from the MATES V database was exported from the LIMS and stored in a MS Access database. The MATES V database is comprised of $PM_{2.5}$ mass and its components (ions, metals, carbon, sugars), VOCs, carbonyls, TSP metals, and PAHs results for ten fixed sampling locations. The continuous BC and UFP data is stored in a separate MS Excel database. The database contains information regarding station names, station abbreviations (four letter acronyms), sampling dates, sample types, analyses, analytes, concentrations, units, MDLs, invalid qualifiers, and comment qualifiers.

APPENDIX III-A Air Contaminants Measured in MATES V Program

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

APPENDIX III-B WSD Monthly Quality Control Maintenance Check Sheet

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

MONTHLY QUALITY CONTROL MAINTENANCE CHECK SHEET

MAKE/MODEL________________________________Wind Speed and Direction System

Location ____________________________________ Month/Year _________________________
Station No.__________________________________ Specialist _________________________
Control No._______________ Reviewed by ________________________ Date _______________

Date	Zero Speed		Zero Direction		Visual Wind Transmitter Check	Chart Time	
	As Found	Final	As Found	Final		As Found	Final

OPERATOR INSTRUCTIONS:

Daily Checks: Chart trace and time.
Weekly Checks: Zero speed and direction inking system

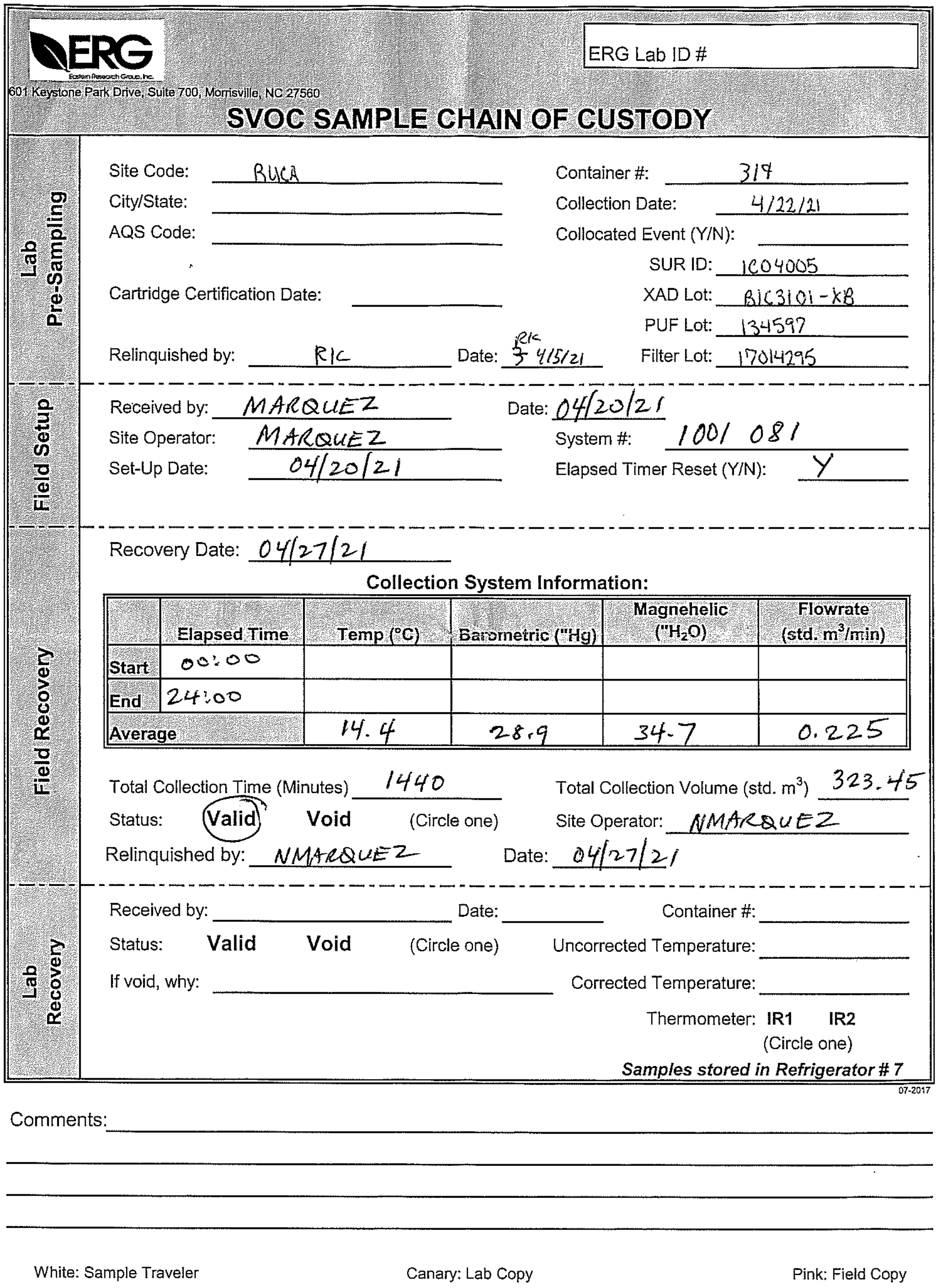
Visual wind transmitter check. The station operator will visually check the wind transmitter to confirm the direction coincides with recorder. Notify supervisor immediately if problem occurs.

Bi-monthly
Maintenance:

DATE	COMMENTS OR MAINTENANCE PERFORMED

Calibration Date:______ Operator _________________________

APPENDIX III-C PAH (PUF) Chain of Custody (COC)



ERG

Eastern Research Group, Inc.

601 Keystone Park Drive, Suite 700, Morrisville, NC 27560

ERG Lab ID #

SVOC SAMPLE CHAIN OF CUSTODY

Lab Pre-Sampling

Site Code: RUCA

City/State:

AQS Code:

Cartridge Certification Date:

Relinquished by: RIC

Date: ~~3~~ RIC 4/15/21

Container #: 319

Collection Date: 4/22/21

Collocated Event (Y/N):

SUR ID: 1C04005

XAD Lot: BIC3101-X8

PUF Lot: 134597

Filter Lot: 17014295

Field Setup

Received by: MARQUEZ

Date: 04/20/21

Site Operator: MARQUEZ

System #: 1001 081

Set-Up Date: 04/20/21

Elapsed Timer Reset (Y/N): Y

Field Recovery

Recovery Date: 04/27/21

Collection System Information:

	Elapsed Time	Temp (°C)	Barometric ("Hg)	Magnehelic ("H_2O)	Flowrate (std. m^3/min)
Start	00:00				
End	24:00				
Average		14.4	28.9	34.7	0.225

Total Collection Time (Minutes) 1440

Total Collection Volume (std. m^3) 323.45

Status: [✓ Valid] Void (Circle one)

Site Operator: NMARQUEZ

Relinquished by: NMARQUEZ

Date: 04/27/21

Lab Recovery

Received by:

Date:

Container #:

Status: Valid Void (Circle one)

Uncorrected Temperature:

If void, why:

Corrected Temperature:

Thermometer: IR1 IR2 (Circle one)

Samples stored in Refrigerator # 7

07-2017

Comments:

White: Sample Traveler Canary: Lab Copy Pink: Field Copy

South Coast Air Quality Management District

Tisch/Thermo Sampler for Ambient PAH Measurements

Field Work Sheet

Station:	RUCA		Location:	Rubidoux	[✓ A] B
Sampler Control #:	[✓ 1001-081]	1001-078	Property #:	33144	
Run Date:	4-22-2021		Day of Week:	M T W [✓ Th] F Sat Sun	

Filter Data

Filter Assembly ID #: RL 4/6/21 ~~13~~ 15 Initial: RL

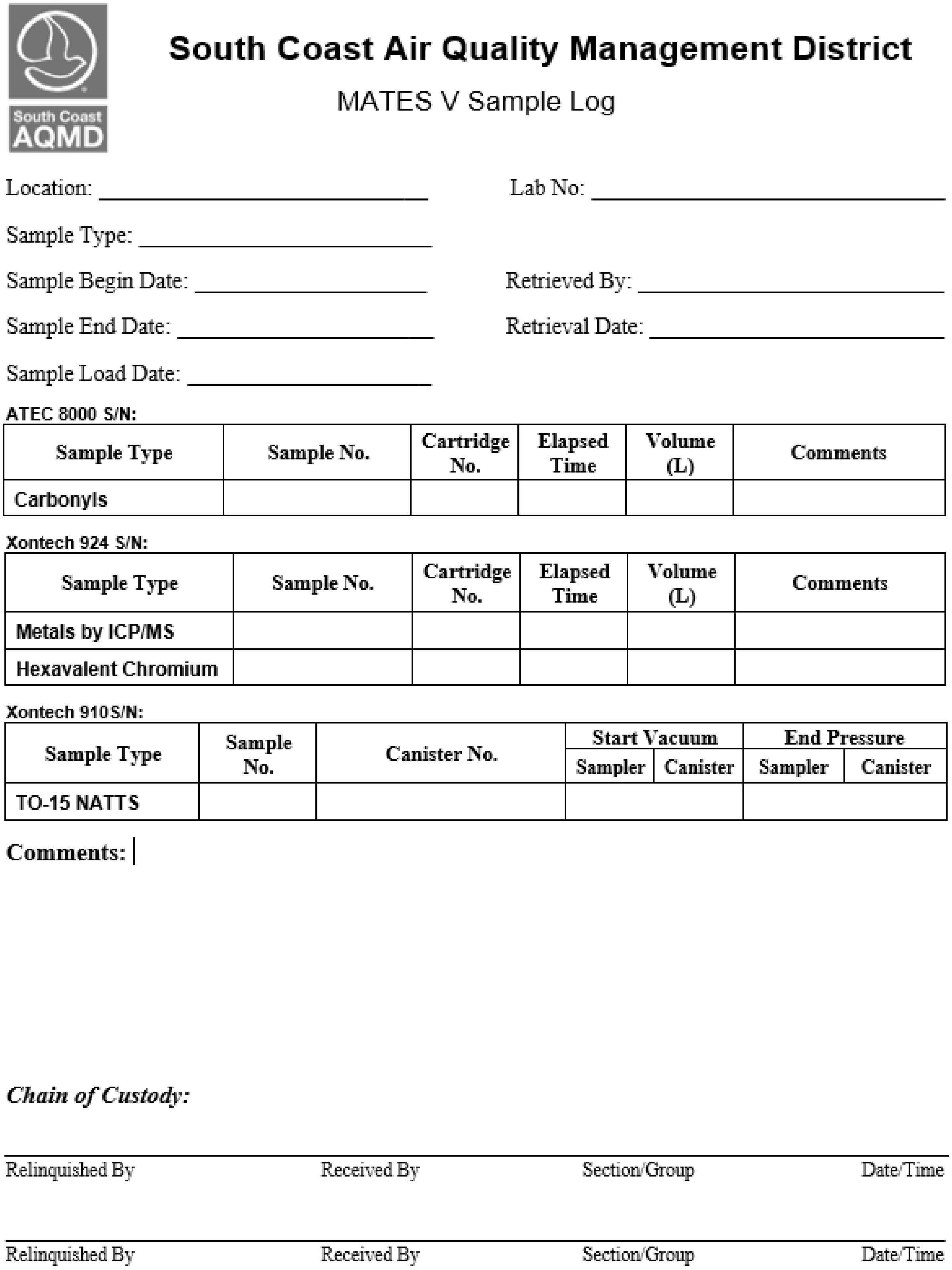
Placed on Sampler	Date: 04/20/21	Time: 14:10	Initial: NM
Removed from Sampler	Date: 04/27/21	Time: 11:30	Initial: NM
Returned to AQMD Lab	Date: 04/27/21	Time: 13:00	Initial: NM
Sent to ERG Lab	Date: 04/27/21	Time: 14:35	Initial: RL

Sampler Calibration Date: 08/13/20

Remarks:

Above Entries by: MARQUEZ

APPENDIX III-D MATES V Sample Chain of Custody (COC)



South Coast Air Quality Management District

MATES V Sample Log

Location: ____________________ Lab No: ____________________

Sample Type: ____________________

Sample Begin Date: ____________________ Retrieved By: ____________________

Sample End Date: ____________________ Retrieval Date: ____________________

Sample Load Date: ____________________

ATEC 8000 S/N:

Sample Type	Sample No.	Cartridge No.	Elapsed Time	Volume (L)	Comments
Carbonyls					

Xontech 924 S/N:

Sample Type	Sample No.	Cartridge No.	Elapsed Time	Volume (L)	Comments
Metals by ICP/MS					
Hexavalent Chromium					

Xontech 910S/N:

Sample Type	Sample No.	Canister No.	Start Vacuum		End Pressure	
			Sampler	Canister	Sampler	Canister
TO-15 NATTS						

Comments:

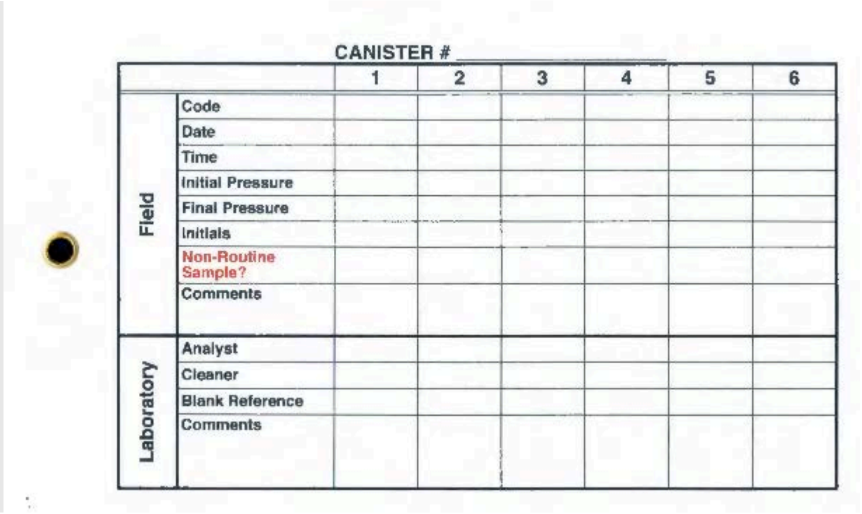
Chain of Custody:

Relinquished By Received By Section/Group Date/Time

Relinquished By Received By Section/Group Date/Time

APPENDIX III-E VOC Canister Tag

VOC CANISTER TAG



CANISTER # ____________________

		1	2	3	4	5	6
Field	Code						
	Date						
	Time						
	Initial Pressure						
	Final Pressure						
	Initials						
	Non-Routine Sample?						
	Comments						
Laboratory	Analyst						
	Cleaner						
	Blank Reference						
	Comments						

APPENDIX III-F Method Description for Sampling and Analysis of Carbonyls by UHPLC at the South Coast AQMD Laboratory

Sampling - Ambient air is drawn through an acidified dinitrophenylhydrazine (DNPH) coated silica cartridge mounted on an ATEC 8000 sampler. The samplers are located inside South Coast AQMD monitoring stations. A denuder is located upstream of the ATEC 8000 sampler and DNPH cartridge to eliminate or reduce ozone which interferes with carbonyl determination. The sampling cartridges are coated with a minimum of 300 mg of DNPH on Waters Sep-Pak silica cartridges. A volume of air is pulled through the cartridge at approximately 0.7 lpm for 24-hour sampling (1008 liters). Before and after sampling, each cartridge is kept capped and refrigerated at ≤ 4°C in a foil envelope to prevent loss of captured carbonyls or contamination.

Laboratory Analysis - The laboratory currently uses a Thermo Vanquish ultra high-performance liquid chromatograph (UHPLC) with autosampler. After elution of the Sep-Pak cartridge with three milliliters of acetonitrile, the samples are placed in an autosampler. Samples are analyzed using a gradient mode starting with 42% acetonitrile and 58% water at a flow rate of 0.6 ml per minute on an Acclaim Carbonyl RSLC 2.2 µm, 2.1 mm by 150 mm column. One microliter of each sample is injected onto the column by the autosampler.

MATES V carbonyl samples from 2018 were analyzed using a Waters Millennium HPLC with autosampler and Waters C-18, 5 µm, 4.6 mm by 250 mm column. A Thermo Vanquish UHPLC was used starting with 2019 carbonyls samples.

Quantification - A six-point calibration curve is created from triplicate injections of standards from 0.4 ug/ml to 10.0 ug/ml range. A second set of standards is obtained from a separate source and used to verify the calibration. PAMS/NATTS compounds, acetaldehyde, formaldehyde, and acetone (along with methyl ethyl ketone, propionaldehyde, and benzaldehyde) are quantified by comparison to the calibration curve. The concentrations are reported as ug/m^3 based on approximately 1000 L of air volume collected.

QA/QC – The Method Detection Limit (MDL) is determined according to EPA Appendix B to Part 136, 40CFR Ch.1 and Technical Assistance Document for the National Air Toxics Trends Stations Program, Revision 3, Chapter 4.0 Collection and Analysis Methods. A mid-level and a low-level control standard are added every 10 samples within each set, or batch, of analyses. For each set, or batch of 20 or less samples, an extraction solvent blank, a cartridge method blank, and a sample replicate injection are added. A duplicate sample from a second sampler is collected and analyzed every other month. For MATES V, duplicates were collected at Central Los Angeles and Rubidoux. A field blank is analyzed each month.

APPENDIX III-G Method Description for Sampling and Analysis of Elements by Energy Dispersive X-ray Fluorescence (ED-XRF) Spectrometry at the South Coast AQMD Laboratory

Sampling - Ambient air is drawn through a 47-mm Teflon filter loaded in a $PM_{2.5}$ sampler. Typically, 24-hour sampling at about 20 liters per minute provides sufficient sample mass on the filter for analysis. The sampler must collect a homogeneous sample across the surface of the filter.

Laboratory Analysis - The Panalytical Epsilon 5 ED-XRF spectrometer is used to analyze 44 elements collected on a filter sample. Sample preparation involves bringing the filters to room temperature. Each filter is loaded onto an autosampler, placed in a sample chamber kept under vacuum and a small cross section of the filter near the center is scanned under eight different analytic conditions. Each condition is optimized for certain groups of elements. After spectral acquisition, an identification and deconvolution process extracts the net contributions to the counts for each of the 44 elements.

Speciation and Quantification - Each element has a unique spectral pattern. After accounting for overlaps, each of the elements is identified qualitatively. By using previously calibrated standard values, the net counts for each element are converted to actual concentrations in $\mu g/cm^2$. Using air volume data gathered during sampling, the μg/filter concentrations of the elements are converted to ng/m^3.

QA/QC - The X-ray instrument is calibrated using 46 single and dual element standards. These calibration standards are verified using an NIST multi-element thin film standard. The NIST is run at the beginning and end of each sequence. Filter blanks are analyzed and used to subtract background from subsequent runs using the Epsilon 5 software. Field blanks are taken at specified times depending on the frequency of sampling. Field blank results are reported in accordance with data reporting and analysis requirements. Finally, all runs are checked in duplicate for precision. Collocated samples are collected at specified sites and times to verify sampling and analytical precision.

APPENDIX III-H Method Description for Sampling and Analysis of Elements by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) at the South Coast AQMD Laboratory

Sampling - Ambient air is drawn through a 37-mm Cellulose filter loaded in a TSP sampler. Typically, 24-hour sampling at about 12 liters per minute provides sufficient sample mass on the filter for analysis.

Laboratory Analysis - A Perkin Elmer ICP-MS is used to analyze 38 elements collected on a filter sample. Sample preparation procedures include digesting the whole filter in 11% nitric acid in a microwave oven, centrifuging the digested solution and diluting 10 times with 2% nitric acid. The diluted solution is then analyzed by ICP-MS.

Speciation and Quantification - The ICP-MS is calibrated daily using a certified calibration standard mixture containing all elements of interest. The standard is diluted to eight concentrations and a 9 point calibration curve is generated and used to determine the concentration of elements in samples. The elements in the sample solutions are ionized with inductively coupled plasma and are separated in the mass spectrometer based on their mass to charge ratio and then their concentrations are determined by the detector based on the intensities of ion counts. Using air volume data gathered during sampling, the μg/L concentrations of the elements are converted to ng/m^3.

QA/QC - MDLs are performed annually to determine the analytical method sensitivity for the ICP-MS. A calibration check and blank analysis are required at the beginning and end of each analysis period and at intervals of ten samples to verify the calibration and check for contamination. Filter/ reagent blanks and filter/reagent spiked samples are digested and analyzed in each batch to examine the extraction efficiency and any matrix effects. Sample duplicates are performed for determining extraction and analysis precision. Interference check standards and serial dilutions are analyzed to insure matrix and instrument interferences are not present. Field blanks are taken at specified times depending on the frequency of sampling and reported in accordance with the data reporting and analytic requirements. Collocated samples are collected at specified sites and times to verify sampling and analytic precision.

APPENDIX III-I Method Description for Sampling and Analysis of Organic and Elemental Carbon by Thermal/Optical Carbon Analyzer at the South Coast AQMD Laboratory

Sampling - Ambient air is drawn through a 47-mm quartz filter loaded in a $PM_{2.5}$ sampler. Typically, 24-hour sampling provides sufficient sample mass on a filter for analysis. The sampler must collect a homogeneous sample across the surface of the filter. A one-centimeter diameter punch from any sample portion of the filter is used in the instrument.

Laboratory Analysis - A Desert Research Institute (Reno, Nevada) thermal/optical carbon analyzer is used to determine the total carbon content of aerosol deposited on quartz filters. The analyzer is able to distinguish and characterize organic and inorganic carbon by a thermal/optical method with flame ionization detection. Sample preparation involves bringing the filters to room temperature. A small circular filter area is punched out from the quartz filter and loaded onto the carrier quartz tube. The filter is pushed into an oven whose temperature is raised in steps from ambient temperature to approximately 840 degrees Celsius. Helium is continuously passed over the filter until 480 degrees Celsius is attained, at which time a Helium/Oxygen mixture is then continuously passed over the punch until 840 degrees Celsius is reached to burn off elemental carbon. At the same time the surface of the filter is monitored with a laser beam to determine the point at which all the elemental carbon (soot) is burned off. The combusted carbon forms carbon dioxide that is carried over to a methanizer. The methanizer (active nickel with the addition of hydrogen gas) converts the carbon dioxide to methane. The methane flows to a flame ionization detector. The detector output is integrated and converted to μg of carbon per filter using previously calibrated standards.

Speciation and Quantification - The light organic fraction is driven off the filter at the early stages of heating. The elemental carbon fraction is then oxidized at a higher temperature with an oxygen enriched carrier gas. A laser beam constantly scans the filter surface to identify the point at which the organic and elemental carbon fractions are removed from the filter. The two fractions are summed to give the total carbon concentration of the sample. The analysis results in determination of the elemental, organic, and total carbon content of the sample. Using air volume data gathered during sampling, the μgC/filter concentrations are converted to $\mu gC/m^3$ of air.

QA/QC - The optical-thermal carbon analyzer is calibrated using two types of standards. One consists of carbon containing gases (methane and carbon dioxide) in an inert gas. These are passed through the entire system to calibrate the instrument. In addition, filters impregnated with solution containing a known concentration of carbon are run as external standards. Field blanks are taken at specified times depending on the frequency of sampling. Field blank results are reported in accordance with the data reporting and analysis requirements. Finally, all samples are checked in duplicate and collocated runs are analyzed as a check of precision.

APPENDIX III-J Method Description for Sampling and Analysis of VOCs by GC/MS at the South Coast AQMD

Sampling - Ambient air is pumped through a properly sited probe and manifold into an evacuated Summa® polished and/or a silonite coated (Entech TM) 6 liter canister using a Xontech 910A air sampler at the sample location. The sample is integrated over 24 hours to fill the canister to approximately 12 PSI, according to SOP00080 "Xontech 910 Canister Sampler/Multichannel Controller." The canister is returned to the laboratory for analysis by Gas Chromatography with a Mass Spectrometer (GC/MS).

Laboratory Analysis - The Laboratory uses an Agilent 6890 Gas Chromatograph with an Agilent 5973 Mass Selective Detector. The sample is concentrated using an Entech 7200 cryo-concentrator then injected into a GC/MS. The sample canister is attached to the cryo-concentrator and a 600-milliliter aliquot is chilled in a trap to minus 150 degrees centigrade. For removal of the ambient humidity (water), the trap is heated to 10 degrees centigrade and transferred to a second trap cooled to -45 C for removal of CO_2 collected with the sample. The concentrator loop is then heated and the contents cryo-focused at the head of a GC column for subsequent separation of the VOCs. The mass selective detector records the mass spectrum of each peak (compound) and the analyst uses certified standards to compare selected ions for each compound to determine its concentration according to SOP0008B "Standard Operating Procedure for TO15 (VOC)."

Quantitation - A calibration curve is derived by injection of a gas standard containing the compounds of interest at ppb levels. Every sample run is preceded and ended with a calibration check. Every analysis day is begun with a system blank run. Selected quantitation ions for each compound are compared to those for injected gas standards to determine concentration in parts per billion.

QA/QC - The Method Detection Limit (MDL) is determined for the GC/MS according to the method outlined in the EPA NATTS TAD (October 2016). Collocated samples may be collected on a scheduled frequency, depending on the program. All canisters from the canister cleaning system are batch verified by analysis of purified humidified nitrogen contained in the canisters for the presence of the compounds of interest. Presence of analytes of interest above 0.2 ppb is cause for corrective action.

APPENDIX III-K Method Description for Sampling and Analysis of PAH Compounds

Sampling - Ambient air is drawn through an Andersen Instruments Poly-Urethane Foam (PUF) sampler. The method uses a high volume (Hi-Vol) air sampler equipped with a quartz fiber filter and PUF/Tenax glass adsorbent module for sampling between 325 and 400 cubic meters of air in a 24-hour sampling period. The laboratory is responsible for receipt of the quartz fiber filter and PUF/Tenax sorbent collection module, pre-cleaned and blanked, from Eastern Research Group (ERG) which is received by the Laboratory in a cold pack. The received modules are refrigerated at ≤ 4°C until needed and then constructed for sampling by a Laboratory Technician for use by the field Instrument Technician. The Instrument Technician installs the filter with PUF/Tenax collection module onto the Hi-Vol sampling unit and collects the sample after sampling completion. The Instrument Technician returns the sample immediately after sampling and places it in the laboratory refrigerator which is at ≤ 4°C. The Laboratory Technician then deconstructs the sampling module for shipment to ERG in a cooler with blue ice. Turnaround time for the sample to reach ERG from the sampling date is approximately 7 days.

Laboratory Analysis- Analysis of the collected sample (in accordance with the chain of custody) is performed by ERG, Morrisville, North Carolina. The protocol used is EPA Compendium Method TO-13. The results are reported to the South Coast AQMD Project Manager and U.S. EPA Air Quality System (AQS). Per ERG, “The test results are in compliance with NELAC accreditation requirements for certified parameters. All analyses are performed as described in the U.S. EPA approved QAPP, under the contract for NATTS.”

QA/QC- The South Coast AQMD portion of Quality Assurance/Quality Control is limited to the sampling process. The Thermo Andersen PUF sampler is calibrated using an orifice transfer standard that has been standardized against a primary standard Roots meter. The orifice transfer standard is referenced to 25 degrees centigrade and 760 millimeters of mercury (Hg). In the field leak checks and sampling flow rate checks are performed each run. Field blanks are run at the prescribed frequency as found in the National Air Toxics Trends study work plan. Non-contaminating and cold transfer of all materials is maintained up through the shipment under cold conditions to ERG.

APPENDIX III-L Method Description for Sampling and Analysis of Hexavalent Chromium by Ion Chromatography at the South Coast AQMD Laboratory

Sampling - Ambient air is drawn through a 37-mm sodium bicarbonate treated cellulose filter loaded in a Xontech 924 sampler. Ambient air is pulled though the filter at a rate of approximately 12.0 liters per minute for 24-hours with an aggregate total air volume of approximately 17.2 m^3. Samples are refrigerated at ≤ 4°C to minimize the reduction of hexavalent chromium to trivalent chromium.

Laboratory Analysis – Thermo Fischer Scientific ICS-5000 ion chromatograph (IC) is utilized to determine the hexavalent chromium concentration in ambient air samples. The entire filter sample is extracted in 10 mL of 20 mM sodium bicarbonate solution via ice bath sonication for one hour. The extract is then filtered to remove solids/particles and analyzed by IC. This system is comprised of an autosampler, guard column, analytical column, post-column derivatization module, a UV-Vis detector, and Chromeleon software. Hexavalent chromium is detected using a visible light lamp emitting at a wavelength of 530 nm after forming a complex with diphenylcarbazide in a post-column reaction.

Quantification – A five-point calibration curve is generated from prepared standards ranging from 50 to 2000 part per trillion (ppt). The hexavalent chromium sample concentrations are quantified by area comparisons to the area obtained for the calibration standards. Chromeleon software calculates the concentrations for each sample based on the calibration curve. The ppt concentrations are then converted to ng/m^3 by multiplying the ppt by the extraction volume (Liters) and dividing by the air volume (m^3).

QA/QC – MDLs are performed annually to determine the analytical method sensitivity for the IC. The IC is calibrated weekly to achieve a minimum correlation coefficient of 0.9990. Blank and check standard analyses are performed every 10 samples to verify the precision of the analytical data. An external standard is prepared for every batch of samples to verify the accuracy of the calibration standard. Blank and spike QCs are extracted with every sample batch. Spike QCs are spiked with known hexavalent chromium and trivalent chromium concentrations to verify the accuracy of the method. A duplicate (DUP) injection of the first sample is analyzed at the end of the sequence to check for instrument drift and Cr^{III}/ Cr^{VI} conversion. Field blanks are taken at specified times depending on the frequency of sampling and reported in accordance with the data reporting and analysis requirements. Collocated samples are collected at specified sites and times to verify sampling and analytical precision. Detailed procedures are described in SOP00046, *The Analysis of Hexavalent Chromium in Ambient Air by Ion Chromatography.*

APPENDIX III-M Method Description for Sampling and Analysis of Levoglucosan and Related Monosaccharide Anhydrides at the South Coast AQMD Laboratory

Sampling - Fine particulate matter ($PM_{2.5}$) is collected by ambient air filtration onto 47 mm quartz fiber filters using Met One Instruments SASS™ samplers. Each sampler is programmed to sample approximately 9.8 m^3 of air over 24 hours. Levoglucosan and associated monosaccharide anhydrides (mannosan, galactosan) are analyzed by extraction of whole filters.

Laboratory Analysis – Monosaccharide anhydride concentrations in filter samples are determined with a Thermo Trace 1310 Gas Chromatograph (GC) coupled to an ISQ LT single quadrupole mass spectrometer (MS). Filters are spiked with an isotopically labeled internal standard ($^{13}C_6$-levoglucosan) and extracted by ultrasonication in acetonitrile. An aliquot of each extract is derivatized by a silanizing reagent to convert monosaccharide anhydrides to trimethylsilyl (TMS) derivatives suitable for GC/MS analysis. Samples are analyzed by GC/MS within 24 hours of derivization.

Speciation and Quantification – Samples are analyzed by GC/MS using a simultaneous selective ion monitoring (SIM)/full scan method. Each compound is positively identified by three characteristic mass fragments and quantified using the response of a primary fragment relative to the isotopically labeled internal standard. Using air volume data gathered during sampling, instrument concentrations (μg/filter) are converted to $\mu g/m^3$ of air.

QA/QC - Calibration curves for all compounds of interest are constructed with authenticated standards referenced to the isotopically labelled internal standard. The levoglucosan calibration curve is confirmed with a secondary authenticated standard. Instrument stability is verified by injection of low- and mid-level calibration standards following every 10 sample injections and at the close of each sequence. Due to the instability of TMS-derivatives, all calibration and secondary standards are prepared and derivatized in parallel to each sample batch. Blank contributions are assessed with instrument blanks run at the beginning of each sequence and after every 10 sample injections, a filter blank extracted as part of each sample batch, and monthly field blanks. Extraction efficiency is assessed with one filter blank spike sample per sample batch. Results from replicate injections and collocated samples are used to characterize instrument and sampling variability, respectively.

APPENDIX IV

MATES V

FINAL REPORT

Summaries for the MATES II-V Fixed Monitoring Sites

Appendix IV

Summaries for the MATES II-V Fixed Monitoring Sites

IV.1 Method Detection Limit (MDL) and Data Reporting

The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from the analysis of samples in a given sample matrix containing the analyte (EPA, 2017) [1]. Guidance for determination of the method detection limit (MDL) and data reporting was taken from the U. S. EPA's National Air Toxics Pilot City Monitoring Program. The MDL, as defined in 40 CFR Appendix B, Part 136, "Definition and Procedure for Determination of the Method Detection Limit" was used.

The South Coast AQMD Laboratory used this MDL determination method for the analyses conducted. It consists of performing seven replicate analyses of samples containing the analyte of interest at a level not to exceed five times the projected MDL. A standard deviation is determined using results of the analysis. The standard deviation multiplied by 3.14 (from the Tables of Student's t Values at the 99% confidence level) is the reported MDL.

In the tables below, the average generally represents the Kaplan-Meier (KM) mean, and the 95% confidence intervals (CI) are taken from bootstrapping the KM mean. The KM mean cannot be reliably calculated if more than 80% of the data points are below the MDL. In this situation, two average calculations are provided. The first average is found by substituting zero for all data below the MDL and calculating the average. 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. The second average is found by substituting the MDL for all data below the MDL and calculating the average. The 95% confidence intervals are calculated for the MDL-substituted mean using bootstrapping. In the tables 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. Data for which more than 80% of the sample are below the MDL are denoted with a footnote ("a"). See Appendix XI for more information about the statistical methods used in this report.

Fine particulate matter ($PM_{2.5}$) is a component of the total suspended particle (TSP) mass. Metals in the $PM_{2.5}$ size fraction often have more than 80% of the data below the MDL, e.g., arsenic, antimony, and cadmium due to limitations in measurement techniques. The upper bound estimate of the average using MDL substitution is sometimes higher than the KM mean from the TSP analysis for the same metal. Since $PM_{2.5}$ is a subset of TSP, an upper bound estimate higher than the TSP KM mean is unrealistic. In this situation, the KM mean and upper bound of the 95% confidence interval from the TSP analysis are used instead of MDL substitution. The data for $PM_{2.5}$ metals is more uncertain than other analytes in the MATES report, and staff urge caution in the

---

[1] Reference: Environmental Protection Agency, 40 CFR Part 136, Clean Water Act Methods Update Rule for the Analysis of Effluent. https://www.govinfo.gov/content/pkg/FR-2017-08-28/pdf/2017-17271.pdf

interpretation of the $PM_{2.5}$ metal data, especially for older MATES data. In some cases (antimony for MATES III, tin and uranium for MATES IV), the KM mean from the TSP analysis is lower than the zero-substituted mean from the PM2.5 analysis, indicating that these data should be interpreted with caution. Data for which the TSP KM mean is used in place of MDL-substituted mean are denoted with a footnote ("b"). The station names, abbreviations, latitude (Lat.) and longitude (Lon.) l for MATES II-V are in Table IV-1 below.

Table IV-2 shows the MDLs. Some data sets have multiple MDLs for a given MATES project, pollutant, and station, in which case the minimum and maximum MDLs are provided separated by a comma. Not all pollutants were monitored during all of the MATES projects, leading to empty spaces in Table IV-2. In a few instances, MDLs were not available for certain pollutants from previous MATES projects, also resulting in empty spaces in Table IV-2. Data with missing MDL values could not be analyzed with the methods used for this report and no statistics were calculated. These are denoted as "Unk MDL" for unknown MDL in later tables in this appendix. Table IV-3 through Table IV-157 present statistical summaries for all pollutants for all MATES projects by station.

Figure IV-1 through Figure IV-297 present the MATES data as bar graphs and geographic plots to visualize all of the data for a single species both temporally and spatially. For the geographic plots, both the heights of the bars and the color scale represent the pollutant concentration. The bars that consist of a solid color represent KM mean concentrations. As described above, the KM mean is not calculated if more than 80% of the data were below detection limit, and upper and lower-bound estimates are provided using MDL and zero substitution for the data below detection limit. For this situation, the bar has a color gradient from the lower to upper bound estimates. Additionally, when upper and lower bound estimates are used, the bottom of the bar may not extend all the way to the axis, but instead the height of the bottom of the bar represents the lower bound estimate of the concentration. The location of each station is represented by a blue dot, usually at the intersection of the horizontal and vertical axes for the bar plot. To avoid overlapping bar plots, some of the bar plots are moved away from the location of the station and an arrow points to the blue dot representing the station location. The "x" in the bar graphs indicate that either no measurements were conducted, or the MDL is not available.

The bar charts show the concentration on the left vertical axis. Cancer risk and/or chronic hazard quotient (HQ) estimates are shown on the right vertical axis or axes. If there is no cancer risk and/or chronic HQ axis on the right side of the bar graph, then cancer potency values and/or chronic Reference Exposure Levels (RELs) have not been defined by OEHHA for that analyte and a health risk calculation could not be completed.

Section IV.2 describes multiple methods that were used for handling missing analytes in the aggregate risk calculations. The results from each of these methods are shown in Figure IV-298 through Figure IV-301.

Table IV-1 Station names, abbreviations, latitude (Lat.) and longitude (Lon.) l for MATES II-V.

Station	MATES II Name (Lat., Lon.)	MATES III Name (Lat., Lon.)	MATES IV Name (Lat., Lon.)	MATES V Name (Lat., Lon.)
AN	Anaheim (33.8199, -117.9144)	Anaheim (33.8199, -117.9144)	Anaheim (33.8307, -117.9406)	Anaheim (33.8307, -117.9403)
BU	Burbank (34.176, -118.317)	Burbank (34.176, -118.317)	Burbank (34.176, -118.317)	Burbank Area (34.2616, -118.4123)
CP	Compton (33.9015, -118.2065)	Compton (33.9015, -118.2065)	Compton (33.9015, -118.2065)	Compton (33.9014, -118.2069)
SB	Fontana (34.0996, -117.4919)	Inland Valley San Bernardino (34.0996, -117.4919)	Inland Valley San Bernardino (34.0996, -117.4919)	Inland Valley San Bernardino (34.0996, -117.4919)
HP	Huntington Park (33.9833, -118.2306)	Huntington Park (33.9833, -118.2306)	Huntington Park (33.9833, -118.2306)	Huntington Park (33.9798, -118.2159)
LB	Long Beach (34.176, -118.317)	North Long Beach (34.176, -118.317)	North Long Beach (34.176, -118.317)	Long Beach (34.2616, -118.4123)
LA	Los Angeles (34.0665, -118.2276)	Central Los Angeles (34.0665, -118.2276)	Central Los Angeles (34.0665, -118.2276)	Central L.A. (34.0665, -118.2276)
PR	Pico Rivera (34.0135, -118.0604)	Pico Rivera (34.0135, -118.0604)	Pico Rivera (34.0135, -118.0604)	Pico Rivera (34.0135, -118.0604)
RU	Rubidoux (34.0006, -117.4151)	Rubidoux (34.0006, -117.4151)	Rubidoux (34.0006, -117.4151)	Rubidoux (34.0006, -117.4151)
WLB	Wilmington (33.7993, -118.2584)	West Long Beach (33.7924, -118.2158)	West Long Beach (33.8015, -118.2203)	West Long Beach (33.8015, -118.2203)

Table IV-2. Method detection limits (MDLs) for MATES II-V

Analysis	Analyte	MATES II MDL	MATES III MDL	MATES IV MDL	MATES V MDL
Carbonyls	Acetaldehyde	0.1 ppb	0.1 ppb	0.00785 ppb	0.0189, 0.0211 ppb
Carbonyls	Acetone	0.1 ppb	0.1 ppb	0.00455 ppb	0.0838, 0.12 ppb
Carbonyls	Benzaldehyde				0.00346, 0.0205 ppb
Carbonyls	Formaldehyde	0.1 ppb	0.1 ppb	0.0137 ppb	0.0195, 0.0236 ppb
Carbonyls	Methyl Ethyl Ketone	0.1 ppb	0.1 ppb	0.00125 ppb	0.00882, 0.0207 ppb
Carbonyls	Propionaldehyde				0.00463, 0.00842 ppb
VOCs	Acrolein			0.079 ppb	0.03, 0.05 ppb
VOCs	Benzene	0.1, 0.2 ppb	0.1 ppb	0.026 ppb	0.01, 0.04 ppb
VOCs	Bromomethane				0.01, 0.1 ppb
VOCs	1,3 Butadiene	0.04, 1.9 ppb	0.2 ppb	0.028 ppb	0.02, 0.03 ppb
VOCs	Carbon Tetrachloride	0.02, 0.2 ppb	0.05 ppb	0.046 ppb	0.01, 0.05 ppb
VOCs	Chloroform	0.02, 0.1 ppb	0.1 ppb	0.054 ppb	0.01, 0.05 ppb
VOCs	Chloromethane	0.1 ppb			
VOCs	1,2-Dibromoethane	0.1 ppb	0.2 ppb	0.07 ppb	0.03, 0.07 ppb
VOCs	1,2-Dichlorobenzene	0.01, 0.1 ppb	0.3 ppb	0.095 ppb	0.04, 0.07 ppb
VOCs	1,4-Dichlorobenzene	0.02, 0.1 ppb	0.3 ppb	0.057 ppb	0.04, 0.06 ppb
VOCs	Dichloroethane [1,1]	0.1 ppb			
VOCs	1,2-Dichloroethane	0.1 ppb	0.1 ppb	0.044 ppb	0.01, 0.04 ppb
VOCs	1,1-Dichloroethene (VDC)	0.1, 0.5 ppb			
VOCs	1,2-Dichloropropane		0.2 ppb	0.022 ppb	0.02, 0.03 ppb
VOCs	Ethyl Benzene	0.1, 0.6 ppb	0.1 ppb	0.05 ppb	0.02, 0.06 ppb
VOCs	Methylene Chloride	0.1, 1 ppb	0.1 ppb	0.076 ppb	0.02, 0.08 ppb
VOCs	Methyl tertiary-butyl ether (MTBE)		0.3 ppb	0.051 ppb	0.01, 0.05 ppb
VOCs	Non Methane Organic Carbon			0.3 ppbC	
VOCs	Perchloroethylene	0.01, 0.1 ppb	0.1 ppb	0.065 ppb	0.03, 0.04 ppb
VOCs	Styrene	0.1 ppb	0.1 ppb	0.069 ppb	0.04, 0.07 ppb
VOCs	Toluene	0.1, 0.2 ppb	0.1 ppb	0.024 ppb	0.02, 0.09 ppb
VOCs	Trichloroethylene	0.02, 0.1 ppb	0.1 ppb	0.072 ppb	0.008, 0.04 ppb
VOCs	Vinyl Chloride	0.2, 0.7 ppb	0.2 ppb	0.051 ppb	0.01, 0.04 ppb

Analysis	**Analyte**	**MATES II MDL**	**MATES III MDL**	**MATES IV MDL**	**MATES V MDL**
VOCs	Vinyl Chloride	0.2, 0.7 ppb	0.2 ppb	0.051 ppb	0.01, 0.04 ppb
VOCs	Xylene (m-, p-)	0.1, 0.6 ppb	0.1 ppb	0.072 ppb	0.05, 0.09 ppb
VOCs	Xylene (o-)	0.1 ppb	0.2 ppb	0.065 ppb	0.02, 0.05 ppb
TSP Hexavalent Chromium	Hexavalent Chromium	0.06, 0.4 ng/m3	0.06 ng/m3	0.0032 ng/m3	0.002, 0.003 ng/m3
TSP Metals	Aluminum	6, 60 ng/m3	150 ng/m3		
TSP Metals	Antimony	6, 19 ng/m3	2 ng/m3	0.077 ng/m3	0.08, 0.43 ng/m3
TSP Metals	Arsenic	3, 4 ng/m3	1 ng/m3	0.091 ng/m3	0.07 ng/m3
TSP Metals	Barium	19, 25 ng/m3	17 ng/m3	2.4 ng/m3	1.4, 7.24 ng/m3
TSP Metals	Beryllium			0.087 ng/m3	0.04, 0.22 ng/m3
TSP Metals	Bromine	1, 2 ng/m3			
TSP Metals	Cadmium	10 ng/m3	2 ng/m3	0.0785 ng/m3	0.02, 0.09 ng/m3
TSP Metals	Calcium	3, 12 ng/m3	5 ng/m3	0.291 ng/m3	337, 1740 ng/m3
TSP Metals	Cesium			0.291 ng/m3	0.01, 0.07 ng/m3
TSP Metals	Chlorine	7, 13 ng/m3			
TSP Metals	Chromium	2 ng/m3	2 ng/m3	1.05 ng/m3	0.7, 0.74 ng/m3
TSP Metals	Cobalt	16, 35 ng/m3	1 ng/m3	0.122 ng/m3	0.05, 0.25 ng/m3
TSP Metals	Copper	1, 2 ng/m3	1 ng/m3	0.933 ng/m3	0.73, 3.76 ng/m3
TSP Metals	Gallium	3 ng/m3			
TSP Metals	Indium	11 ng/m3	2 ng/m3		
TSP Metals	Iron	2, 8 ng/m3	1 ng/m3	0.291 ng/m3	14, 145 ng/m3
TSP Metals	Lanthanum	67 ng/m3			
TSP Metals	Lead	1, 3 ng/m3	5 ng/m3	0.49 ng/m3	0.2, 1.01 ng/m3
TSP Metals	Magnesium	67 ng/m3			
TSP Metals	Manganese	2 ng/m3	1 ng/m3	0.37 ng/m3	0.28, 1.45 ng/m3
TSP Metals	Mercury	3 ng/m3			
TSP Metals	Molybdenum	1, 3 ng/m3	2 ng/m3	0.12 ng/m3	0.04, 0.22 ng/m3
TSP Metals	Nickel	1, 2 ng/m3	1 ng/m3	0.719 ng/m3	0.21, 0.22 ng/m3
TSP Metals	Palladium	11 ng/m3	3 ng/m3		
TSP Metals	Phosphorus	13, 20 ng/m3	21 ng/m3		
TSP Metals	Potassium	5, 11 ng/m3	2 ng/m3	0.291 ng/m3	56.1, 58.3 ng/m3
TSP Metals	Rubidium	2 ng/m3	1 ng/m3	0.291 ng/m3	0.04, 0.22 ng/m3
TSP Metals	Selenium	1, 2 ng/m3	2 ng/m3	0.868 ng/m3	0.56, 0.59 ng/m3

Analysis	Analyte	MATES II MDL	MATES III MDL	MATES IV MDL	MATES V MDL
TSP Metals	Silicon	5, 64 ng/m3	275 ng/m3		
TSP Metals	Silver	5 ng/m3	2 ng/m3		
TSP Metals	Strontium	2, 3 ng/m3	2 ng/m3	0.211 ng/m3	0.7, 3.62 ng/m3
TSP Metals	Sulfur	4, 32 ng/m3	21 ng/m3		
TSP Metals	Tin	5 ng/m3	3 ng/m3	0.442 ng/m3	0.15, 0.8 ng/m3
TSP Metals	Titanium	4, 14 ng/m3	5 ng/m3	0.882 ng/m3	1.74, 8.97 ng/m3
TSP Metals	Uranium	3, 6 ng/m3		0.0813 ng/m3	0.01, 0.07 ng/m3
TSP Metals	Vanadium	3, 6 ng/m3	2 ng/m3	0.197 ng/m3	0.04 ng/m3
TSP Metals	Yttrium	1, 2 ng/m3	1 ng/m3		
TSP Metals	Zinc	1, 2 ng/m3	1 ng/m3	0.291 ng/m3	8.42, 8.74 ng/m3
TSP Metals	Zirconium	2 ng/m3			
PM10 Mass	PM10 Mass	22 µg/m3		0.0613 µg/m3	
PM10 Carbon	Elemental Carbon	947 ng/m3		7.47 ng/m3	
PM10 Carbon	Organic Carbon	3320 ng/m3		99.6 ng/m3	
PM10 Carbon	Total Carbon	5010 ng/m3		99.6 ng/m3	
PAH	Acenaphthene		0.037 ng/m3	0.0302, 0.346 ng/m3	0.0689, 0.69 ng/m3
PAH	Acenaphthylene		0.037 ng/m3	0.0212, 0.229 ng/m3	0.00807, 0.0444 ng/m3
PAH	Anthracene		0.037 ng/m3	0.0219, 0.306 ng/m3	0.0124, 0.0321 ng/m3
PAH	Benzo(a)anthracene		0.0018 ng/m3	0.0349, 0.377 ng/m3	0.00863, 0.00965 ng/m3
PAH	Benzo(a)pyrene	0.05 ng/m3	0.0018 ng/m3	0.0407, 0.47 ng/m3	0.00984, 0.0133 ng/m3
PAH	Benzo(b)fluoranthene	0.05 ng/m3		0.032, 0.352 ng/m3	0.0077, 0.0198 ng/m3
PAH	Benzo(b+j+k)Fluoranthene		0.0018 ng/m3		
PAH	Benzo(e)pyrene			0.0389, 0.42 ng/m3	0.0051, 0.00975 ng/m3
PAH	Benzo(g,h,i)perylene	0.05 ng/m3	0.0018 ng/m3	0.0288, 0.396 ng/m3	0.00538, 0.0538 ng/m3
PAH	Benzo(k)fluoranthene	0.05 ng/m3		0.0404, 0.459 ng/m3	0.0039, 0.0108 ng/m3

Analysis	Analyte	MATES II MDL	MATES III MDL	MATES IV MDL	MATES V MDL
PAH	Chrysene		0.0018 ng/m3	0.0186, 0.347 ng/m3	0.00633, 0.00747 ng/m3
PAH	Coronene			0.0394, 0.438 ng/m3	0.00278, 0.0278 ng/m3
PAH	Cyclopenta(c,d)pyrene			0.0304, 0.582 ng/m3	0.00386, 0.0066 ng/m3
PAH	Dibenz(a,h)anthracene	0.05 ng/m3	0.0018 ng/m3	0.0293, 0.393 ng/m3	0.0121, 0.121 ng/m3
PAH	Fluoranthene		0.037 ng/m3	0.0355, 0.612 ng/m3	0.023, 0.23 ng/m3
PAH	Fluorene		0.037 ng/m3	0.0301, 0.325 ng/m3	0.0643, 0.688 ng/m3
PAH	9-Fluorenone			0.0364, 0.393 ng/m3	0.0375, 0.563 ng/m3
PAH	Indeno(1,2,3-c,d)pyrene	0.05 ng/m3	0.0018 ng/m3	0.0264, 0.455 ng/m3	0.0123, 0.132 ng/m3
PAH	Naphthalene		0.037 ng/m3	0.118, 1.71 ng/m3	1.07, 16.9 ng/m3
PAH	Perylene			0.0291, 0.469 ng/m3	0.0084, 0.0841 ng/m3
PAH	Phenanthrene		0.037 ng/m3	0.0297, 0.321 ng/m3	0.116, 0.207 ng/m3
PAH	Pyrene		0.037 ng/m3	0.0376, 0.601 ng/m3	0.0117, 0.155 ng/m3
PAH	Retene			0.0762, 1.1 ng/m3	0.0572, 1.77 ng/m3
PM2.5 Mass (SASS)	PM2.5 Mass		0.104 µg/m3	0.104 µg/m3	0.0001 µg/m3
PM2.5 Carbon	EC1				40 ng/m3
PM2.5 Carbon	EC2				40 ng/m3
PM2.5 Carbon	EC3				40 ng/m3
PM2.5 Carbon	Elemental Carbon		74.2 ng/m3	37.5 ng/m3	40 ng/m3
PM2.5 Carbon	OC1				490, 500 ng/m3
PM2.5 Carbon	OC2				490, 500 ng/m3
PM2.5 Carbon	OC3				490, 500 ng/m3
PM2.5 Carbon	OC4				490, 500 ng/m3
PM2.5 Carbon	Organic Carbon		557 ng/m3	500 ng/m3	490, 500 ng/m3
PM2.5 Carbon	Total Carbon		557 ng/m3	500 ng/m3	490, 500 ng/m3
PM2.5 Ions	Ammonium Ion		43.8 ng/m3	43.8 ng/m3	40 ng/m3
PM2.5 Ions	Chloride		150 ng/m3	150 ng/m3	150, 160 ng/m3
PM2.5 Ions	Nitrate		150 ng/m3	150 ng/m3	154, 156 ng/m3
PM2.5 Ions	Potassium Ion				80 ng/m3
PM2.5 Ions	Sodium		15.6 ng/m3	15.6 ng/m3	20 ng/m3

Analysis	Analyte	MATES II MDL	MATES III MDL	MATES IV MDL	MATES V MDL
PM2.5 Ions	Sulfate		150 ng/m3	150 ng/m3	154, 156 ng/m3
PM2.5 Metals	Aluminum		1.2 ng/m3	42.2 ng/m3	42 ng/m3
PM2.5 Metals	Antimony		1.4 ng/m3	59.8 ng/m3	42 ng/m3
PM2.5 Metals	Arsenic		0.2 ng/m3	13.1 ng/m3	12 ng/m3
PM2.5 Metals	Barium		10 ng/m3	123 ng/m3	68 ng/m3
PM2.5 Metals	Cadmium		1 ng/m3	42.7 ng/m3	25 ng/m3
PM2.5 Metals	Calcium		1 ng/m3	13.9 ng/m3	17 ng/m3
PM2.5 Metals	Cesium			154 ng/m3	123, 124 ng/m3
PM2.5 Metals	Chlorine			12.4 ng/m3	14 ng/m3
PM2.5 Metals	Chromium		1 ng/m3	8.86 ng/m3	6 ng/m3
PM2.5 Metals	Cobalt		0.4 ng/m3	10.3 ng/m3	7 ng/m3
PM2.5 Metals	Copper		0.2 ng/m3	11.7 ng/m3	7 ng/m3
PM2.5 Metals	Indium		1 ng/m3		
PM2.5 Metals	Iron		0.4 ng/m3	15.8 ng/m3	25 ng/m3
PM2.5 Metals	Lead		3 ng/m3	22.2 ng/m3	14 ng/m3
PM2.5 Metals	Magnesium				67 ng/m3
PM2.5 Metals	Manganese		0.5 ng/m3	14.7 ng/m3	9 ng/m3
PM2.5 Metals	Molybdenum		1 ng/m3		10 ng/m3
PM2.5 Metals	Nickel		0.2 ng/m3	8.03 ng/m3	4 ng/m3
PM2.5 Metals	Palladium		1.5 ng/m3		
PM2.5 Metals	Phosphorus		12 ng/m3	15.4 ng/m3	15 ng/m3
PM2.5 Metals	Potassium		1 ng/m3	7.16 ng/m3	7 ng/m3
PM2.5 Metals	Rubidium		0.4 ng/m3	13.3 ng/m3	12 ng/m3
PM2.5 Metals	Samarium				123, 124 ng/m3
PM2.5 Metals	Selenium		1 ng/m3	25.6 ng/m3	25 ng/m3
PM2.5 Metals	Silicon		160 ng/m3	28.7 ng/m3	28, 29 ng/m3
PM2.5 Metals	Silver		1.2 ng/m3		
PM2.5 Metals	Strontium		1 ng/m3	16.4 ng/m3	9 ng/m3
PM2.5 Metals	Sulfur		12 ng/m3	31.3 ng/m3	28, 29 ng/m3
PM2.5 Metals	Thallium				25 ng/m3
PM2.5 Metals	Tin		1.5 ng/m3	49.8 ng/m3	25 ng/m3
PM2.5 Metals	Titanium		3 ng/m3	17.5 ng/m3	20 ng/m3
PM2.5 Metals	Uranium			23.4 ng/m3	25 ng/m3

Analysis	Analyte	MATES II MDL	MATES III MDL	MATES IV MDL	MATES V MDL
PM2.5 Metals	Vanadium		1.2 ng/m3	15.5 ng/m3	11 ng/m3
PM2.5 Metals	Yttrium		0.2 ng/m3	15.7 ng/m3	12 ng/m3
PM2.5 Metals	Zinc		0.2 ng/m3	8.37 ng/m3	7 ng/m3
PM2.5 Levoglucosan	Galactosan				2 ng/m3
PM2.5 Levoglucosan	Levoglucosan				2 ng/m3
PM2.5 Levoglucosan	Mannosan				2 ng/m3
Diesel PM	Diesel PM				

Carbonyls Analysis

Acetaldehyde

Table IV-3. Ambient Concentrations (ppb) of Acetaldehyde from the Carbonyls analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1.6	2.35	1.99	1.85	1.33	1.32	1.77	2.13	1.99	1.1
95% CI LB	1.33	1.99	1.62	1.49	0.993	1.09	1.45	1.73	1.59	0.908
95% CI UB	1.88	2.72	2.37	2.26	1.71	1.57	2.15	2.61	2.41	1.33
N	51	55	41	59	50	62	51	52	49	40
% < MDL	2	0	0	1.7	20	0	0	0	2	2.5
Max	3.8	6.1	5.4	8.5	4.5	4.9	5.4	10.3	7.1	2.7
MATES III										
Average	1.3	1.96	1.54	1.88	1.39	1.31	1.89	1.68	1.73	1.42
95% CI LB	1.22	1.85	1.43	1.76	1.23	1.22	1.76	1.55	1.62	1.32
95% CI UB	1.39	2.06	1.65	2.02	1.55	1.4	2.01	1.8	1.85	1.52
N	243	240	228	238	117	242	241	119	239	237
% < MDL	0.4	0	0.4	0	0.9	0.8	0.4	0	0	0
Max	3.73	5	4.67	4.71	4	3.99	5.22	3.9	4.31	4.52
MATES IV										
Average	0.587	1.08	0.83	0.992	1.04	0.667	0.944	1.25	0.838	0.746
95% CI LB	0.48	0.941	0.69	0.869	0.891	0.568	0.839	1.11	0.741	0.598
95% CI UB	0.716	1.23	0.987	1.12	1.2	0.779	1.06	1.39	0.939	0.914
N	60	59	60	59	57	59	59	59	59	55
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	3.07	2.7	2.94	2.44	2.94	2.07	2	2.61	1.95	2.79
MATES V										
Average		1.77	1.46	2.11	1.63	1.24	1.32	1.38	1.05	1.16
95% CI LB		1.55	1.26	1.82	1.44	1.09	1.1	1.24	0.849	1.02
95% CI UB		1.97	1.65	2.42	1.84	1.4	1.56	1.54	1.27	1.32
N	0	59	61	59	60	55	18	58	12	60
% < MDL		0	0	1.7	0	0	0	0	0	0
Max		4	3.71	7	4.5	3.26	2.78	3.26	1.87	3.26

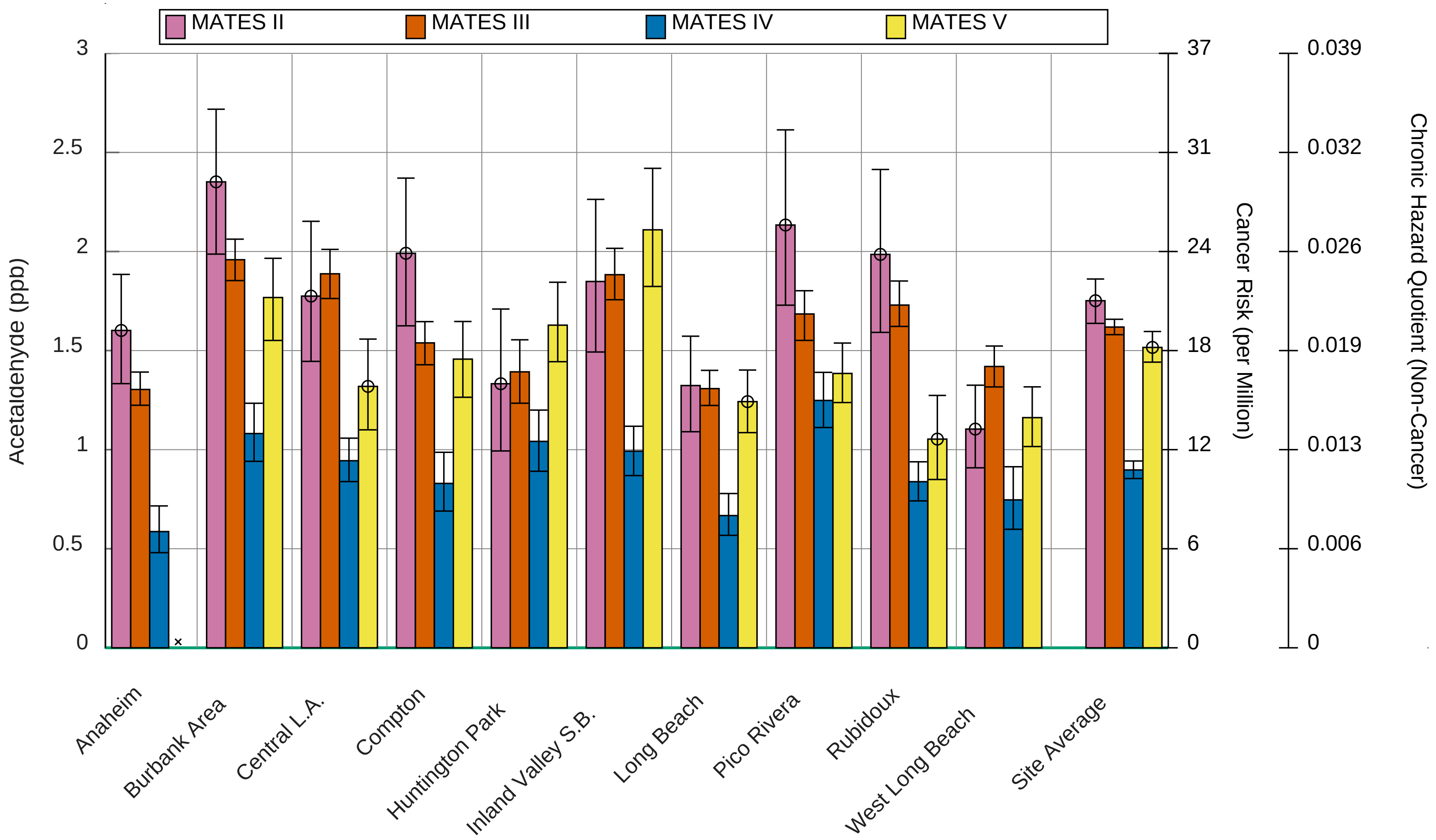


Figure IV-1. Annual Average Concentrations of Acetaldehyde in the Carbonyls Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

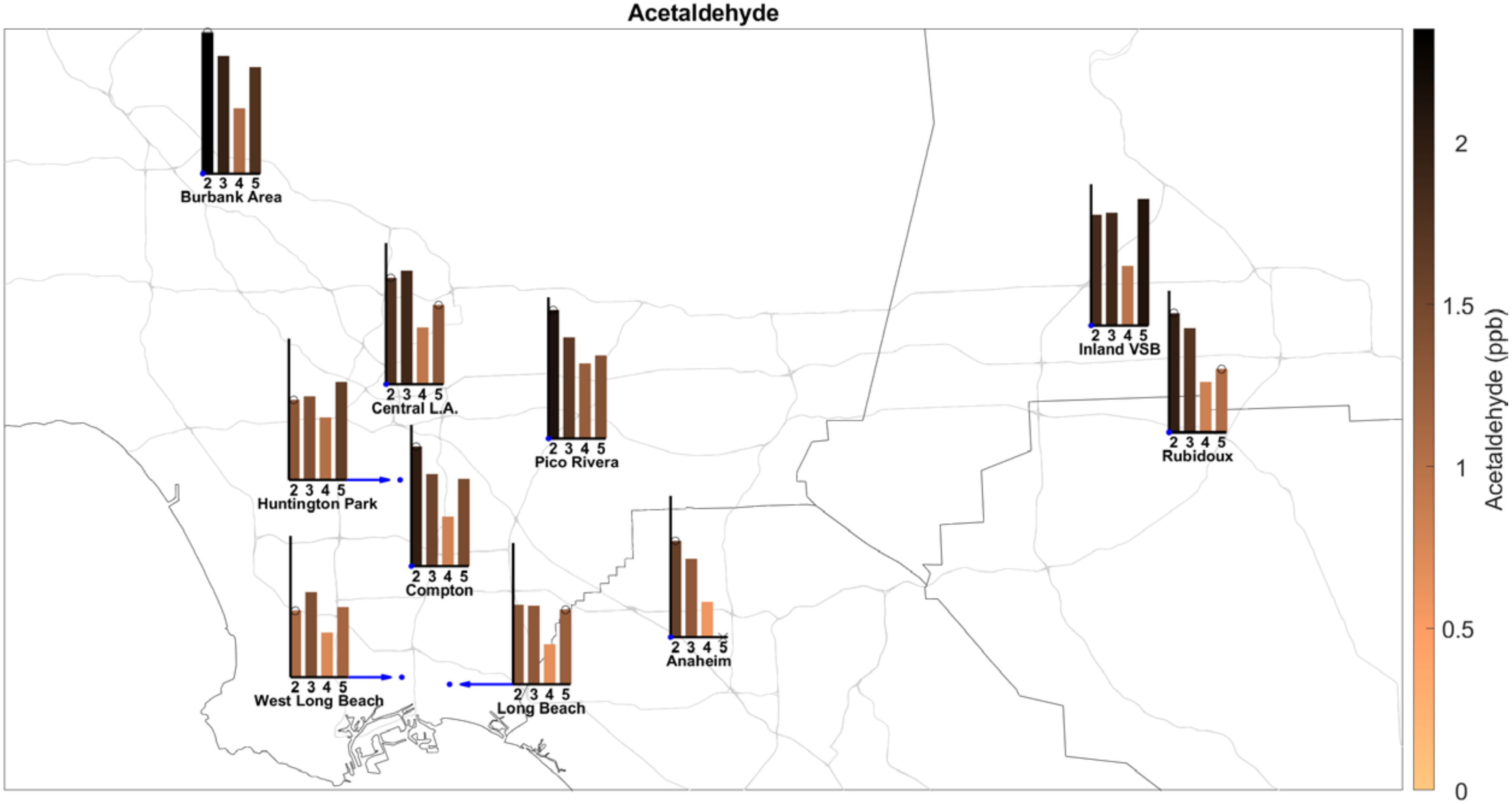


Figure IV-2. Geographic distribution of Acetaldehyde from the Carbonyls Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Acetone

Table IV-4. Ambient Concentrations (ppb) of Acetone from the Carbonyls analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1.85	2.75	1.95	2.79	1.82	1.15	1.95	2.14	3.15	1.36
95% CI LB	1.25	1.95	1.24	2.08	1.01	0.885	1.38	1.33	2.37	0.924
95% CI UB	2.56	3.67	2.78	3.56	2.86	1.45	2.62	3.09	4.03	1.9
N	27	26	20	30	24	28	27	28	25	19
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	8.71	9.97	7.7	7.2	9.62	3.78	5.9	8.65	8.5	5.15
MATES III										
Average	1.81	1.84	1.46	1.63	2.02	0.933	1.42	1.76	1.6	1.35
95% CI LB	1.49	1.57	1.27	1.51	1.6	0.796	1.24	1.4	1.47	1.13
95% CI UB	2.15	2.14	1.7	1.77	2.48	1.08	1.61	2.15	1.73	1.61
N	243	240	228	238	117	242	241	119	239	237
% < MDL	0.4	0	1.8	0.4	2.6	2.1	2.1	0.8	0	0.8
Max	21.4	14.1	9.68	5.34	11.2	8.04	9.23	11.5	5.9	12.4
MATES IV										
Average	1.65	2.34	1.62	1.43	2.59	1.17	1.91	1.92	1.14	1.23
95% CI LB	0.896	1.49	0.96	1.19	1.62	0.756	1.39	1.33	0.936	0.74
95% CI UB	2.72	3.4	2.4	1.69	3.74	1.68	2.53	2.61	1.37	1.81
N	59	59	60	59	57	59	59	60	59	55
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	21.8	19.5	12.4	4.77	19.7	8.95	9.97	11.4	5.05	9.93
MATES V										
Average		3.09	2.41	3.12	2.56	1.96	1.14	2.33	1.54	1.85
95% CI LB		2.66	1.84	2.51	1.99	1.58	0.963	1.87	1.09	1.28
95% CI UB		3.56	3.05	3.87	3.18	2.42	1.32	2.85	2.11	2.55
N	0	58	61	59	60	56	18	58	12	60
% < MDL		0	1.6	1.7	0	1.8	0	0	0	0
Max		8.54	10.5	16.3	9.99	6.7	1.75	8.57	3.89	15.7

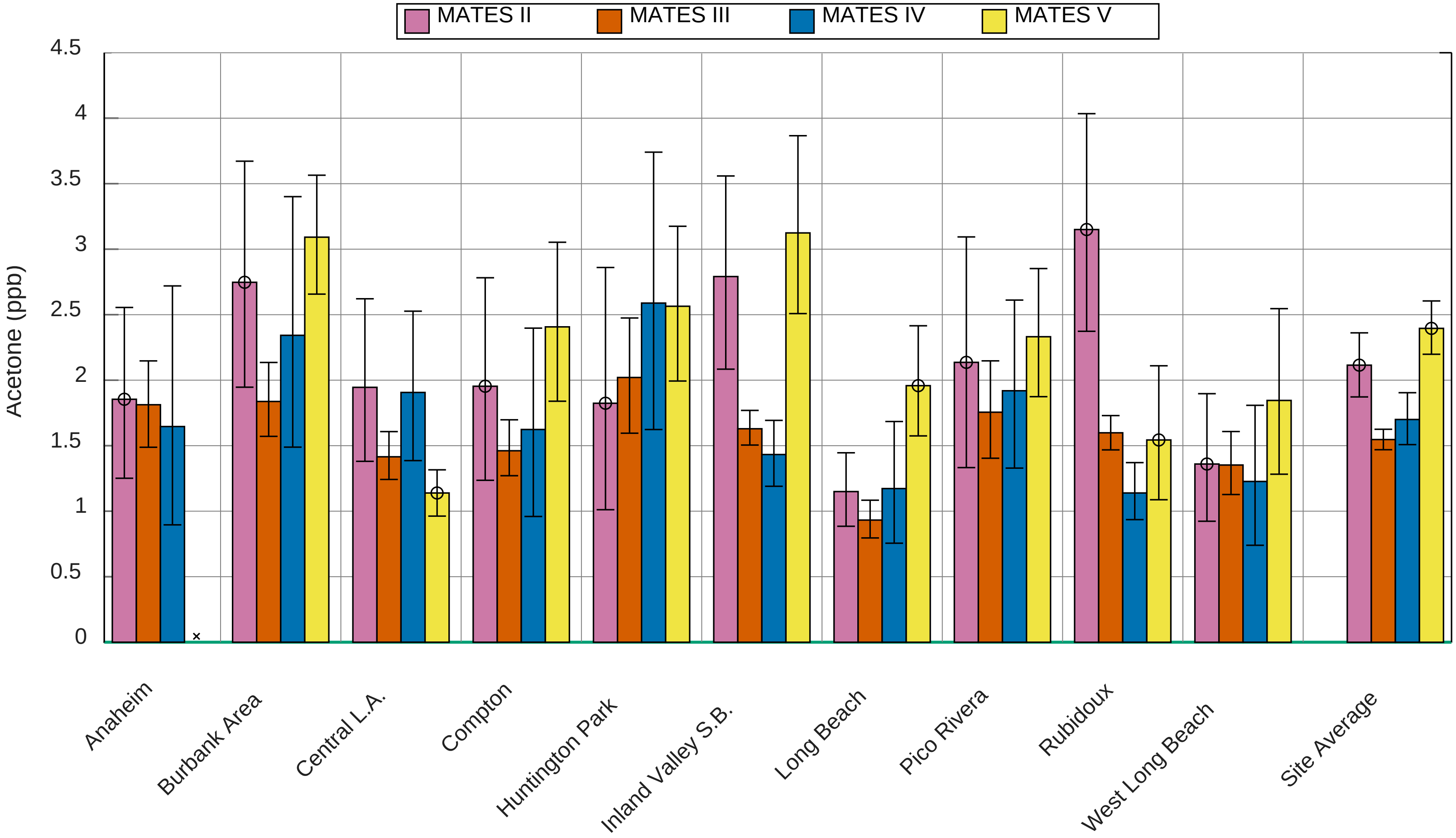


Figure IV-3. Annual Average Concentrations of Acetone in the Carbonyls Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

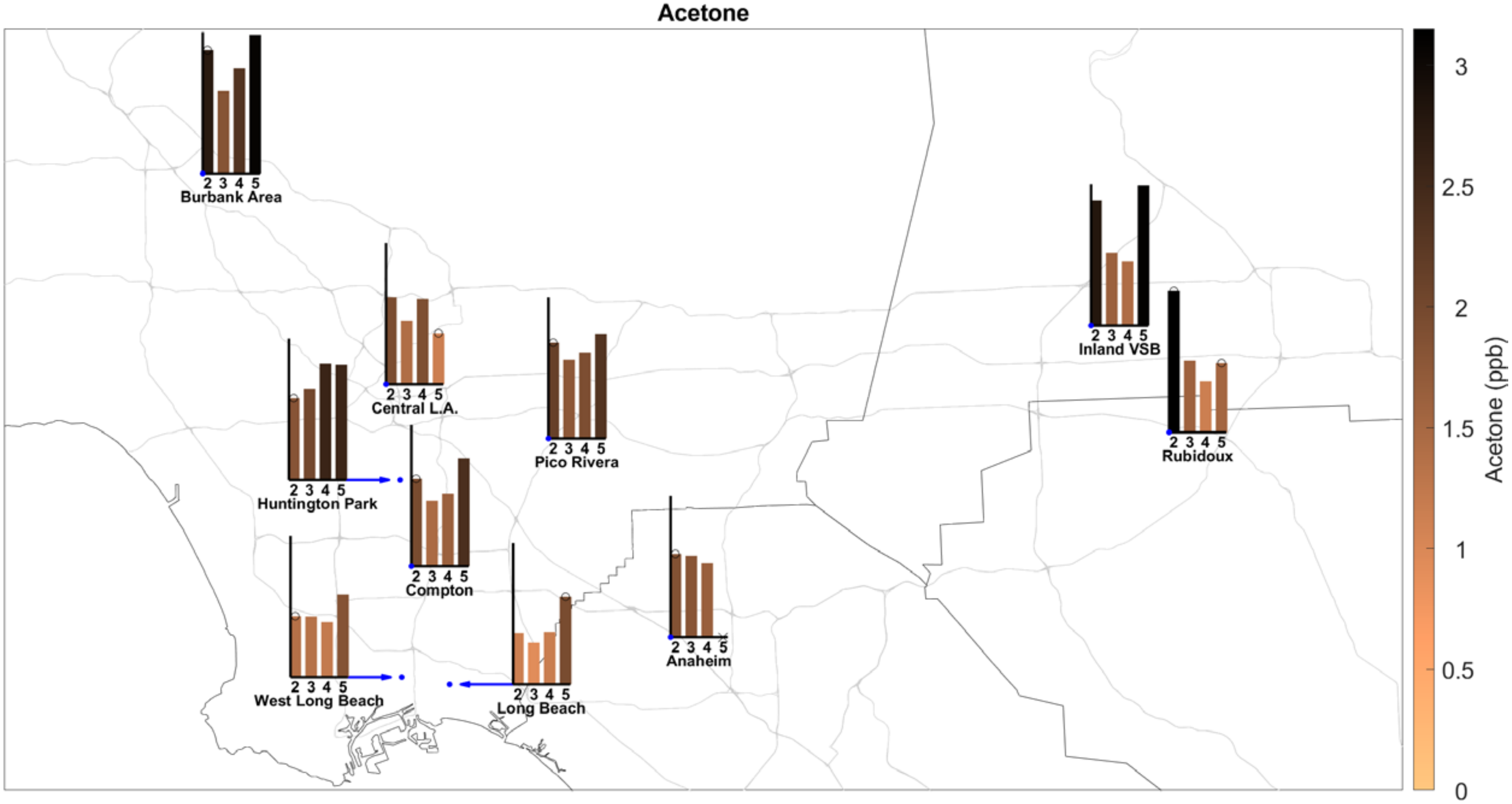


Figure IV-4. Geographic distribution of Acetone from the Carbonyls Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Benzaldehyde

Table IV-5. Ambient Concentrations (ppb) of Benzaldehyde from the Carbonyls analysis at the Fixed Sites.

	Measurement Site									
Statistic	AN	BU	CP	SB	HP	LB	LA	PR	RU	WLB
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average		0.0608	0.0796	0.0853	0.0631	0.0466	0.0551	0.063	0.0415	0.0496
95% CI LB		0.051	0.0679	0.0678	0.0545	0.0385	0.0446	0.0552	0.0311	0.0422
95% CI UB		0.0718	0.0917	0.107	0.0723	0.0554	0.0662	0.071	0.0542	0.0572
N	0	58	61	59	60	56	18	58	12	60
% < MDL		1.7	1.6	5.1	0	1.8	0	0	0	1.7
Max		0.259	0.182	0.57	0.191	0.13	0.108	0.137	0.0871	0.138

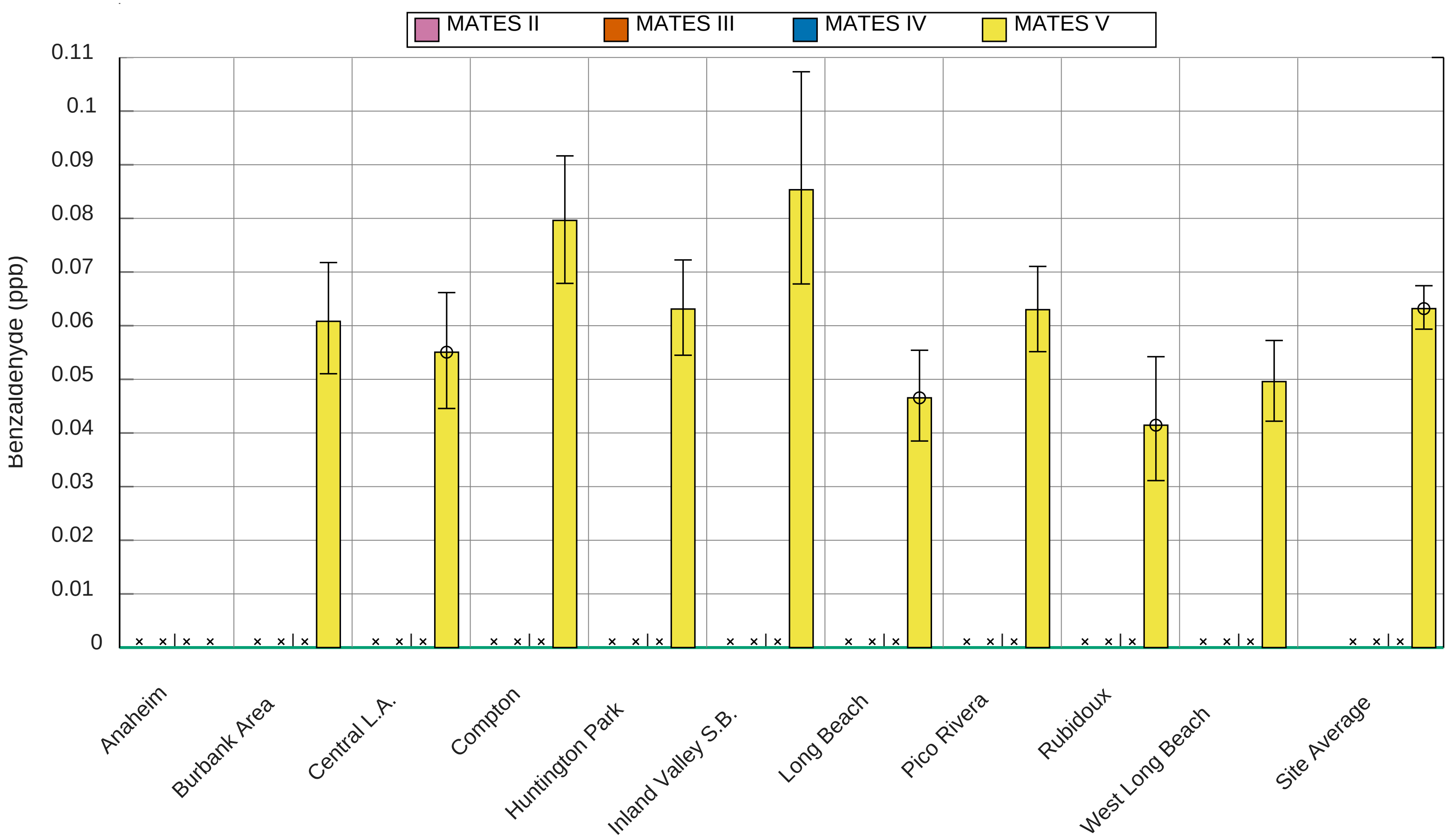


Figure IV-5. Annual Average Concentrations of Benzaldehyde in the Carbonyls Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

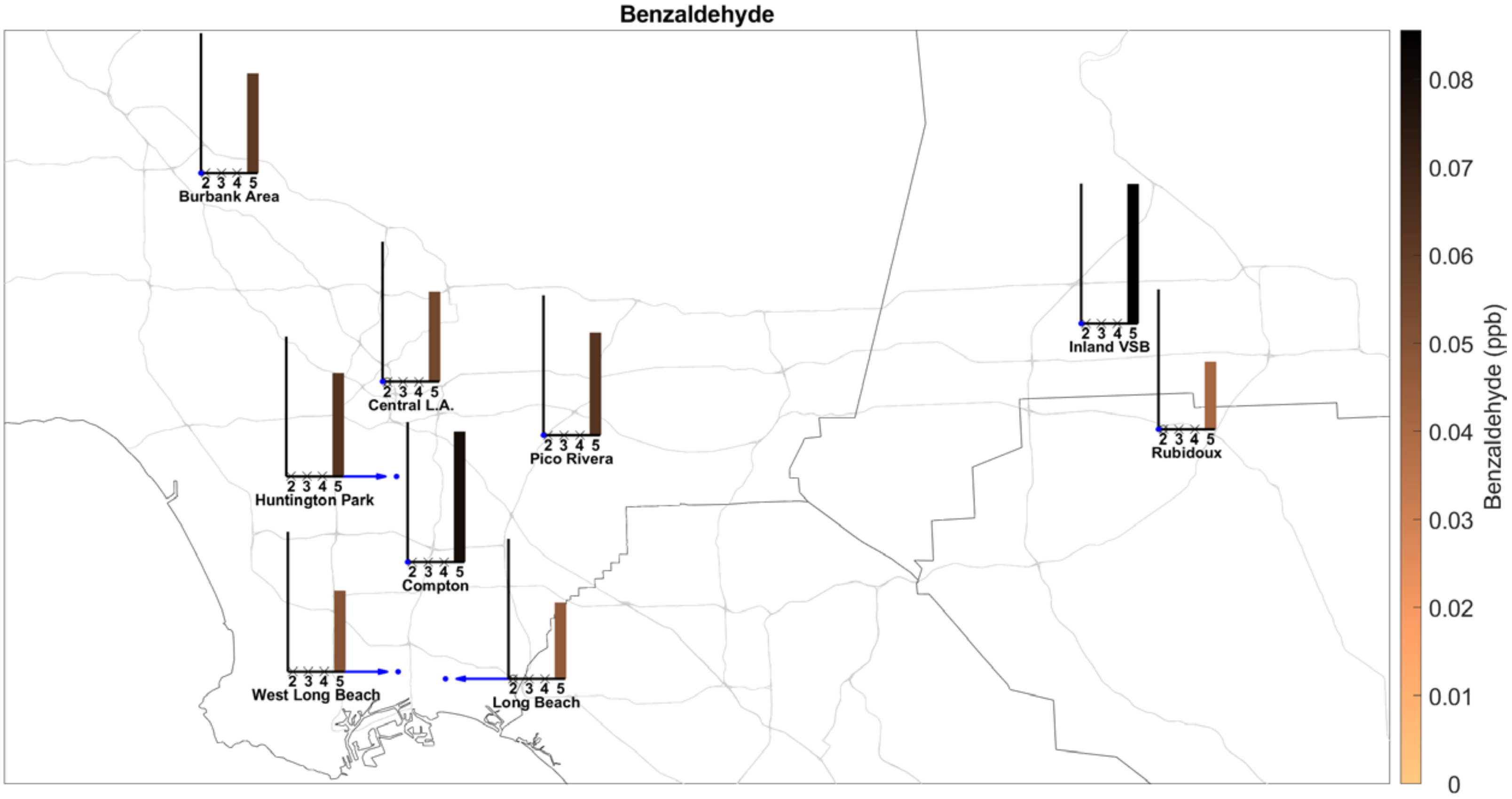


Figure IV-6. Geographic distribution of Benzaldehyde from the Carbonyls Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Formaldehyde

Table IV-6. Ambient Concentrations (ppb) of Formaldehyde from the Carbonyls analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	3.72	5.27	4.8	3.7	3.12	3.23	3.88	4.31	4.2	2.71
95% CI LB	3.2	4.49	4.04	3.12	2.29	2.79	3.2	3.7	3.54	2.26
95% CI UB	4.26	6	5.51	4.32	3.99	3.68	4.62	4.94	4.93	3.16
N	52	55	41	59	50	62	51	53	50	40
% < MDL	1.9	0	0	0	18	0	0	1.9	0	2.5
Max	7.6	13.6	10	9.5	10.9	7.32	12	10	11.4	5.8
MATES III										
Average	2.96	3.79	3.06	3.6	4.18	3.7	4.24	3.49	3.74	3.26
95% CI LB	2.8	3.61	2.89	3.36	3.9	3.48	4.01	3.24	3.5	3.07
95% CI UB	3.13	3.99	3.24	3.86	4.46	3.9	4.48	3.73	3.98	3.46
N	243	240	228	238	88	242	241	119	239	237
% < MDL	0	0	0	0	0	0	0.4	0	0	0
Max	7.74	7.71	8.43	8.96	8.49	11.5	10.6	6.85	8.95	12.8
MATES IV										
Average	1.19	2.58	2.05	2.63	2.73	1.86	2.94	2.81	2	1.55
95% CI LB	0.994	2.27	1.85	2.34	2.48	1.69	2.7	2.55	1.71	1.3
95% CI UB	1.4	2.87	2.26	2.92	2.96	2.05	3.18	3.08	2.29	1.83
N	58	59	60	59	57	59	59	59	57	51
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	3.73	4.72	4.18	5.15	5.4	3.79	5.06	6.32	4.4	4.06
MATES V										
Average		3.73	2.43	4.4	2.56	2.08	3.32	3	2.59	2.33
95% CI LB		3.17	2.2	3.34	2.3	1.92	2.84	2.69	2.16	2.14
95% CI UB		4.4	2.67	6.1	2.82	2.27	3.89	3.3	3.03	2.51
N	0	59	61	59	60	56	18	58	12	60
% < MDL		0	0	1.7	0	0	0	0	0	0
Max		19.3	4.55	46.3	5.63	3.95	6.35	5.73	3.89	4.49

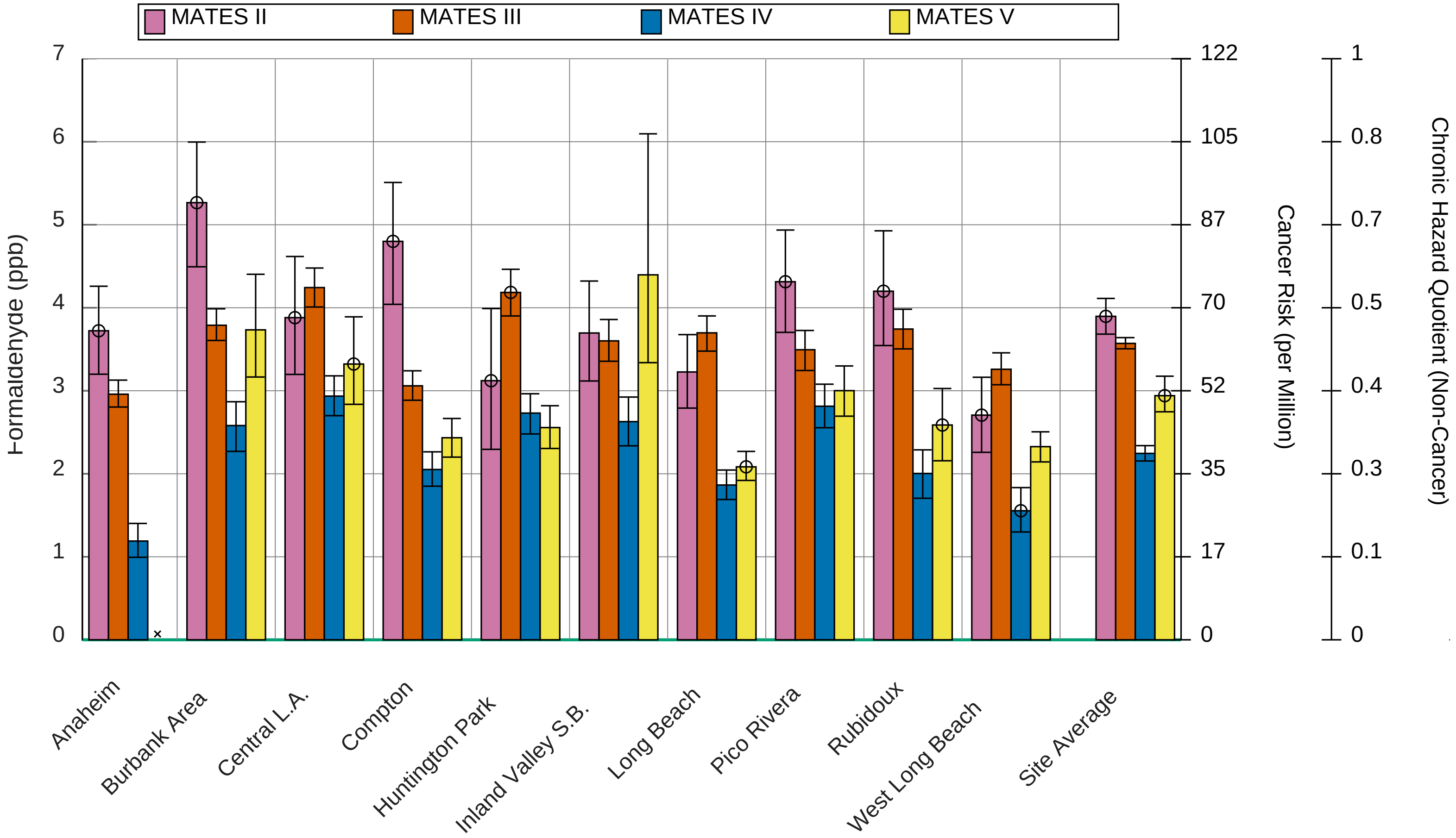


Figure IV-7. Annual Average Concentrations of Formaldehyde in the Carbonyls Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

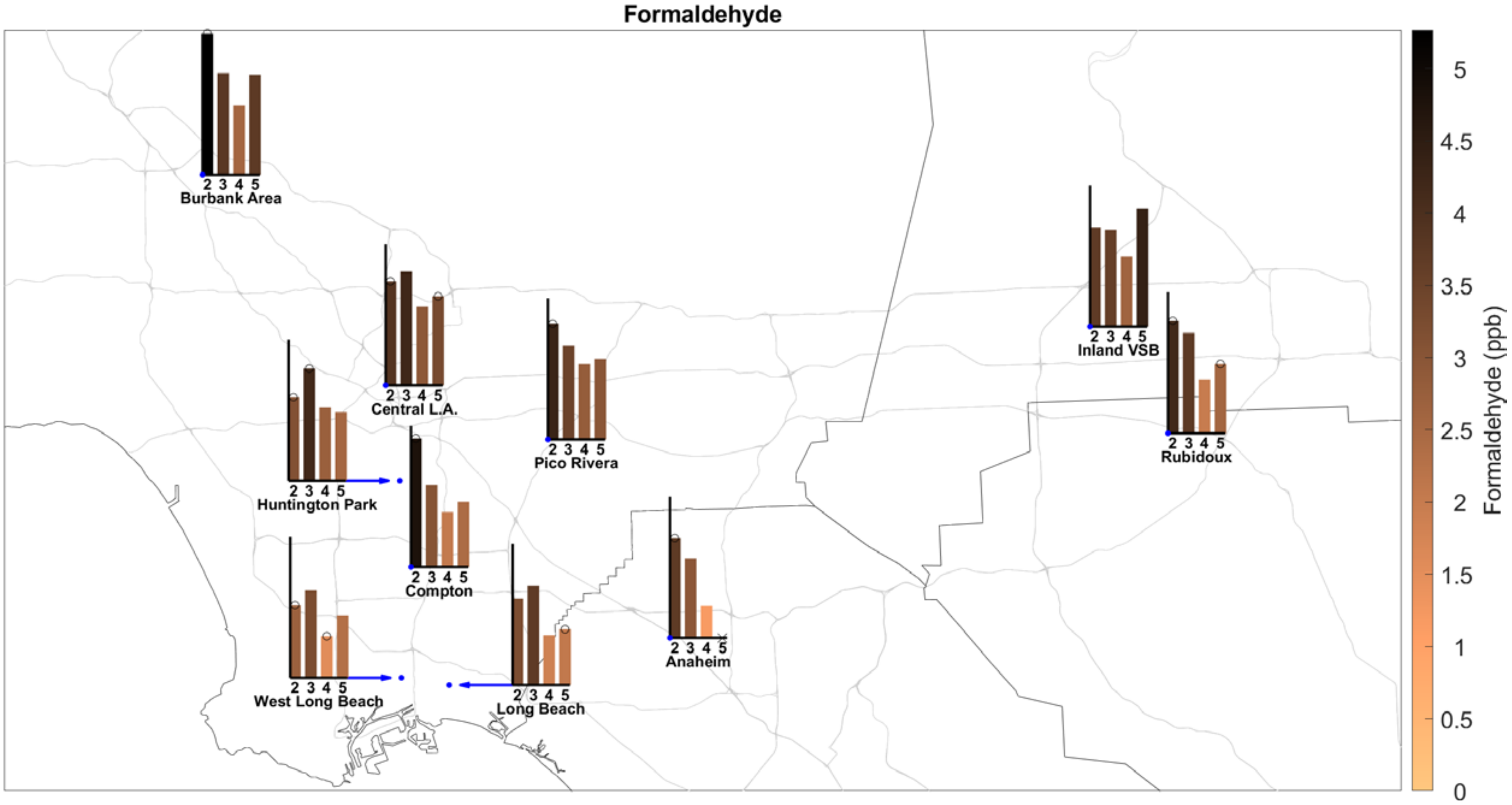


Figure IV-8. Geographic distribution of Formaldehyde from the Carbonyls Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Methyl Ethyl Ketone

Table IV-7. Ambient Concentrations (ppb) of Methyl Ethyl Ketone from the Carbonyls analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.377	0.565	0.417	0.353	0.272	0.295	0.31	0.391	0.416	0.255
95% CI LB	0.286	0.439	0.312	0.274	0.198	0.224	0.23	0.293	0.323	0.192
95% CI UB	0.478	0.704	0.531	0.441	0.362	0.382	0.397	0.502	0.517	0.327
N	46	47	41	50	46	54	43	46	46	40
% < MDL	19.6	2.1	26.8	16	39.1	25.9	34.9	19.6	13	32.5
Max	1.42	2.19	1.35	1.35	1.53	1.83	1.15	1.72	1.22	1.03
MATES III										
Average	0.276	0.369	0.292	0.366	0.338	0.241	0.317	0.421	0.359	0.326
95% CI LB	0.251	0.338	0.264	0.339	0.293	0.218	0.292	0.369	0.333	0.286
95% CI UB	0.302	0.4	0.322	0.394	0.387	0.264	0.342	0.474	0.386	0.37
N	243	240	228	238	117	242	241	119	239	237
% < MDL	20.6	6.7	15.8	5.5	12.8	23.1	9.5	10.1	6.3	16.9
Max	1.07	1.2	1.22	1.06	1.39	0.88	1.07	1.32	1.11	2.4
MATES IV										
Average	0.0646	0.11	0.0764	0.0895	0.115	0.0639	0.084	0.146	0.0748	0.0695
95% CI LB	0.0425	0.0757	0.0503	0.0756	0.0776	0.0453	0.0657	0.106	0.0623	0.0447
95% CI UB	0.0921	0.152	0.107	0.104	0.16	0.0864	0.105	0.192	0.089	0.0999
N	58	59	60	58	57	59	59	60	59	54
% < MDL	1.7	0	3.3	0	0	0	0	0	0	3.7
Max	0.568	0.619	0.547	0.227	0.768	0.39	0.345	0.758	0.288	0.472
MATES V										
Average		0.273	0.197	0.252	0.249	0.172	0.0609	0.238	0.165	0.142
95% CI LB		0.235	0.153	0.213	0.188	0.14	0.0432	0.182	0.115	0.107
95% CI UB		0.313	0.243	0.293	0.32	0.209	0.079	0.299	0.229	0.181
N	0	58	60	59	60	56	17	57	12	59
% < MDL		1.7	11.7	1.7	3.3	1.8	17.6	3.5	0	5.1
Max		0.615	0.711	0.669	1.21	0.648	0.172	0.888	0.433	0.623

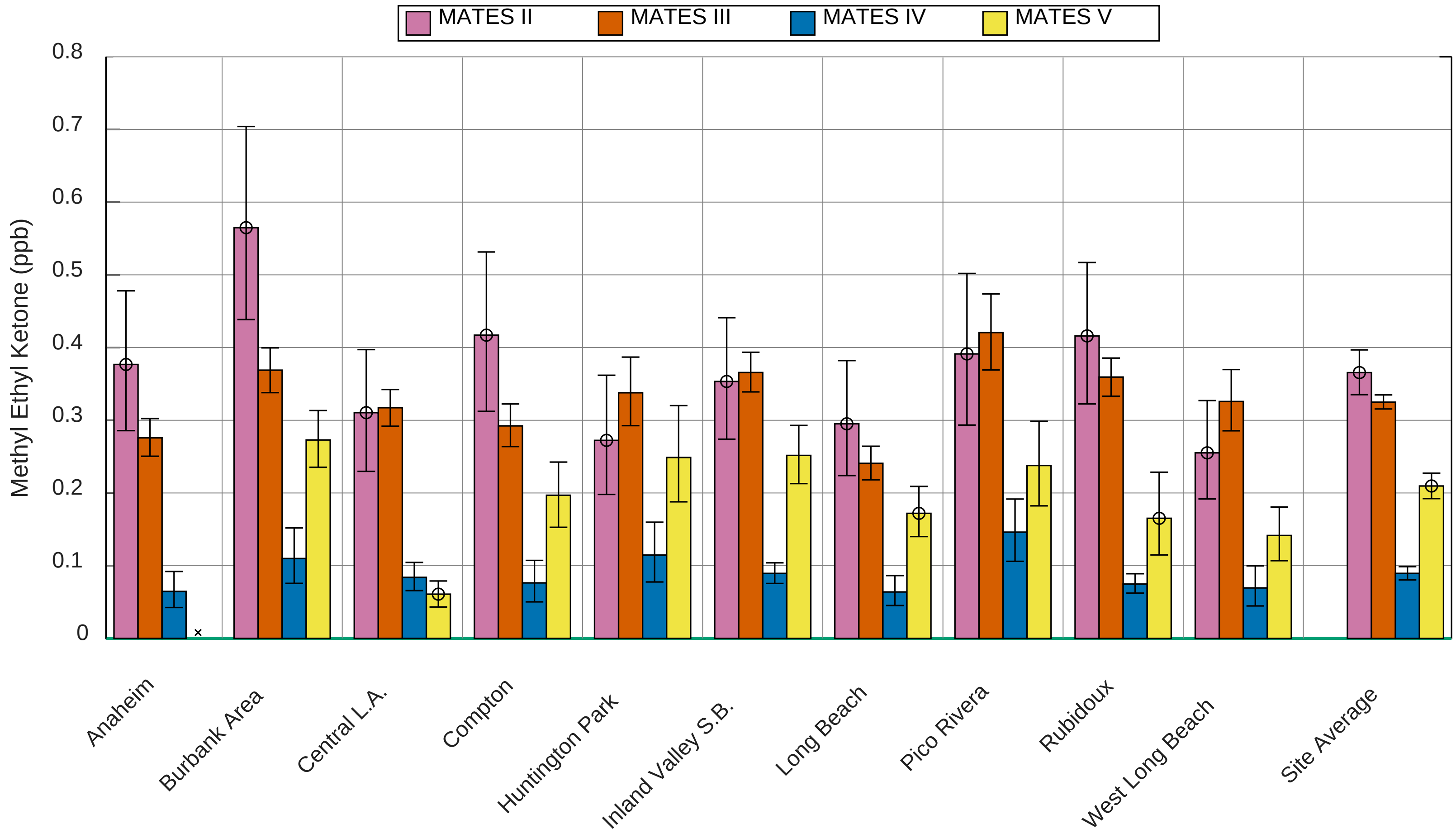


Figure IV-9. Annual Average Concentrations of Methyl Ethyl Ketone in the Carbonyls Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

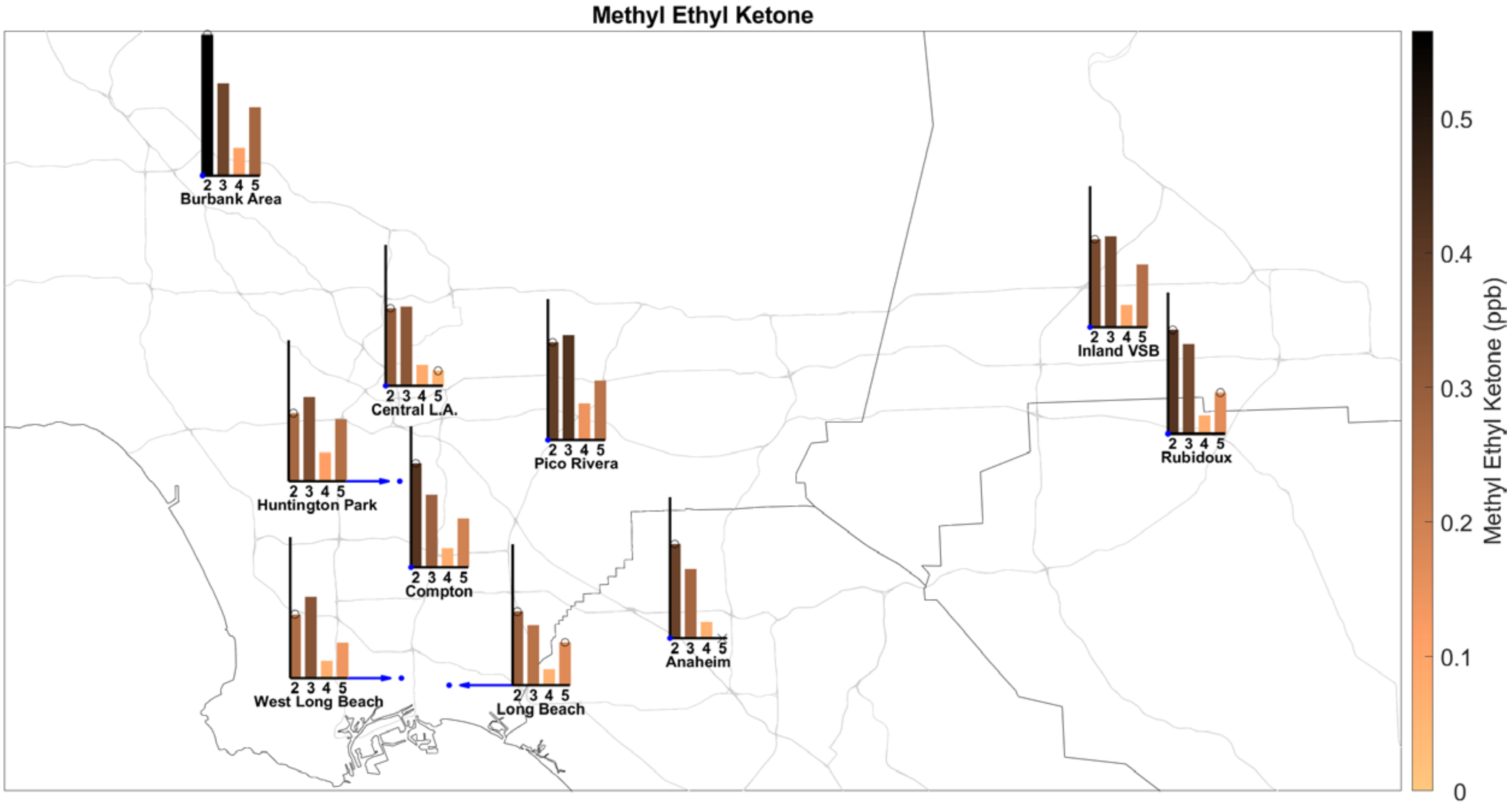


Figure IV-10. Geographic distribution of Methyl Ethyl Ketone from the Carbonyls Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Propionaldehyde

Table IV-8. Ambient Concentrations (ppb) of Propionaldehyde from the Carbonyls analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average		0.215	0.168	0.249	0.175	0.137	0.17	0.164	0.145	0.147
95% CI LB		0.189	0.149	0.216	0.156	0.121	0.142	0.147	0.113	0.13
95% CI UB		0.241	0.187	0.283	0.195	0.156	0.203	0.183	0.181	0.164
N	0	58	61	59	59	56	18	57	12	60
% < MDL		0	1.6	1.7	0	0	0	0	0	0
Max		0.574	0.36	0.636	0.427	0.324	0.353	0.382	0.282	0.364

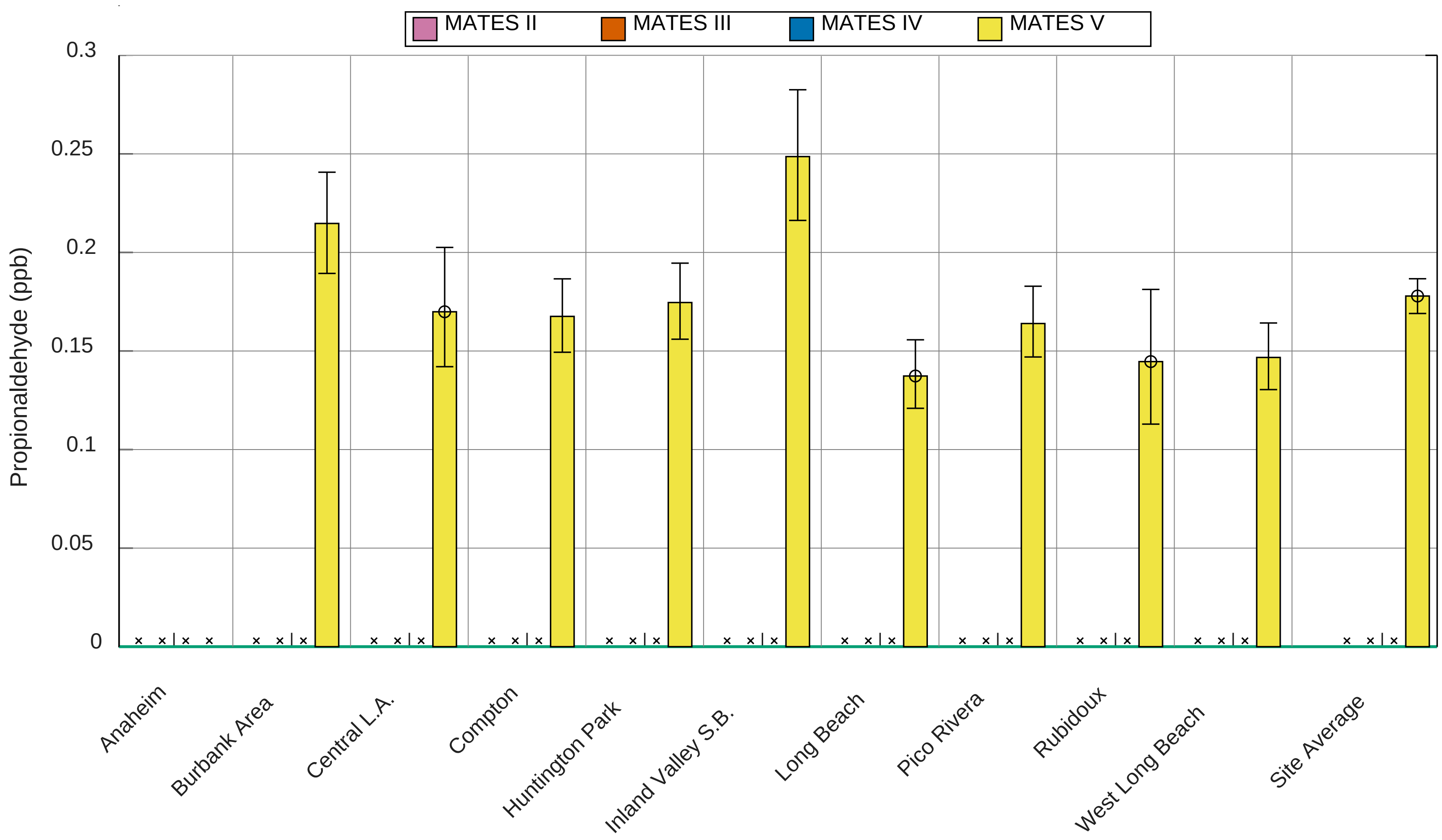


Figure IV-11. Annual Average Concentrations of Propionaldehyde in the Carbonyls Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

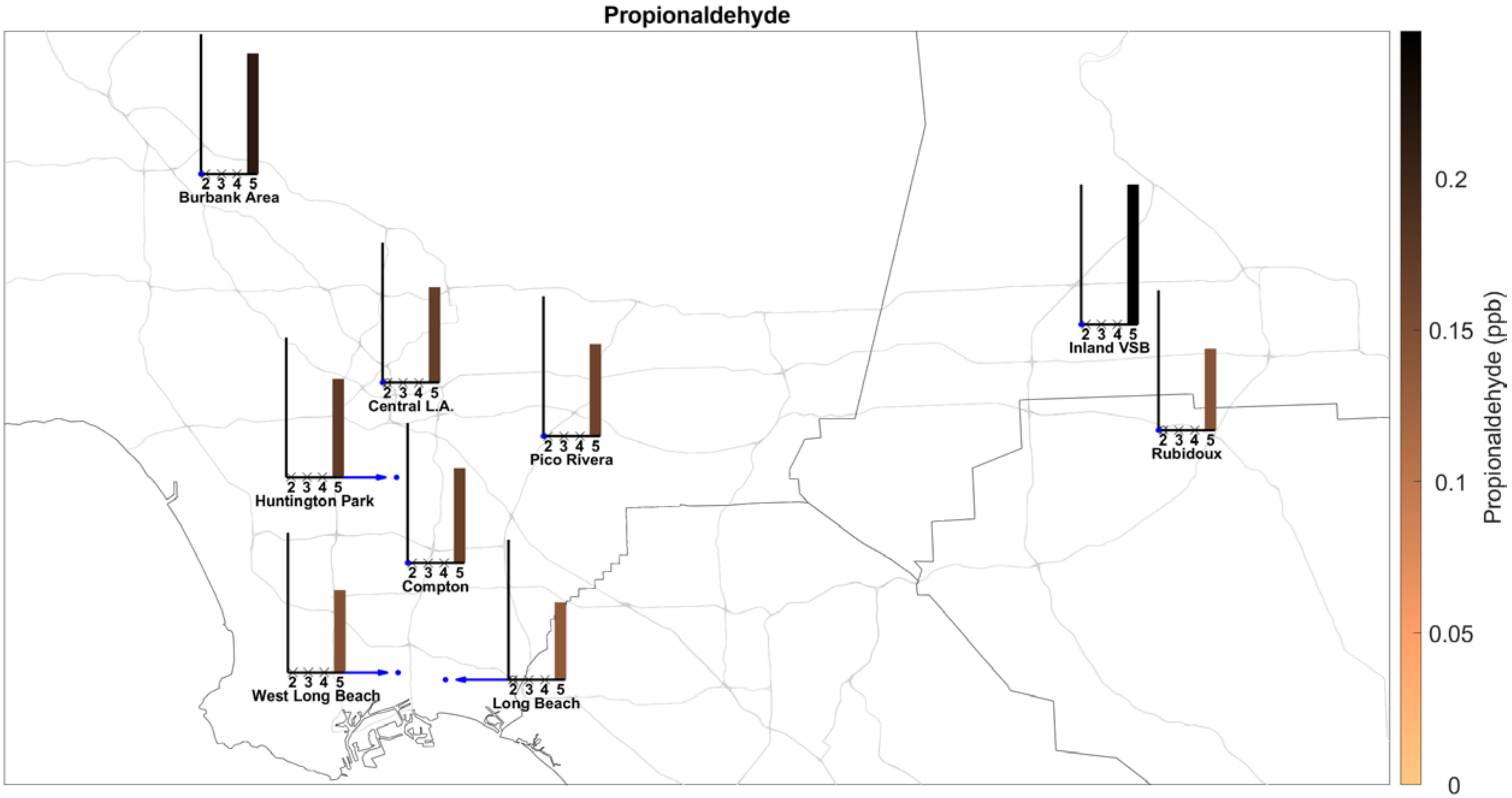


Figure IV-12. Geographic distribution of Propionaldehyde from the Carbonyls Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

VOCs Analysis

Acrolein

Table IV-9. Ambient Concentrations (ppb) of Acrolein from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	0.154	0.197	0.196	0.162	0.196	0.146	0.18	0.155	0.159	0.139
95% CI LB	0.133	0.173	0.171	0.144	0.174	0.13	0.161	0.14	0.138	0.124
95% CI UB	0.176	0.224	0.226	0.18	0.22	0.163	0.201	0.172	0.183	0.156
N	51	55	57	53	53	54	53	57	52	57
% < MDL	9.8	5.5	3.5	15.1	5.7	14.8	11.3	7	3.8	15.8
Max	0.43	0.51	0.56	0.36	0.48	0.41	0.41	0.38	0.52	0.37
MATES V										
Average		0.196	0.219	0.227	0.252	0.169	0.208	0.235	0.263	0.16
95% CI LB		0.178	0.187	0.207	0.224	0.151	0.183	0.203	0.229	0.142
95% CI UB		0.214	0.253	0.247	0.287	0.191	0.238	0.273	0.302	0.178
N	0	58	58	58	57	57	55	50	58	55
% < MDL		0	0	0	0	0	0	0	0	0
Max		0.42	0.65	0.41	0.61	0.55	0.71	0.87	0.77	0.4

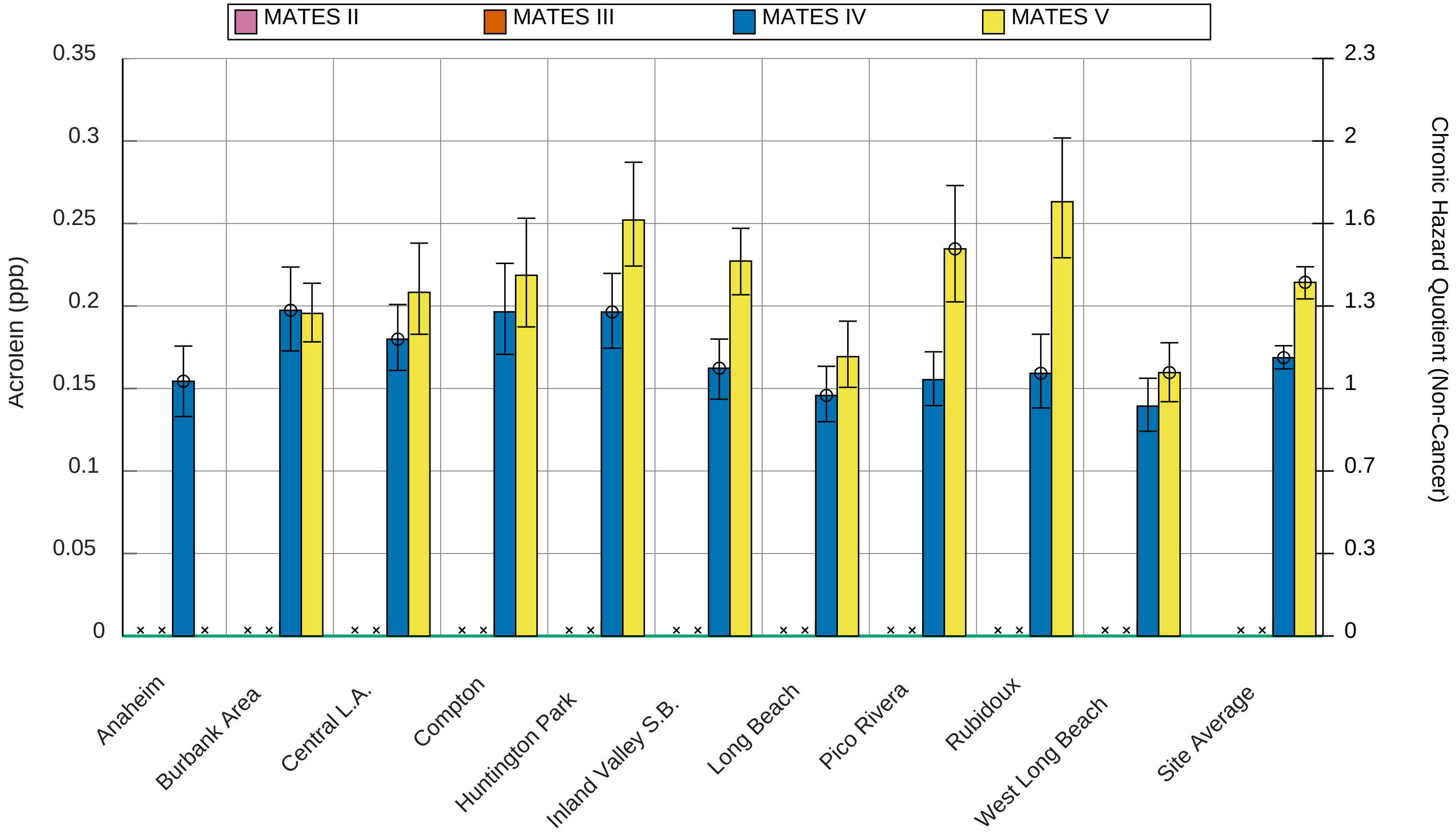


Figure IV-13. Annual Average Concentrations of Acrolein in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

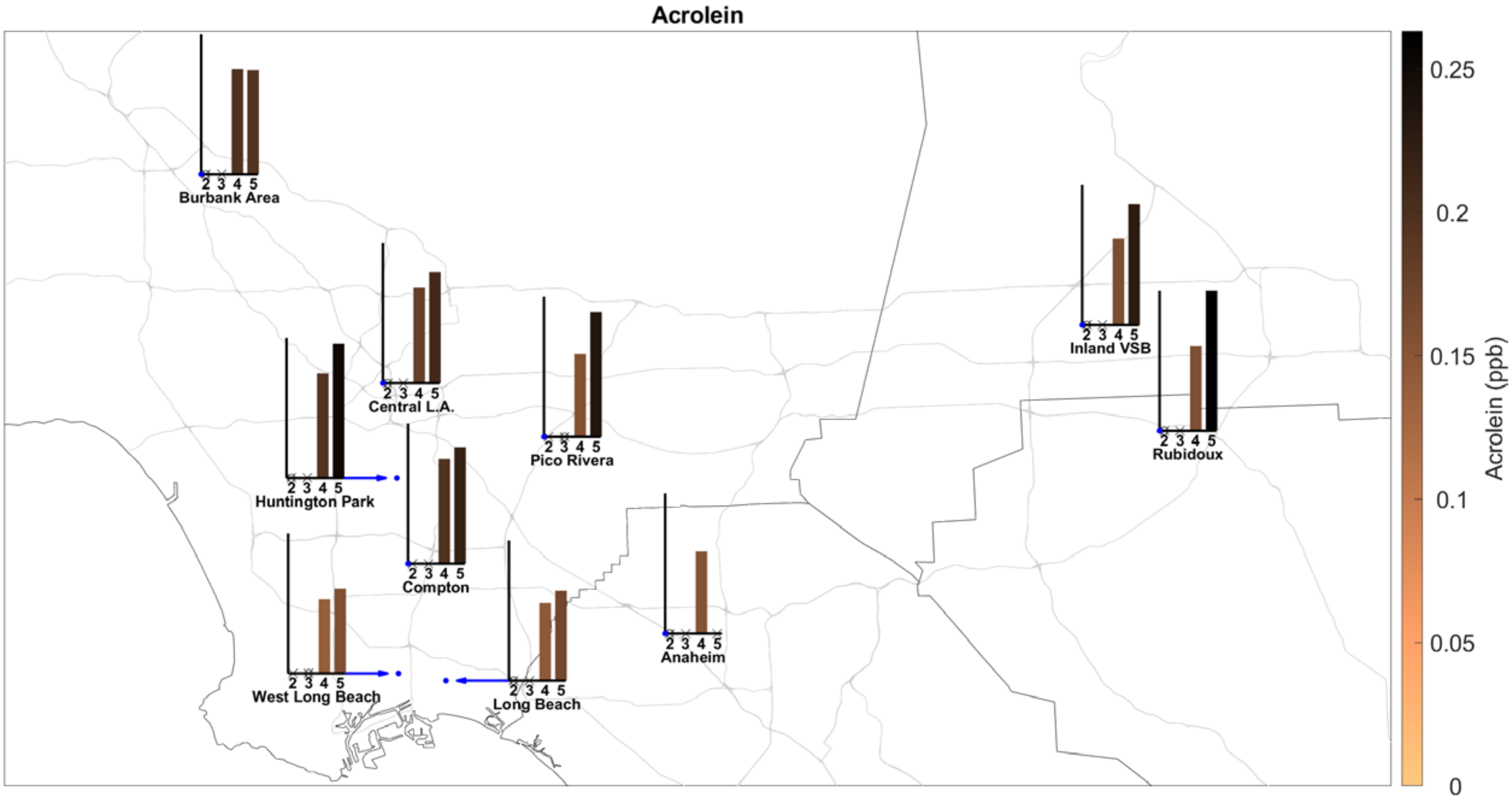


Figure IV-14. Geographic distribution of Acrolein from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Benzene

Table IV-10. Ambient Concentrations (ppb) of Benzene from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1.05	1.27	1.8	0.742	1.65	0.826	1	0.892	0.874	1.27
95% CI LB	0.83	1.02	1.37	0.628	1.32	0.673	0.846	0.746	0.736	0.978
95% CI UB	1.34	1.52	2.29	0.864	1.99	0.996	1.2	1.05	1.02	1.6
N	51	58	42	60	46	60	59	54	45	35
% < MDL	5.9	1.7	2.4	3.3	0	1.7	0	1.9	4.4	5.7
Max	5.2	4.1	6.9	2.2	5.1	3.4	3.6	2.2	2.5	3.9
MATES III										
Average	0.43	0.708	0.804	0.487	0.754	0.52	0.579	0.566	0.438	0.532
95% CI LB	0.392	0.655	0.719	0.456	0.666	0.48	0.541	0.511	0.407	0.481
95% CI UB	0.47	0.763	0.893	0.519	0.846	0.567	0.621	0.626	0.471	0.586
N	233	241	237	232	100	238	238	121	234	235
% < MDL	0	0	0	0.9	0	0	0	0	0	0.4
Max	2.06	2.16	3.53	1.26	2.2	1.7	1.83	1.85	1.32	1.95
MATES IV										
Average	0.33	0.456	0.495	0.291	0.521	0.327	0.388	0.347	0.276	0.356
95% CI LB	0.263	0.38	0.38	0.257	0.423	0.279	0.335	0.295	0.239	0.284
95% CI UB	0.404	0.534	0.614	0.33	0.625	0.379	0.443	0.402	0.321	0.434
N	51	55	57	53	53	54	53	57	52	57
% < MDL	0	0	0	0	1.9	0	1.9	0	0	0
Max	1.33	1.23	1.77	0.91	1.72	0.84	1.15	0.91	0.91	1.17
MATES V										
Average		0.22	0.38	0.233	0.313	0.323	0.257	0.249	0.223	0.298
95% CI LB		0.199	0.289	0.203	0.255	0.251	0.219	0.205	0.188	0.241
95% CI UB		0.241	0.477	0.265	0.376	0.404	0.297	0.3	0.262	0.367
N	0	60	61	61	60	59	56	53	60	58
% < MDL		0	0	0	0	0	0	0	0	0
Max		0.45	1.55	0.69	0.94	1.57	0.69	0.85	0.78	1.12

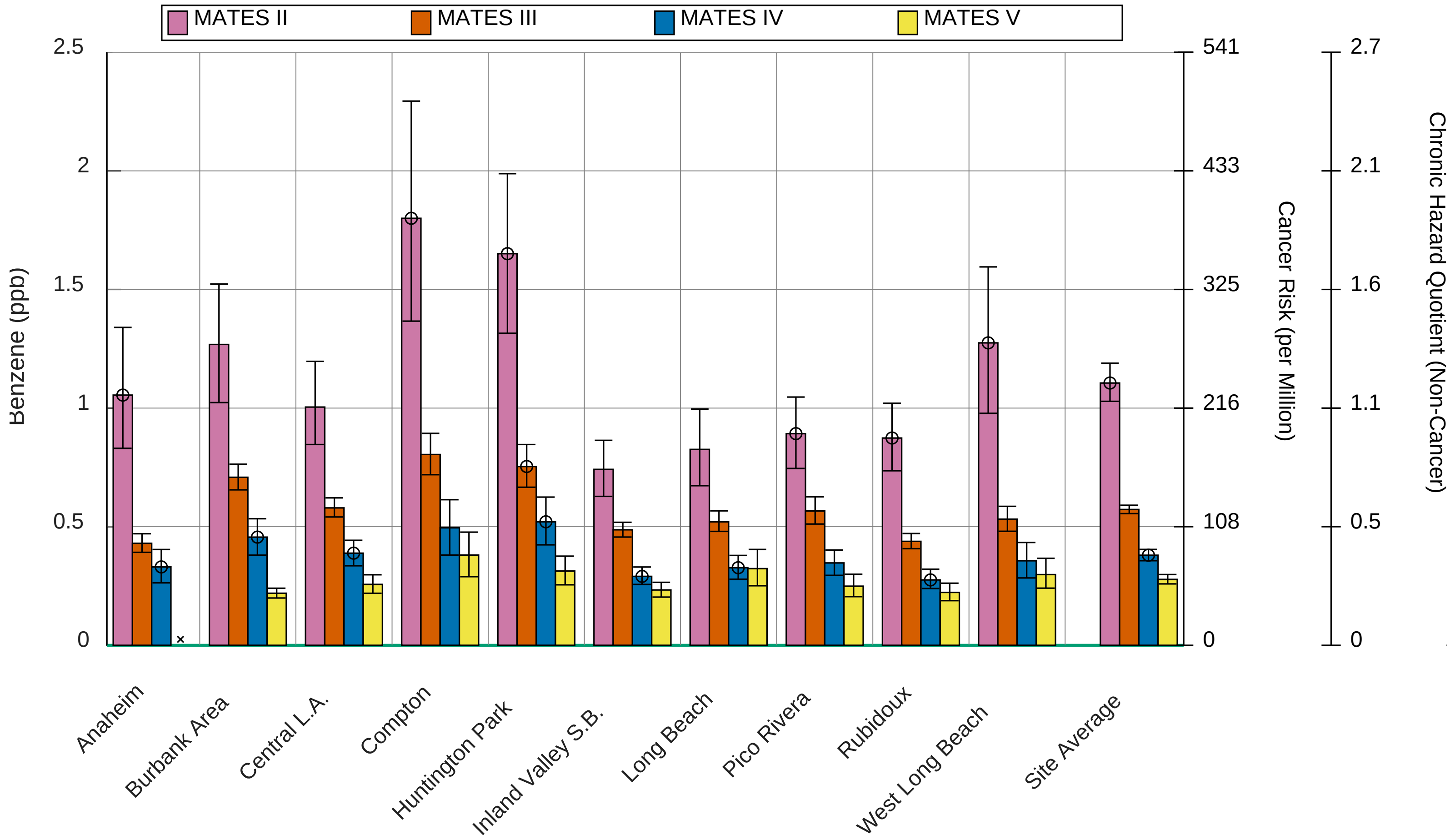


Figure IV-15. Annual Average Concentrations of Benzene in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

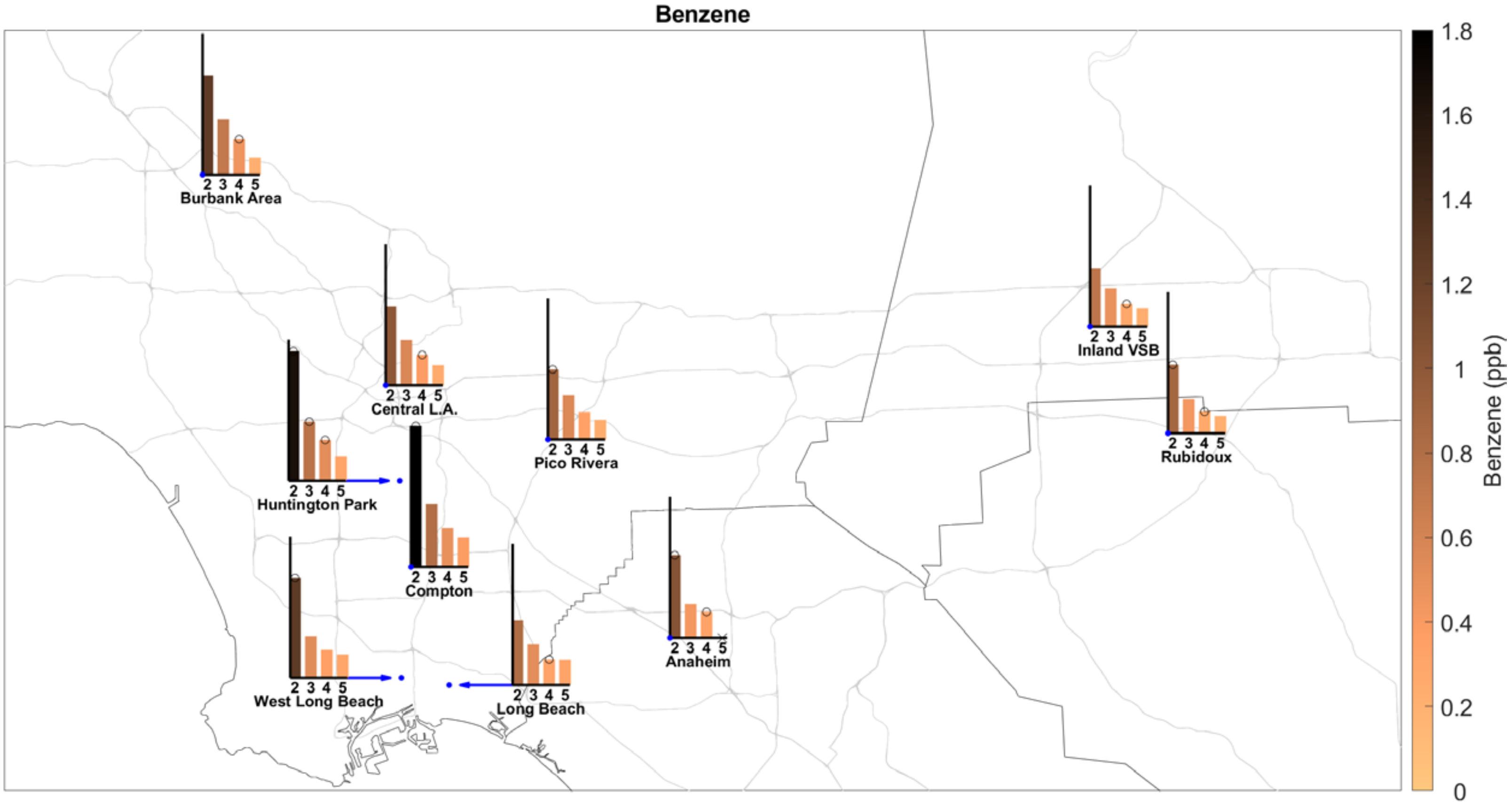


Figure IV-16. Geographic distribution of Benzene from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Bromomethane

Table IV-11. Ambient Concentrations (ppb) of Bromomethane from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average		0.0119	0.0174	0.0126	0.0158	0.0433	0.0129	0.0136	0.0127	1.14
95% CI LB		0.0104	0.0149	0.0108	0.0136	0.0232	0.0109	0.0116	0.0109	0.387
95% CI UB		0.0138	0.0204	0.0147	0.0179	0.0742	0.0152	0.0156	0.015	2.09
N	0	43	43	43	42	41	40	37	42	40
% < MDL		48.8	44.2	48.8	47.6	46.3	52.5	54.1	52.4	30
Max		0.03	0.03	0.03	0.03	0.54	0.03	0.02	0.03	12.2

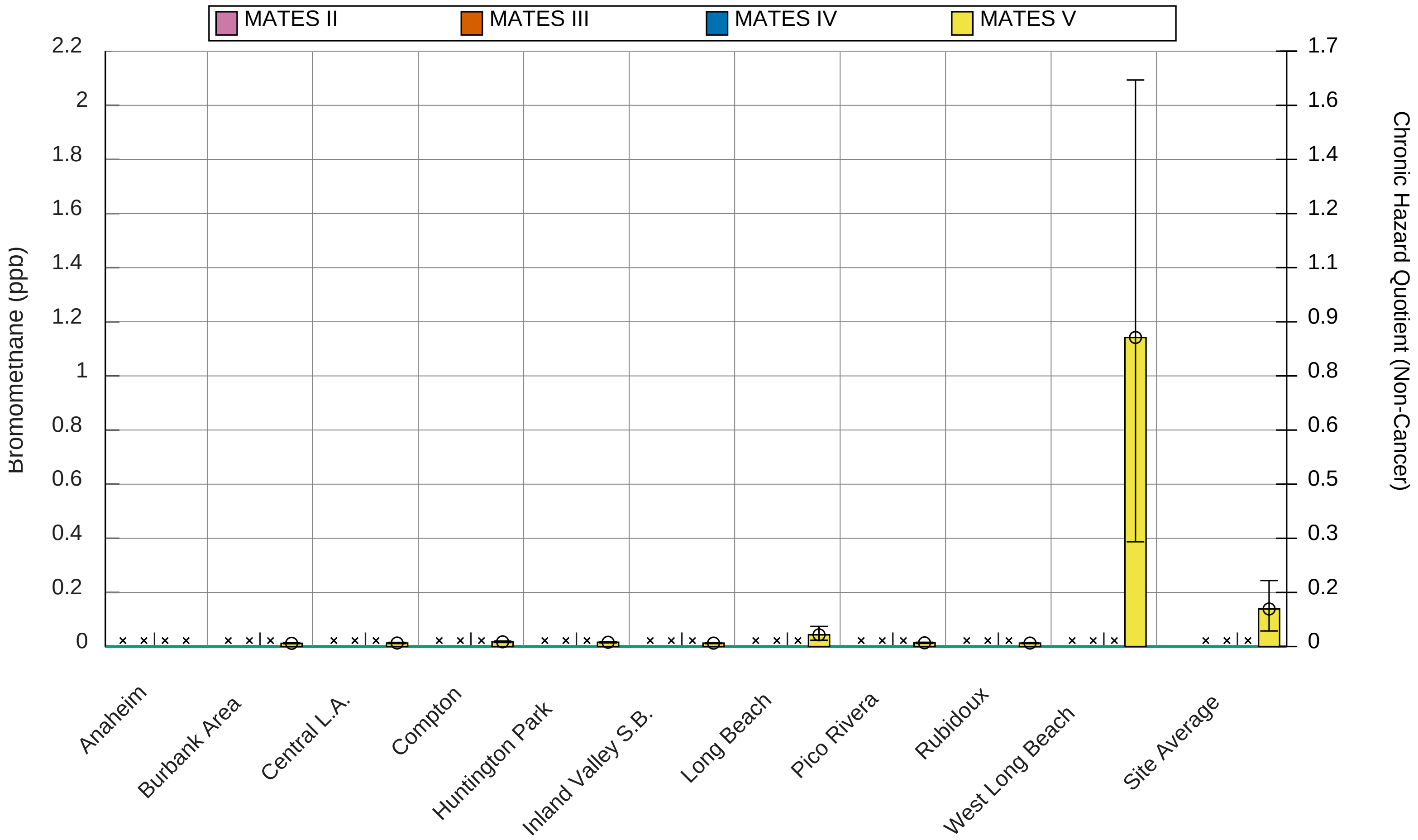


Figure IV-17. Annual Average Concentrations of Bromomethane in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

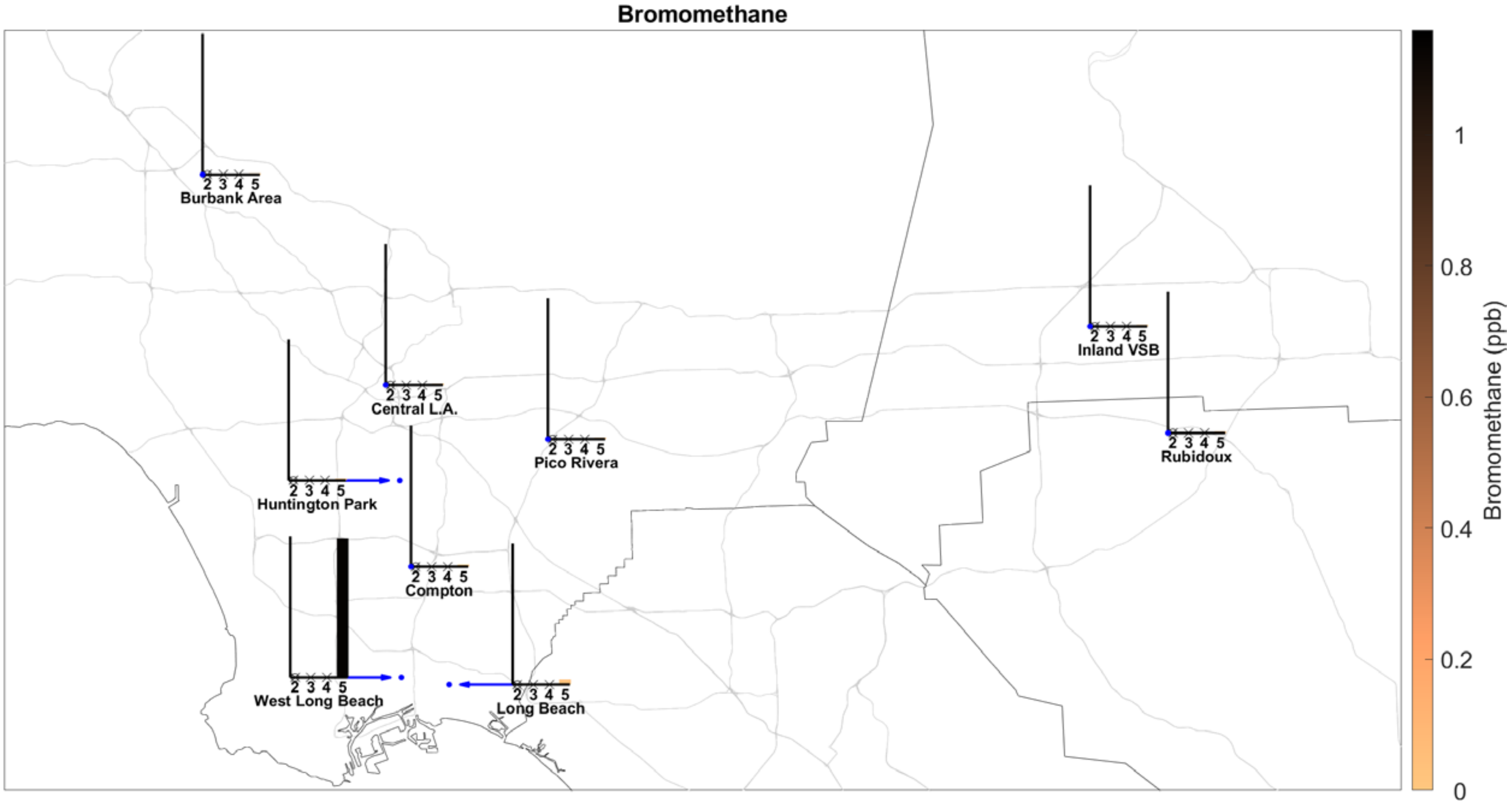


Figure IV-18. Geographic distribution of Bromomethane from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

1,3 Butadiene

Table IV-12. Ambient Concentrations (ppb) of 1,3 Butadiene from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.257	0.428	0.627	0.202	0.579	0.275	0.35	0.295	0.238	0.435
95% CI LB	0.201	0.337	0.464	0.166	0.458	0.217	0.288	0.238	0.187	0.323
95% CI UB	0.323	0.528	0.807	0.24	0.708	0.34	0.422	0.355	0.293	0.554
N	51	58	42	60	46	60	59	54	45	35
% < MDL	13.7	13.8	2.4	16.7	4.3	10	10.2	11.1	13.3	8.6
Max	1	1.5	2.4	0.66	1.9	1.2	1.3	0.972	0.828	1.3
MATES III										
Average	0.0161, 0.203[a]	0.232	0.267	0.0056, 0.2[a]	0.242	0.0424, 0.213[a]	0.0412, 0.21[a]	0.0534, 0.217[a]	0.0143, 0.203[a]	0.0404, 0.215[a]
95% CI LB	0.00854[a]	0.223	0.249	0.00181[a]	0.225	0.0295[a]	0.0295[a]	0.0334[a]	0.00718[a]	0.027[a]
95% CI UB	0.206[a]	0.242	0.286	0.201[a]	0.261	0.218[a]	0.214[a]	0.226[a]	0.205[a]	0.221[a]
N	233[a]	241	237	232[a]	100	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	93.6[a]	78.8	70.9	97.4[a]	69	85.3[a]	84.5[a]	81.8[a]	94.4[a]	87.2[a]
Max	0.34[a]	0.62	1.02	0.24[a]	0.71	0.48[a]	0.42[a]	0.47[a]	0.33[a]	0.5[a]
MATES IV										
Average	0.0833	0.113	0.122	0.0578	0.14	0.0782	0.0996	0.0792	0.0661	0.081
95% CI LB	0.062	0.0852	0.0878	0.0475	0.108	0.0612	0.0828	0.0643	0.0534	0.0612
95% CI UB	0.107	0.143	0.161	0.0698	0.174	0.0971	0.118	0.0961	0.0801	0.103
N	51	55	57	53	53	54	53	57	52	57
% < MDL	23.5	9.1	15.8	24.5	5.7	14.8	9.4	24.6	30.8	38.6
Max	0.41	0.39	0.58	0.22	0.53	0.28	0.36	0.3	0.21	0.32
MATES V										
Average		0.0367	0.0975	0.0516	0.0743	0.0527	0.0535	0.0587	0.0497	0.061
95% CI LB		0.0322	0.0749	0.0438	0.0615	0.0408	0.0454	0.0492	0.0413	0.0472
95% CI UB		0.042	0.123	0.0623	0.0888	0.068	0.0638	0.0698	0.0597	0.0791
N	0	60	61	61	60	59	56	53	60	58
% < MDL		16.7	16.4	16.4	8.3	35.6	17.9	24.5	28.3	29.3
Max		0.14	0.49	0.25	0.25	0.32	0.19	0.21	0.18	0.33

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

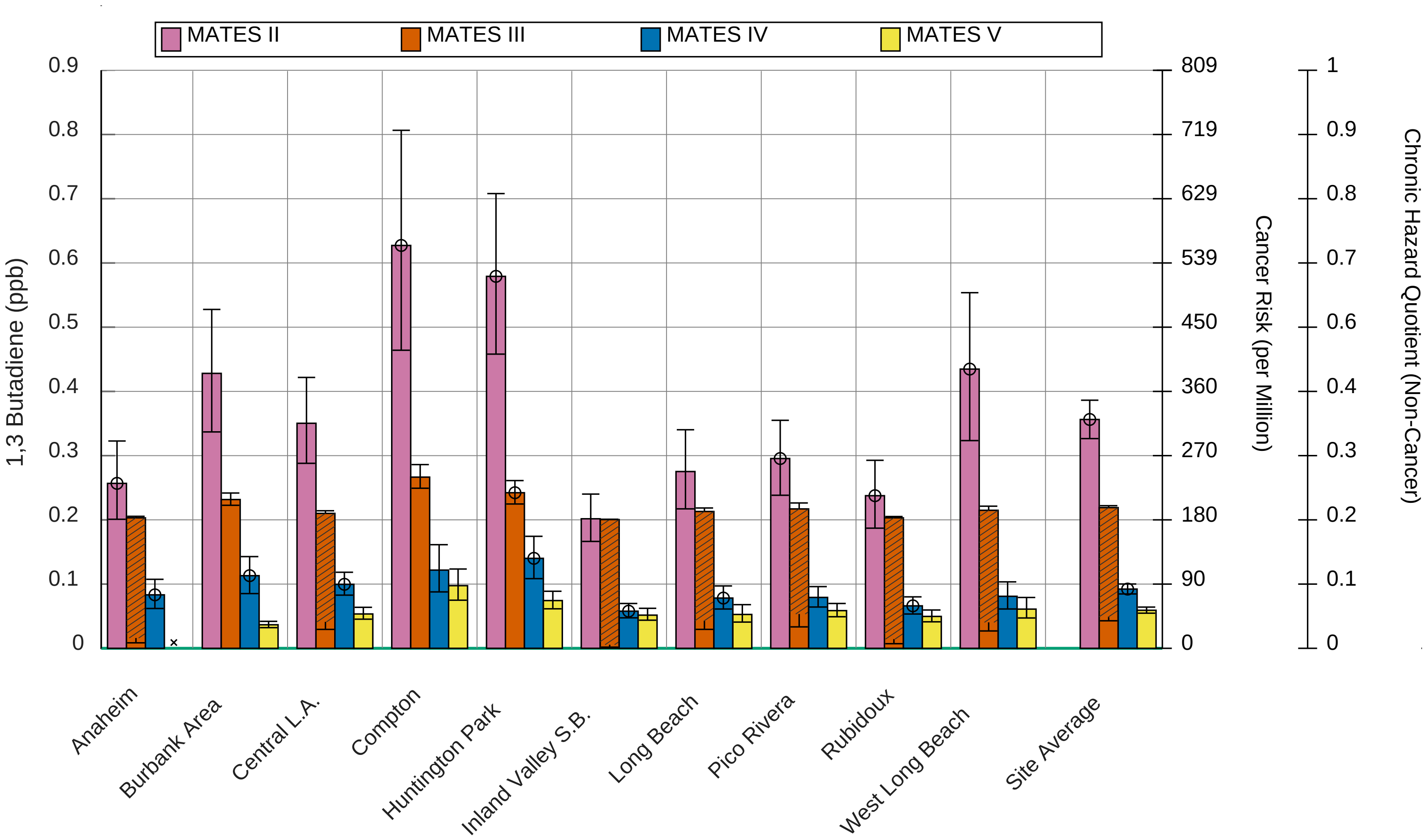


Figure IV-19. Annual Average Concentrations of 1,3 Butadiene in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

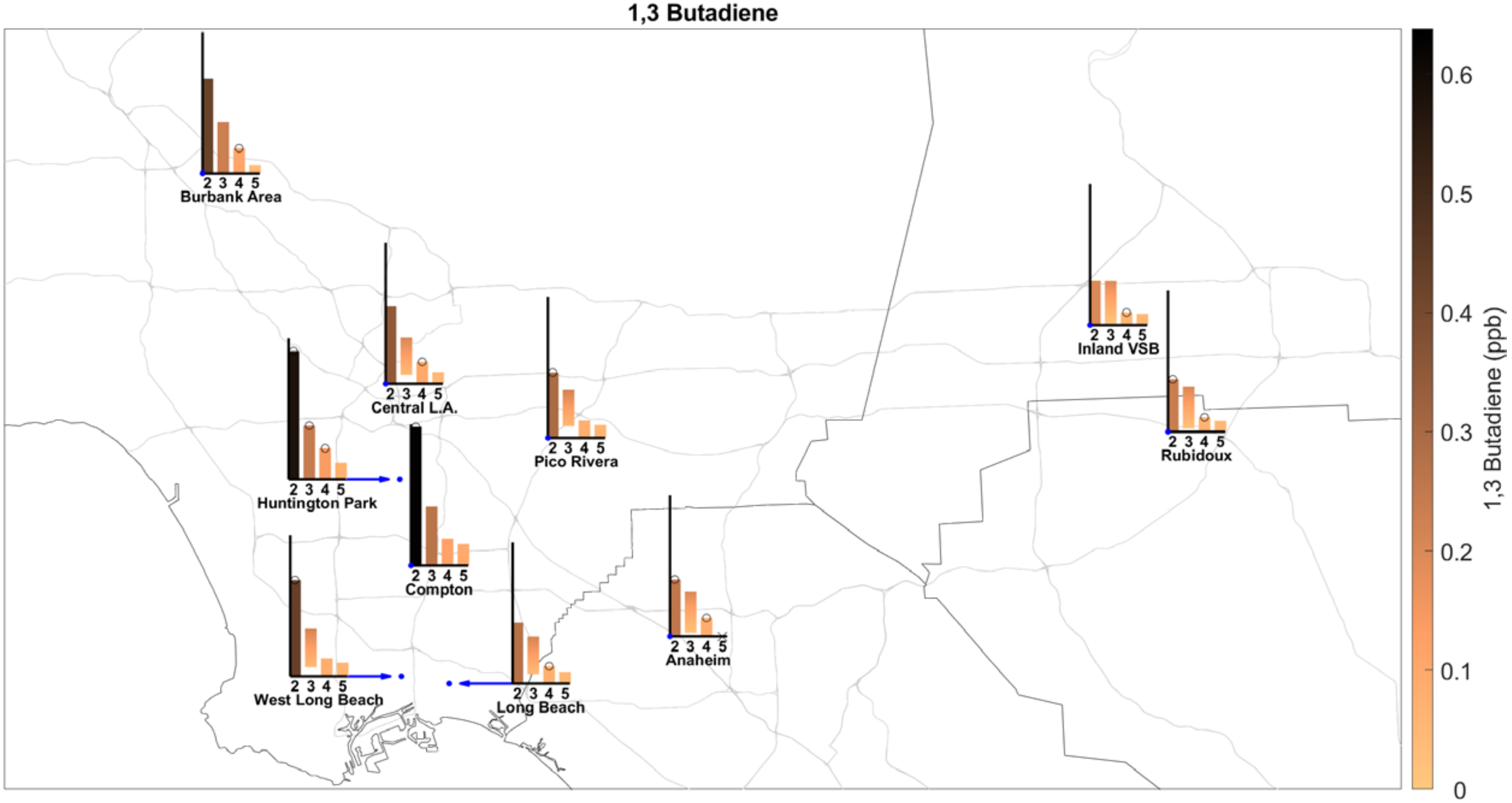


Figure IV-20. Geographic distribution of 1,3 Butadiene from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Carbon Tetrachloride

Table IV-13. Ambient Concentrations (ppb) of Carbon Tetrachloride from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.108	0.105	0.106	0.109	0.108	0.112	0.107	0.105	0.0995	0.104
95% CI LB	0.103	0.0985	0.0992	0.102	0.101	0.106	0.101	0.0968	0.0916	0.0962
95% CI UB	0.114	0.111	0.112	0.115	0.115	0.118	0.114	0.112	0.108	0.113
N	51	56	42	60	44	59	57	53	45	34
% < MDL	51	50	50	50	52.3	50.8	50.9	54.7	53.3	47.1
Max	0.13	0.14	0.13	0.15	0.13	0.17	0.14	0.14	0.13	0.2
MATES III										
Average	0.0837	0.0824	0.0824	0.0837	0.077	0.0818	0.0823	0.0754	0.0809	0.0827
95% CI LB	0.0822	0.0809	0.081	0.0819	0.0752	0.0802	0.081	0.0738	0.0795	0.0811
95% CI UB	0.085	0.0838	0.0838	0.0856	0.0787	0.0832	0.0836	0.0771	0.0824	0.0845
N	233	241	237	232	100	238	238	121	234	235
% < MDL	0.9	1.2	0.8	0.9	2	1.3	0.4	2.5	0.4	1.7
Max	0.12	0.11	0.11	0.13	0.09	0.11	0.11	0.09	0.11	0.12
MATES IV										
Average	0.0845	0.0833	0.0843	0.0827	0.0817	0.0814	0.0818	0.0825	0.082	0.0823
95% CI LB	0.0813	0.0802	0.0816	0.0792	0.0783	0.0782	0.078	0.0796	0.0786	0.0792
95% CI UB	0.0881	0.0863	0.0875	0.0865	0.0849	0.0846	0.0857	0.0858	0.0855	0.0853
N	47	49	51	49	47	50	47	51	49	53
% < MDL	0	0	0	0	0	0	2.1	0	0	0
Max	0.12	0.11	0.11	0.11	0.1	0.11	0.11	0.11	0.11	0.11
MATES V										
Average		0.0757	0.0748	0.0756	0.077	0.0763	0.0757	0.0747	0.075	0.0755
95% CI LB		0.0735	0.0726	0.0734	0.0747	0.0739	0.0736	0.0725	0.073	0.0731
95% CI UB		0.0781	0.0769	0.0779	0.0793	0.0786	0.0779	0.0771	0.077	0.0778
N	0	60	61	61	60	59	56	53	60	58
% < MDL		0	0	0	0	0	0	0	0	0
Max		0.1	0.1	0.1	0.1	0.1	0.1	0.11	0.1	0.11

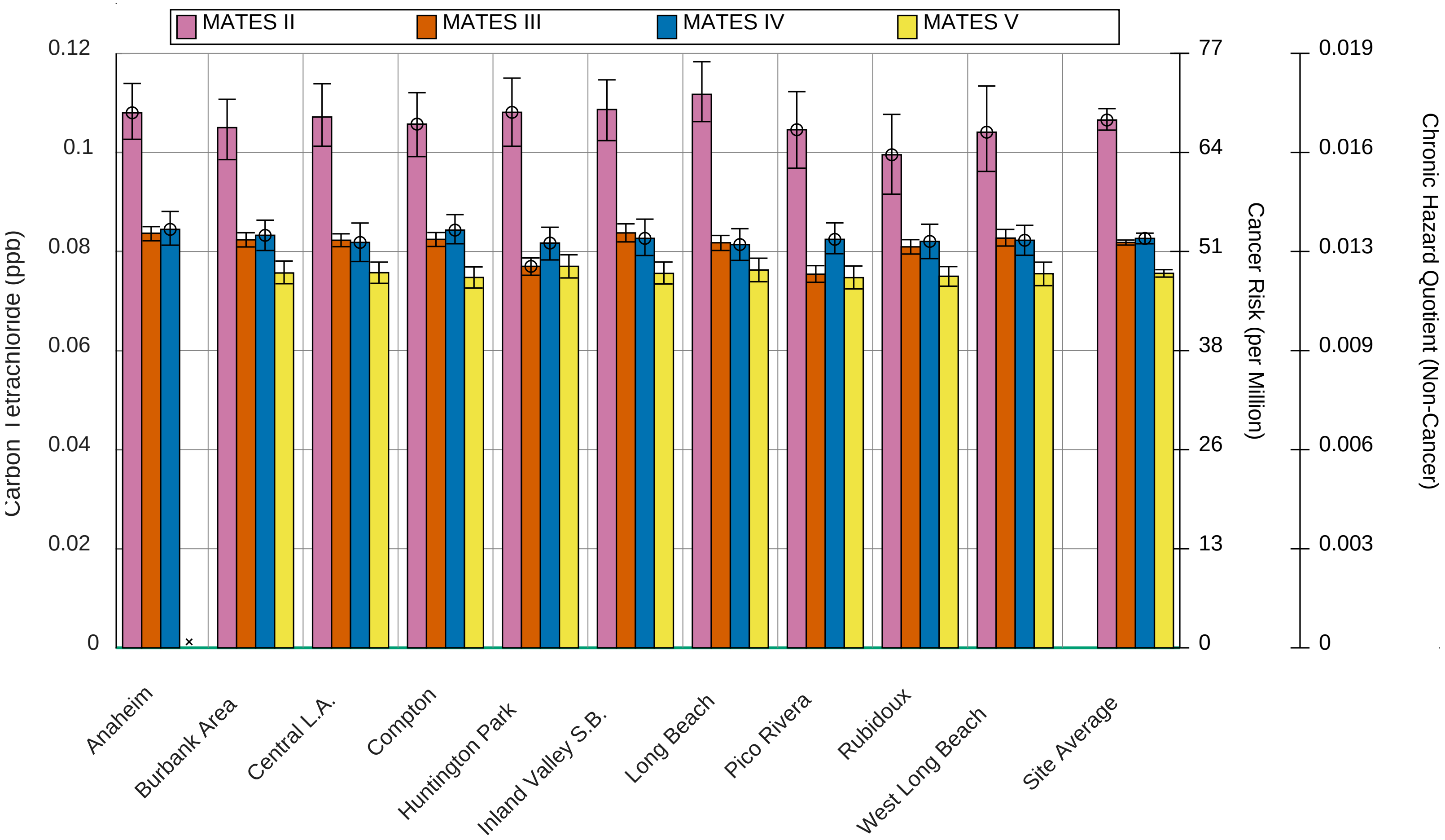


Figure IV-21. Annual Average Concentrations of Carbon Tetrachloride in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

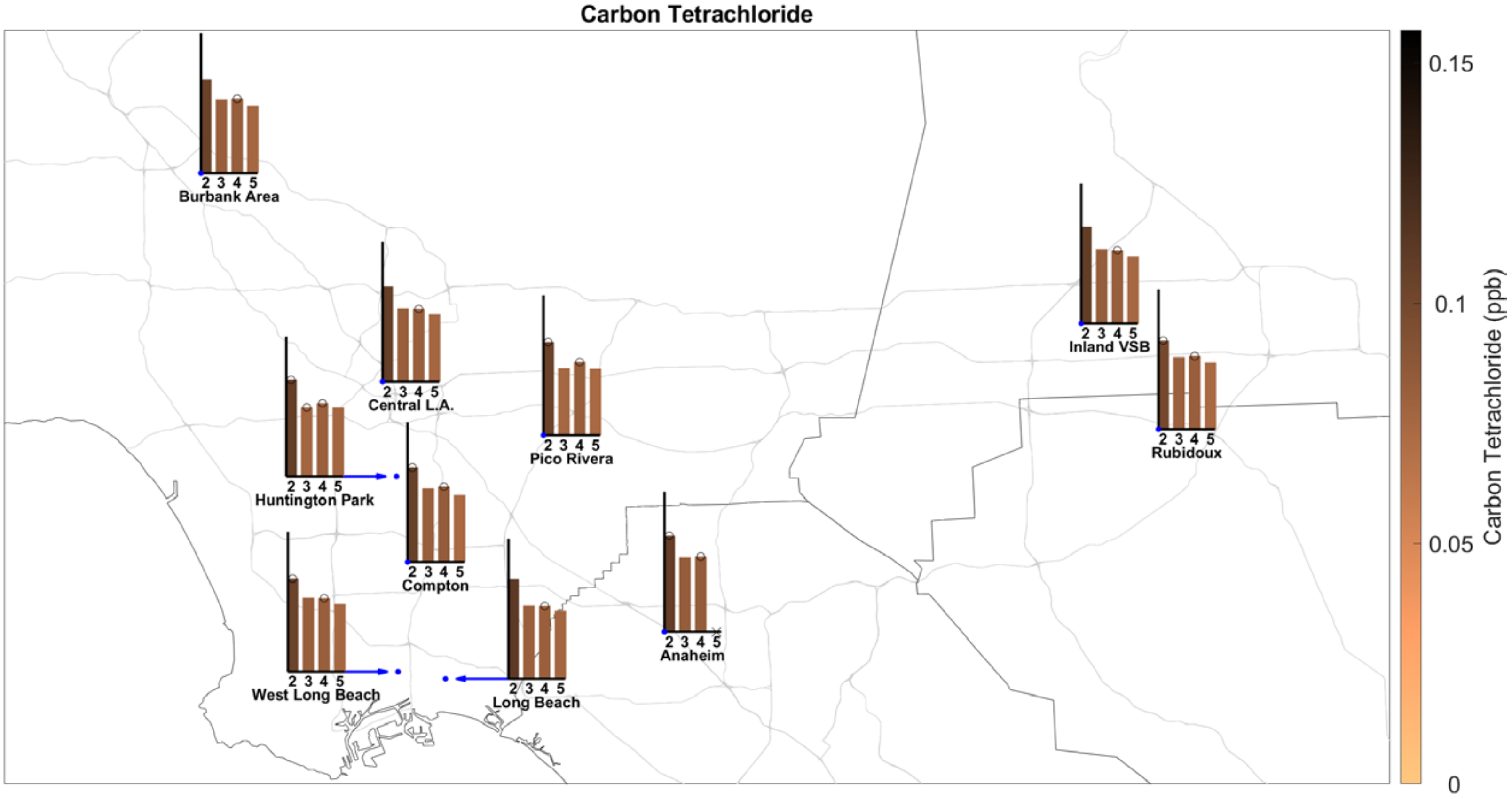


Figure IV-22. Geographic distribution of Carbon Tetrachloride from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Chloroform

Table IV-14. Ambient Concentrations (ppb) of Chloroform from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.037	0.0628	0.0391	0.0397	0.0578	0.0421	0.0483	0.045	0.0382	0.0416
95% CI LB	0.031	0.0535	0.0322	0.0309	0.0431	0.0331	0.0394	0.0386	0.0311	0.0281
95% CI UB	0.0434	0.0724	0.0502	0.0509	0.0759	0.0531	0.0583	0.0517	0.0525	0.0597
N	46	55	36	57	39	56	54	50	41	30
% < MDL	63	41.8	63.9	61.4	56.4	58.9	55.6	60	65.9	63.3
Max	0.06	0.18	0.1	0.24	0.3	0.22	0.2	0.11	0.08	0.2
MATES III										
Average	0, 0.1[a]	0.00469, 0.101[a]	0.000422, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0.00095, 0.1[a]	0, 0.1[a]	0, 0.1[a]
95% CI LB	0[a]	0.00199[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.1[a]	0.101[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]
N	233[a]	241[a]	237[a]	232[a]	100[a]	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	100[a]	95.9[a]	99.6[a]	100[a]	100[a]	100[a]	100[a]	99.2[a]	100[a]	100[a]
Max	< MDL[a]	0.13[a]	0.1[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	0.115[a]	< MDL[a]	< MDL[a]
MATES IV										
Average	0.00843, 0.0561[a]	0.0621	0.00667, 0.055[a]	0.0109, 0.0558[a]	0.00887, 0.0557[a]	0.00111, 0.0541[a]	0.00887, 0.0557[a]	0.0128, 0.0573[a]	0.00769, 0.0555[a]	0.00211, 0.0542[a]
95% CI LB	0.00275[a]	0.0574	0.00211[a]	0.00472[a]	0.0034[a]	0[a]	0.0034[a]	0.00579[a]	0.0025[a]	0[a]
95% CI UB	0.058[a]	0.0671	0.0559[a]	0.0572[a]	0.0578[a]	0.0544[a]	0.0575[a]	0.0598[a]	0.057[a]	0.0545[a]
N	51[a]	55	57[a]	53[a]	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	88.2[a]	74.5	89.5[a]	83[a]	86.8[a]	98.1[a]	86.8[a]	82.5[a]	88.5[a]	96.5[a]
Max	0.08[a]	0.14	0.07[a]	0.08[a]	0.1[a]	0.06[a]	0.09[a]	0.1[a]	0.08[a]	0.06[a]
MATES V										
Average		0.0237	0.0347	0.0342	0.0339	0.0331	0.0386	0.0426	0.0354	0.0341
95% CI LB		0.0204	0.0306	0.0304	0.0295	0.0285	0.0316	0.0373	0.0316	0.0298
95% CI UB		0.0271	0.039	0.0382	0.0387	0.0379	0.0477	0.0481	0.0392	0.0383
N	0	60	61	61	60	59	56	53	60	58
% < MDL		55	49.2	34.4	53.3	54.2	46.4	43.4	41.7	51.7
Max		0.04	0.07	0.08	0.07	0.08	0.23	0.09	0.07	0.07

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

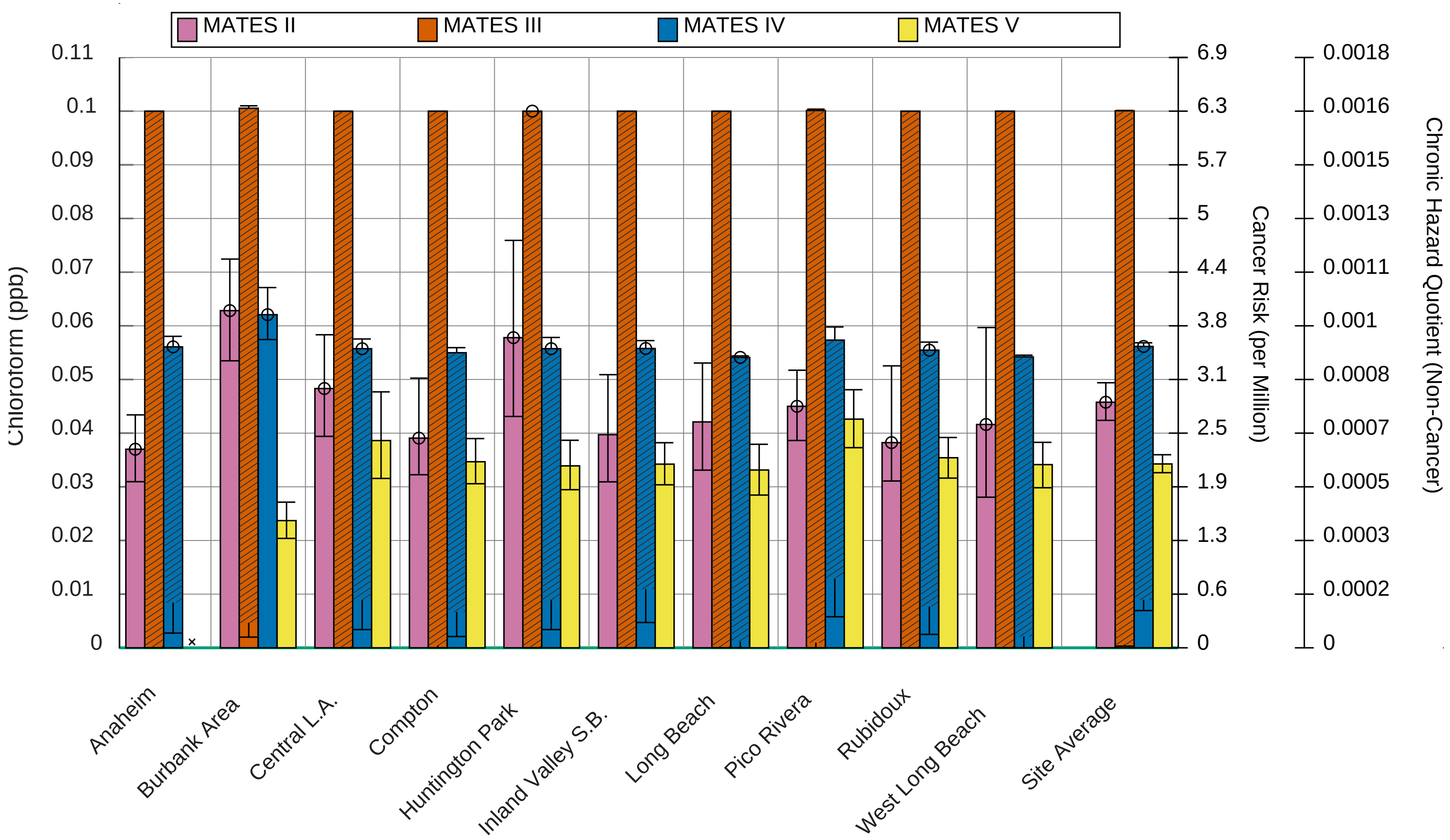


Figure IV-23. Annual Average Concentrations of Chloroform in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

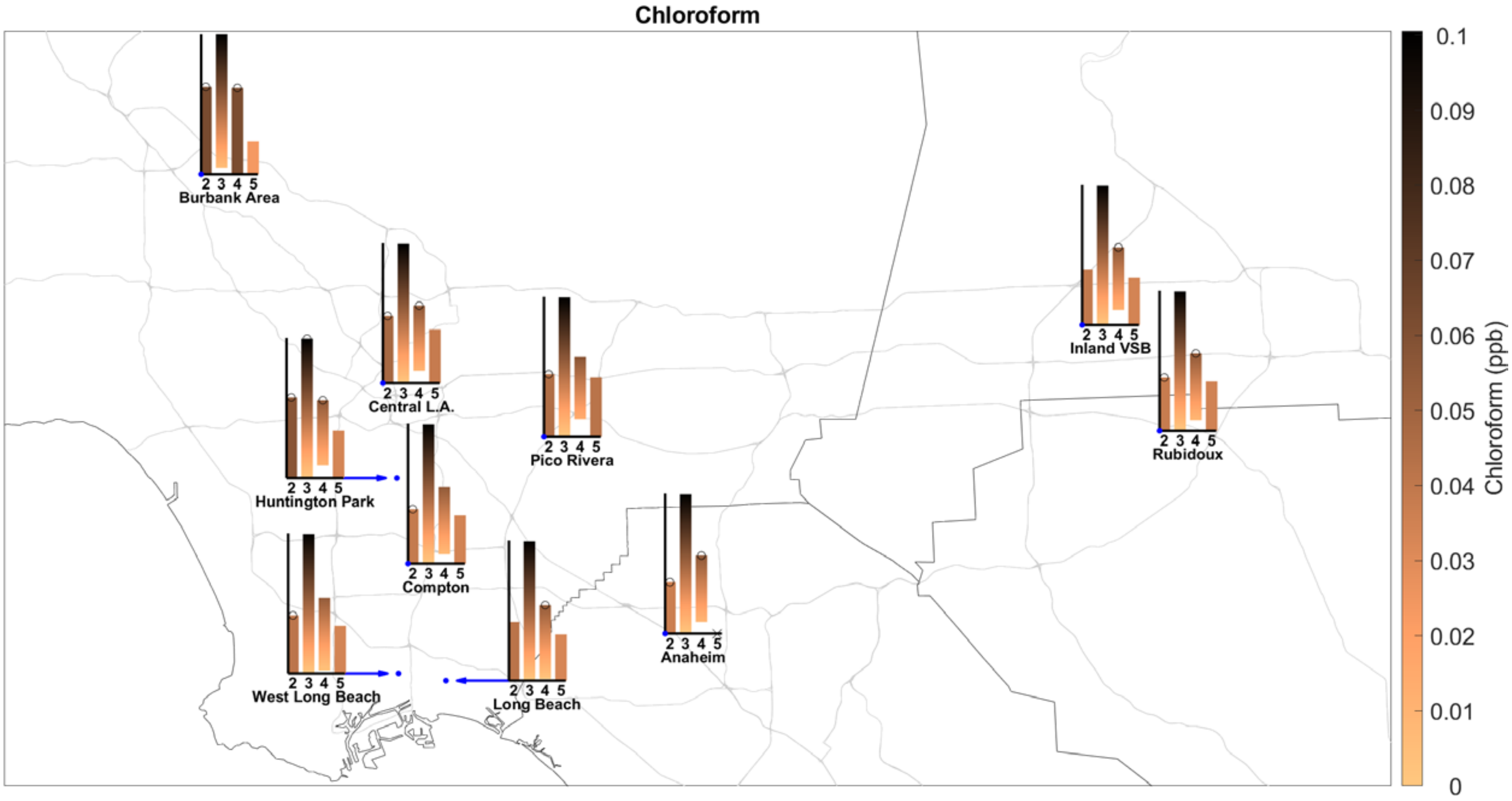


Figure IV-24. Geographic distribution of Chloroform from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Chloromethane

Table IV-15. Ambient Concentrations (ppb) of Chloromethane from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.626	0.623	0.71	0.618	0.643	0.619	0.627	0.596	0.629	0.729
95% CI LB	0.579	0.564	0.624	0.565	0.57	0.569	0.577	0.539	0.558	0.565
95% CI UB	0.684	0.686	0.795	0.671	0.717	0.677	0.683	0.655	0.688	0.994
N	26	28	21	30	23	30	29	29	24	17
% < MDL	0	0	0	0	0	0	0	0	4.2	0
Max	1	1.1	1.2	1	1	1.1	1.1	1	0.9	2.5
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

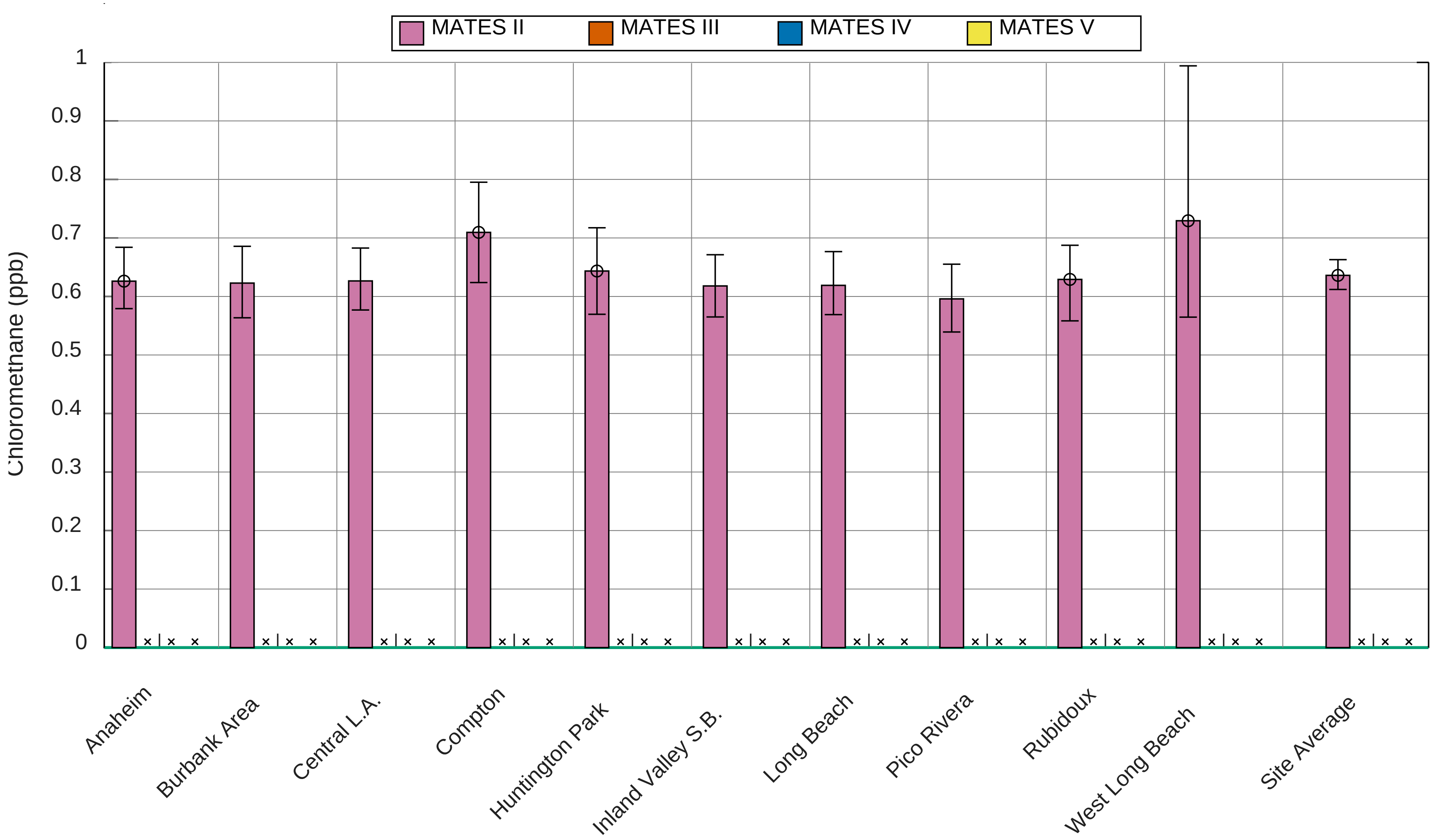


Figure IV-25. Annual Average Concentrations of Chloromethane in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

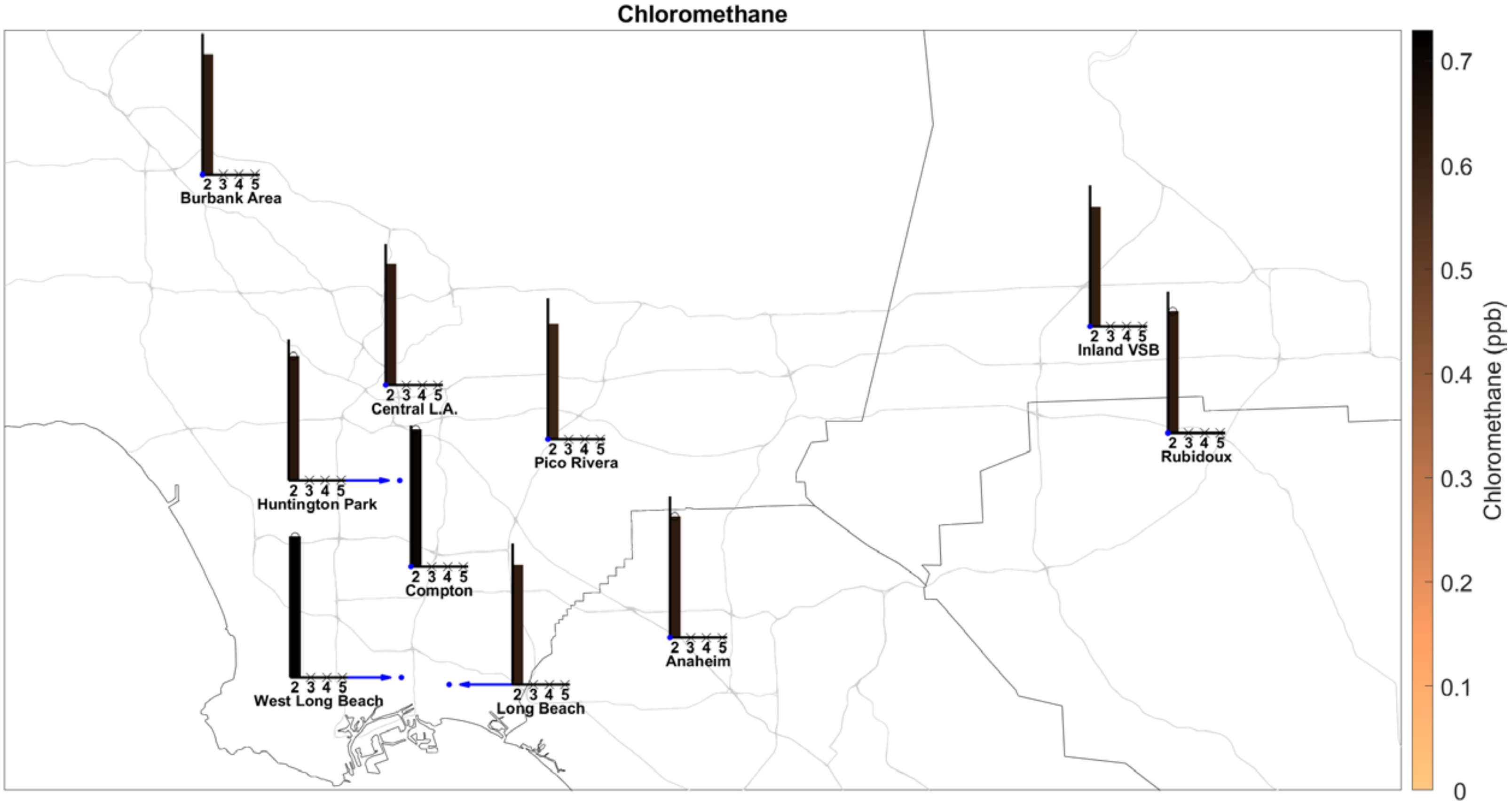


Figure IV-26. Geographic distribution of Chloromethane from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

1,2-Dibromoethane

Table IV-16. Ambient Concentrations (ppb) of 1,2-Dibromoethane from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]
N	26[a]	28[a]	21[a]	30[a]	23[a]	30[a]	29[a]	29[a]	24[a]	17[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES III										
Average	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]
N	233[a]	241[a]	237[a]	232[a]	100[a]	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES IV										
Average	0, 0.07[a]	0, 0.07[a]	0, 0.07[a]	0, 0.07[a]	0, 0.07[a]	0, 0.07[a]	0, 0.07[a]	0, 0.07[a]	0, 0.07[a]	0, 0.07[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.07[a]	0.07[a]	0.07[a]	0.07[a]	0.07[a]	0.07[a]	0.07[a]	0.07[a]	0.07[a]	0.07[a]
N	51[a]	55[a]	57[a]	53[a]	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES V										
Average		0, 0.036[a]	0, 0.0365[a]	0, 0.0365[a]	0, 0.0364[a]	0, 0.0364[a]	0, 0.036[a]	0, 0.0365[a]	0, 0.0364[a]	0, 0.0367[a]
95% CI LB		0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB		0.0383[a]	0.039[a]	0.039[a]	0.0392[a]	0.039[a]	0.0385[a]	0.0395[a]	0.0392[a]	0.0395[a]
N	0	60[a]	60[a]	60[a]	59[a]	58[a]	55[a]	52[a]	59[a]	57[a]
% < MDL		100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max		< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

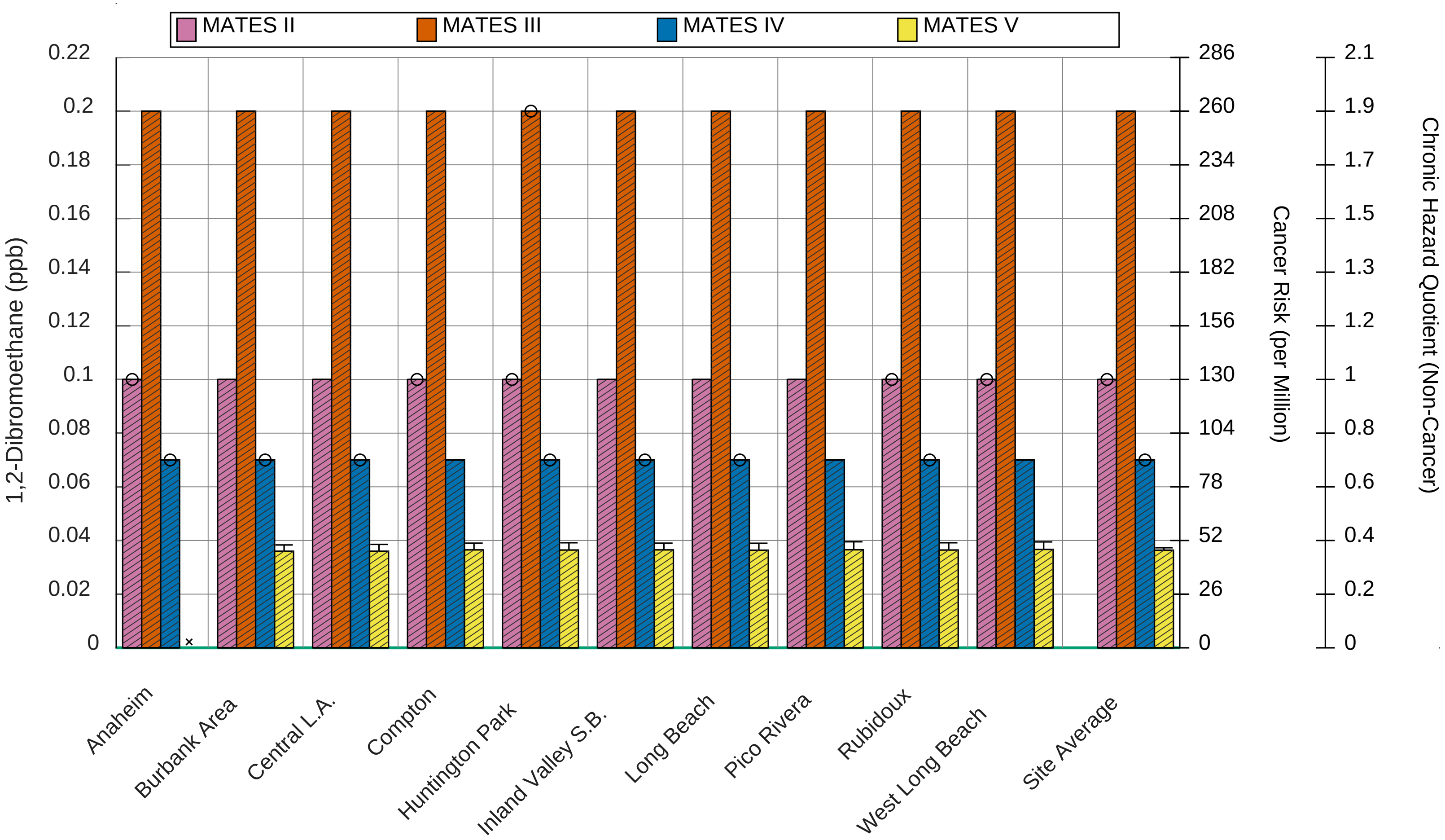


Figure IV-27. Annual Average Concentrations of 1,2-Dibromoethane in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

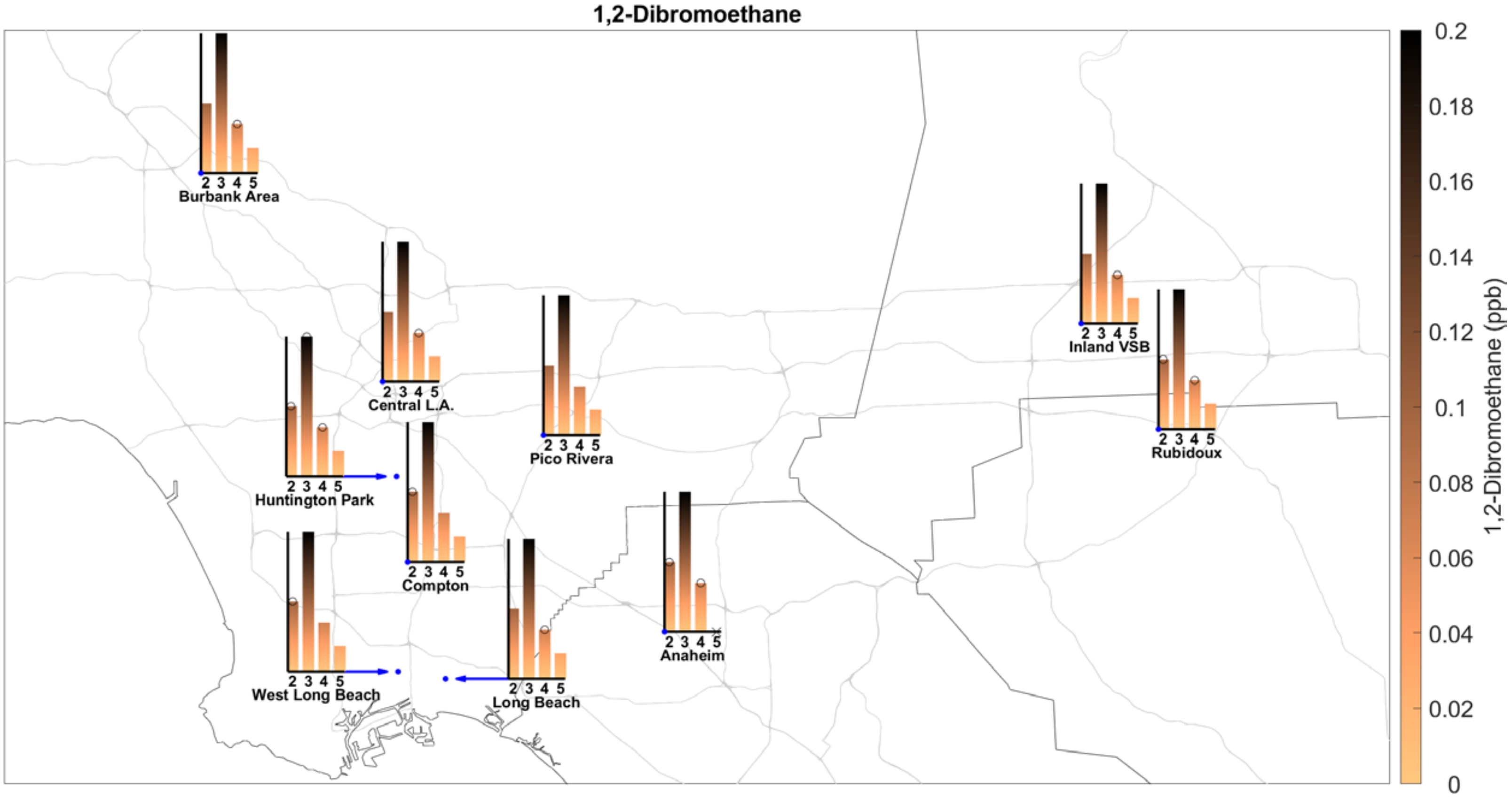


Figure IV-28. Geographic distribution of 1,2-Dibromoethane from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

1,2-Dichlorobenzene

Table IV-17. Ambient Concentrations (ppb) of 1,2-Dichlorobenzene from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.0204, 0.109[a]	0.0578	0.0286, 0.119[a]	0.0556	0.0304, 0.117[a]	0.0176, 0.1[a]	0.0132, 0.0956[a]	0.00968, 0.1[a]	0.0167, 0.108[a]	0.0235, 0.112[a]
95% CI LB	0[a]	0.0531	0[a]	0.05	0[a]	0.00368[a]	0.00294[a]	0[a]	0[a]	0[a]
95% CI UB	0.128[a]	0.105	0.152[a]	0.103	0.152[a]	0.11[a]	0.104[a]	0.109[a]	0.125[a]	0.129[a]
N	27[a]	32	21[a]	36	23[a]	34[a]	34[a]	31[a]	24[a]	17[a]
% < MDL	88.9[a]	78.1	90.5[a]	77.8	87[a]	82.4[a]	82.4[a]	90.3[a]	91.7[a]	88.2[a]
Max	0.3[a]	0.2	0.4[a]	0.2	0.4[a]	0.2[a]	0.2[a]	0.2[a]	0.3[a]	0.2[a]
MATES III										
Average	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]
N	233[a]	241[a]	237[a]	232[a]	100[a]	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES IV										
Average	0, 0.095[a]	0, 0.095[a]	0, 0.095[a]	0, 0.095[a]	0.00226, 0.0955[a]	0, 0.095[a]	0, 0.095[a]	0.00211, 0.0954[a]	0, 0.095[a]	0, 0.095[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.095[a]	0.095[a]	0.095[a]	0.095[a]	0.0964[a]	0.095[a]	0.095[a]	0.0963[a]	0.095[a]	0.095[a]
N	51[a]	55[a]	57[a]	53[a]	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	98.1[a]	100[a]	100[a]	98.2[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	0.12[a]	< MDL[a]	< MDL[a]	0.12[a]	< MDL[a]	< MDL[a]
MATES V										
Average		0.00132, 0.0502[a]	0, 0.0496[a]	0, 0.0496[a]	0, 0.0494[a]	0.00212, 0.0506[a]	0, 0.0492[a]	0, 0.0491[a]	0.000769, 0.0496[a]	0, 0.0498[a]
95% CI LB		0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB		0.0532[a]	0.0524[a]	0.0524[a]	0.0523[a]	0.0546[a]	0.052[a]	0.0524[a]	0.0525[a]	0.0527[a]
N	0	53[a]	54[a]	54[a]	53[a]	52[a]	49[a]	46[a]	52[a]	51[a]
% < MDL		98.1[a]	100[a]	100[a]	100[a]	98.1[a]	100[a]	100[a]	98.1[a]	100[a]
Max		0.07[a]	< MDL[a]	< MDL[a]	< MDL[a]	0.11[a]	< MDL[a]	< MDL[a]	0.04[a]	< MDL[a]

[a]More than 80% of data are < MDL. Values based on zero and MDL substitutions.

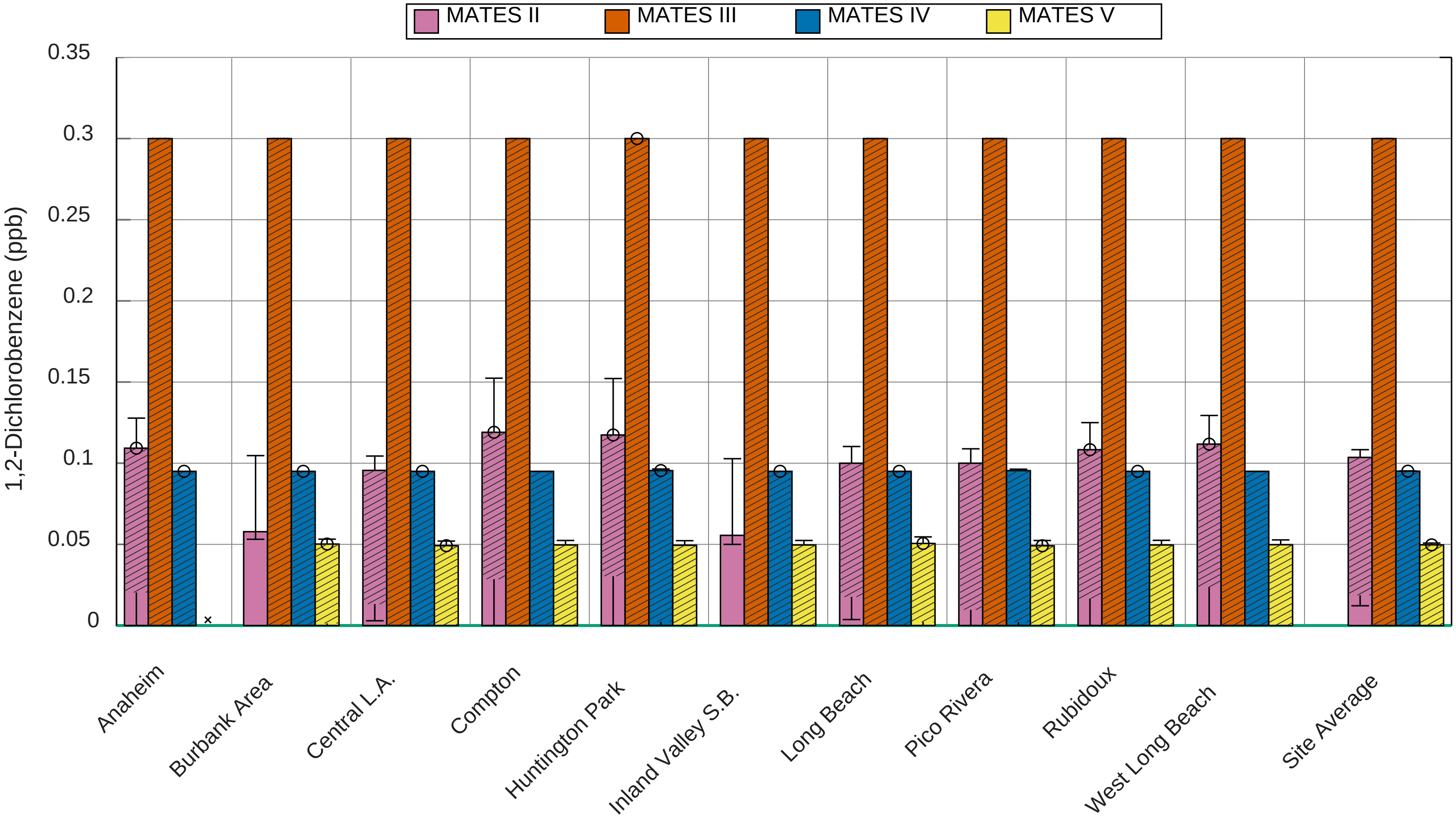


Figure IV-29. Annual Average Concentrations of 1,2-Dichlorobenzene in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

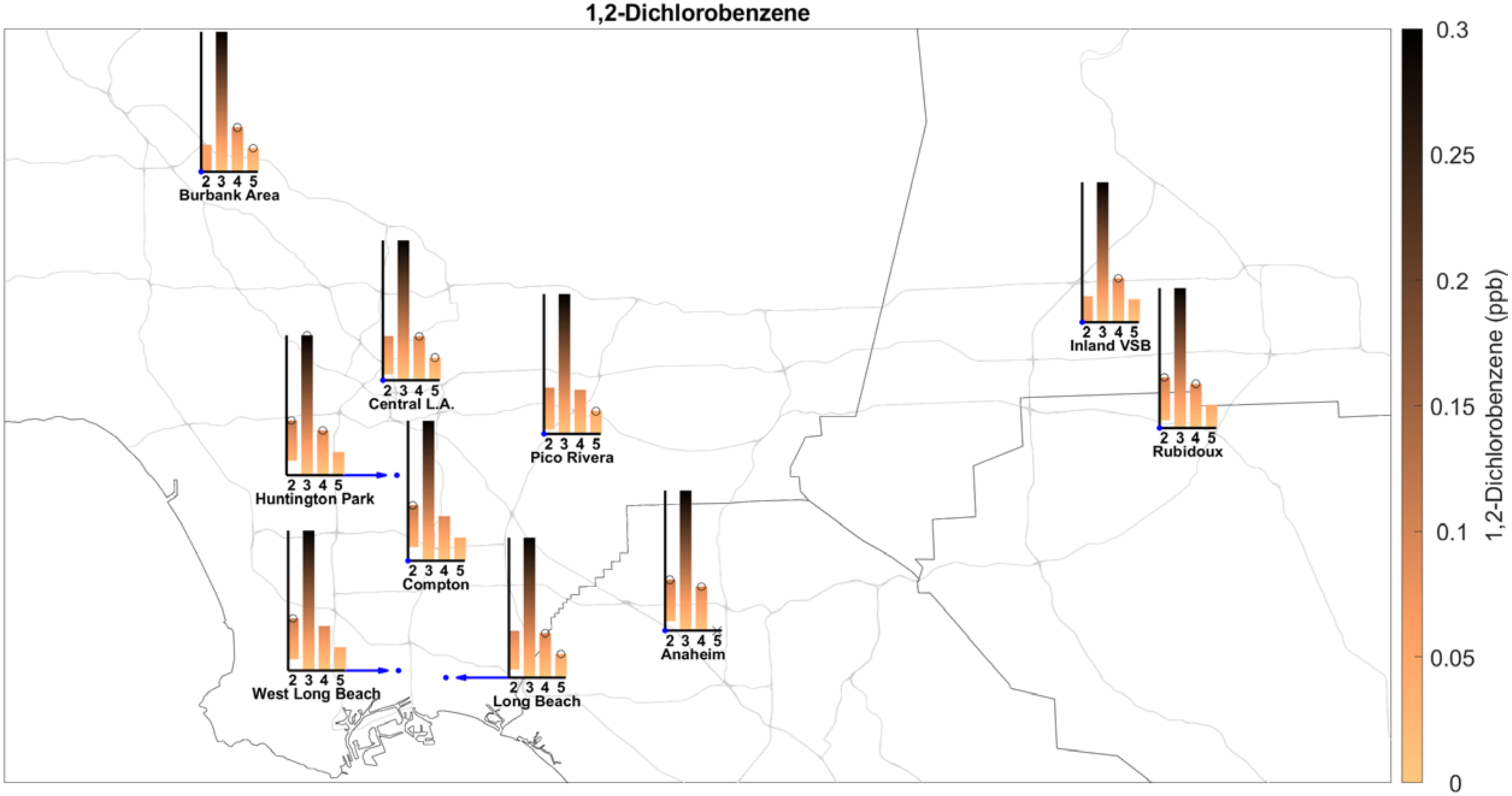


Figure IV-30. Geographic distribution of 1,2-Dichlorobenzene from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

1,4-Dichlorobenzene

Table IV-18. Ambient Concentrations (ppb) of 1,4-Dichlorobenzene from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.136	0.172	0.243	0.136	0.361	0.123	0.165	0.152	0.133	0.153
95% CI LB	0.115	0.138	0.186	0.114	0.261	0.106	0.129	0.126	0.1	0.124
95% CI UB	0.162	0.209	0.305	0.164	0.47	0.143	0.209	0.182	0.179	0.188
N	27	32	21	36	23	34	34	31	24	17
% < MDL	55.6	37.5	14.3	47.2	8.7	52.9	38.2	51.6	70.8	52.9
Max	0.3	0.5	0.5	0.4	1.1	0.3	0.5	0.4	0.5	0.3
MATES III										
Average	0, 0.3[a]	0, 0.3[a]	0.00595, 0.301[a]	0, 0.3[a]	0.0032, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]
95% CI LB	0[a]	0[a]	0.00131[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.3[a]	0.3[a]	0.302[a]	0.3[a]	0.301[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]
N	233[a]	241[a]	237[a]	232[a]	100[a]	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	100[a]	100[a]	98.3[a]	100[a]	99[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	0.42[a]	< MDL[a]	0.32[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES IV										
Average	0, 0.057[a]	0.00145, 0.0574[a]	0, 0.057[a]	0, 0.057[a]	0.00453, 0.0605[a]	0, 0.057[a]	0.00208, 0.058[a]	0, 0.057[a]	0, 0.057[a]	0, 0.057[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.057[a]	0.0583[a]	0.057[a]	0.057[a]	0.0674[a]	0.057[a]	0.06[a]	0.057[a]	0.057[a]	0.057[a]
N	51[a]	55[a]	57[a]	53[a]	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	100[a]	98.2[a]	100[a]	100[a]	98.1[a]	100[a]	98.1[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	0.08[a]	< MDL[a]	< MDL[a]	0.24[a]	< MDL[a]	0.11[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES V										
Average		0.00593, 0.0476[a]	0.0449	0.00545, 0.0455[a]	0.046	0.01, 0.0489[a]	0.0487	0.0116, 0.0484[a]	0.011, 0.0479[a]	0.00824, 0.0473[a]
95% CI LB		0.000926[a]	0.0429	0.00164[a]	0.043	0.00283[a]	0.0442	0.0049[a]	0.00491[a]	0.00275[a]
95% CI UB		0.0526[a]	0.0507	0.0473[a]	0.0504	0.0557[a]	0.0543	0.0516[a]	0.0513[a]	0.0514[a]
N	0	54[a]	55	55[a]	54	53[a]	51	49[a]	56[a]	51[a]
% < MDL		92.6[a]	80	89.1[a]	72.2	86.8[a]	64.7	81.6[a]	82.1[a]	86.3[a]
Max		0.15[a]	0.12	0.07[a]	0.11	0.2[a]	0.14	0.09[a]	0.1[a]	0.13[a]

[a]More than 80% of data are < MDL. Values based on zero and MDL substitutions.

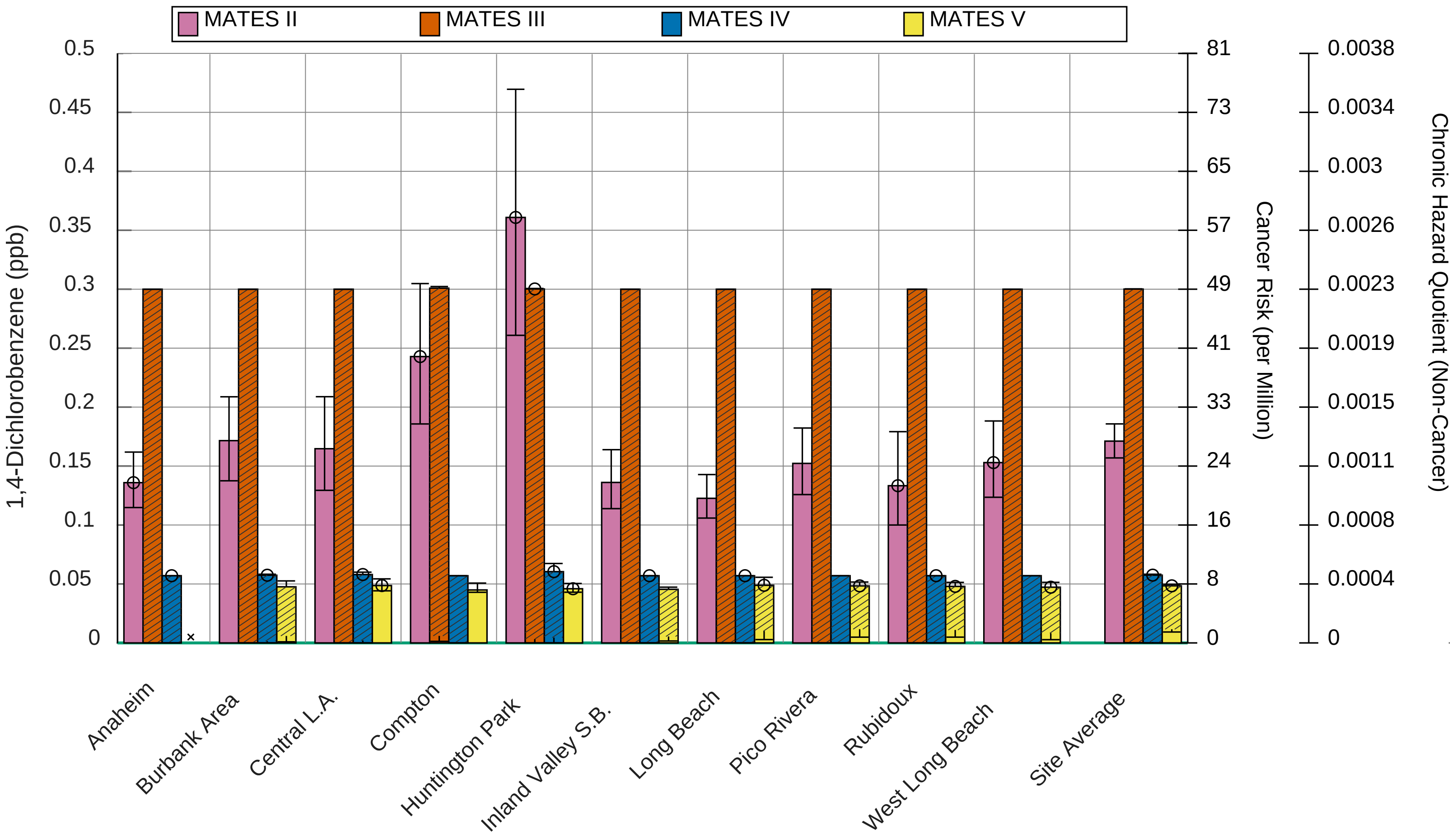


Figure IV-31. Annual Average Concentrations of 1,4-Dichlorobenzene in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

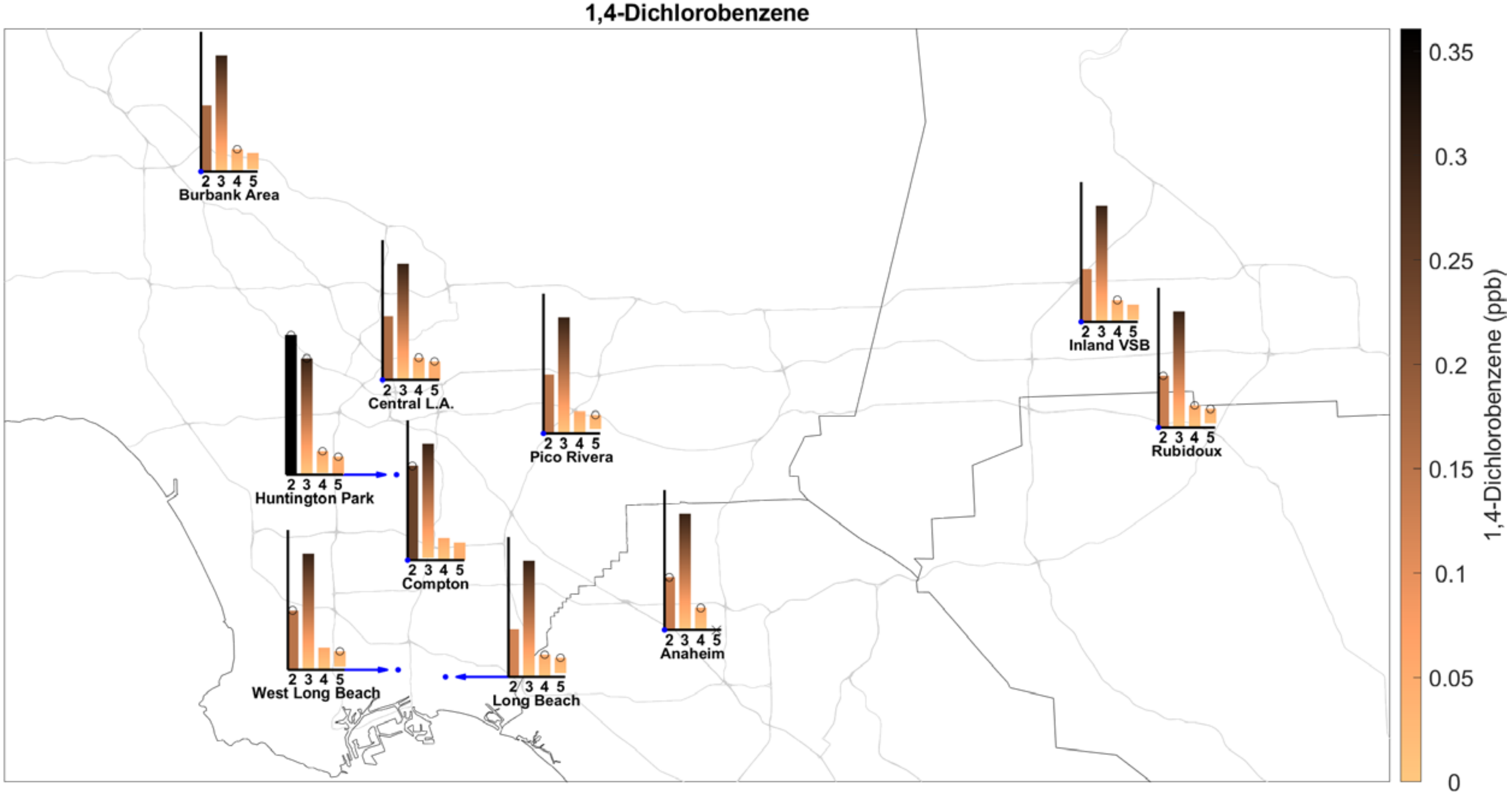


Figure IV-32. Geographic distribution of 1,4-Dichlorobenzene from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Dichloroethane [1,1]

Table IV-19. Ambient Concentrations (ppb) of Dichloroethane [1,1] from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]
N	26[a]	28[a]	21[a]	30[a]	23[a]	30[a]	29[a]	29[a]	24[a]	17[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

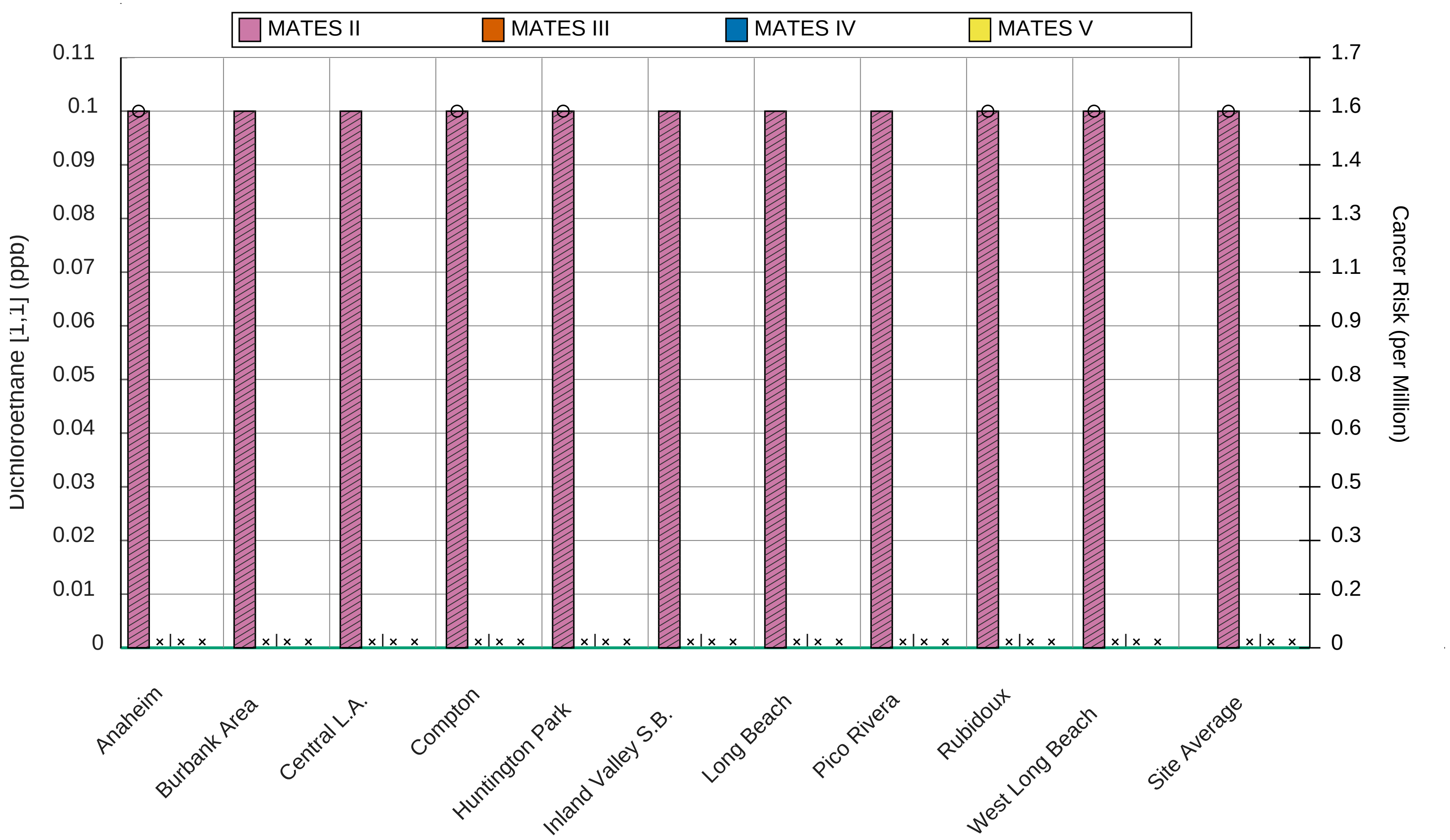


Figure IV-33. Annual Average Concentrations of Dichloroethane [1,1] in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

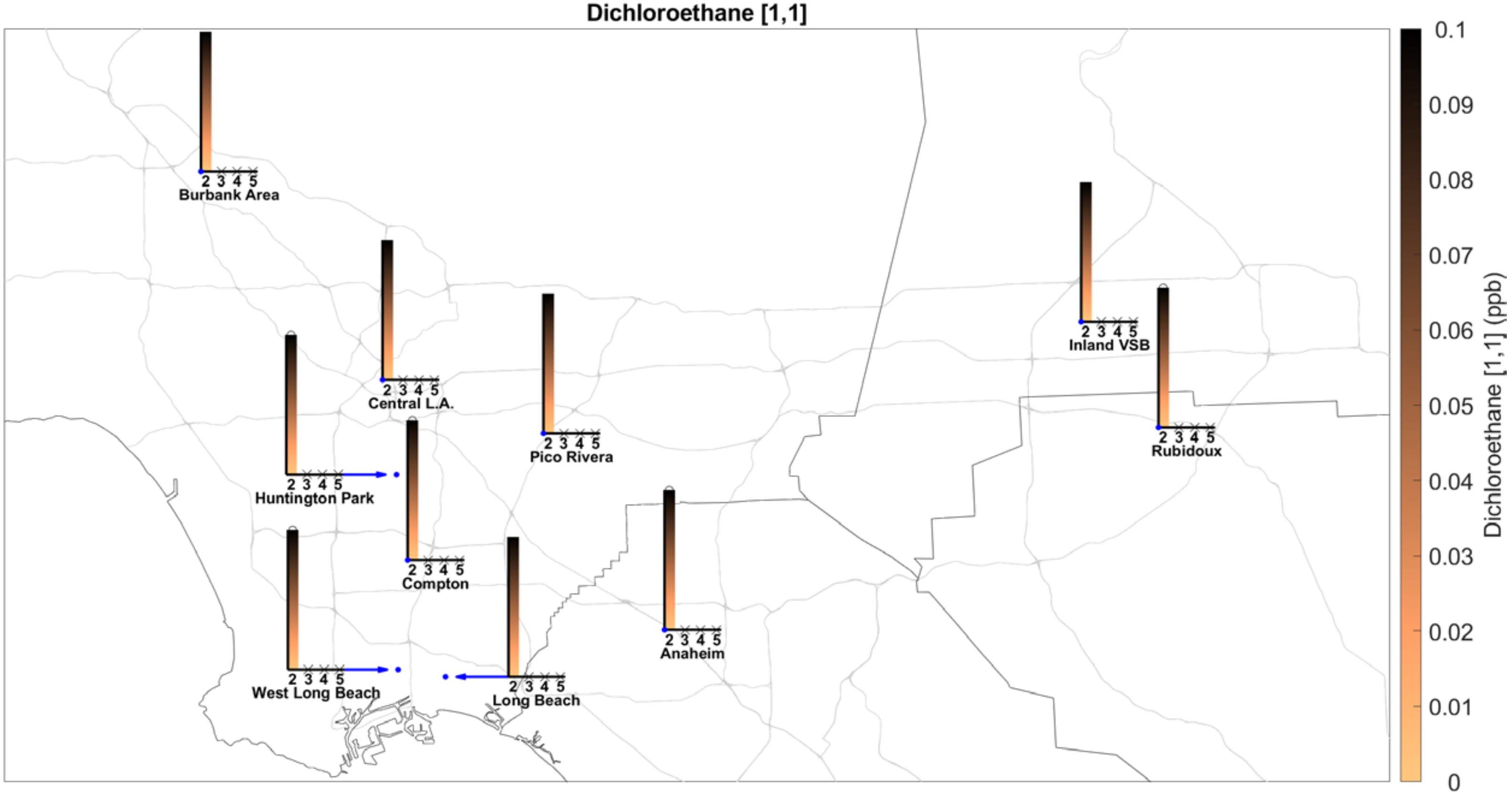


Figure IV-34. Geographic distribution of Dichloroethane [1,1] from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

1,2-Dichloroethane

Table IV-20. Ambient Concentrations (ppb) of 1,2-Dichloroethane from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0.0347, 0.131[a]	0, 0.1[a]	0.0433, 0.14[a]	0.0517, 0.148[a]	0, 0.1[a]	0, 0.1[a]	0.0118, 0.106[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.1[a]	0.1[a]	0.1[a]	0.194[a]	0.1[a]	0.22[a]	0.245[a]	0.1[a]	0.1[a]	0.118[a]
N	26[a]	28[a]	21[a]	30[a]	23[a]	30[a]	29[a]	29[a]	24[a]	17[a]
% < MDL	100[a]	100[a]	100[a]	96.7[a]	100[a]	96.7[a]	96.6[a]	100[a]	100[a]	94.1[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	1.04[a]	< MDL[a]	1.3[a]	1.5[a]	< MDL[a]	< MDL[a]	0.2[a]
MATES III										
Average	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]
N	233[a]	241[a]	237[a]	232[a]	100[a]	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES IV										
Average	0.00098, 0.0441[a]	0.002, 0.0444[a]	0.00439, 0.0445[a]	0.000943, 0.0441[a]	0.00396, 0.0446[a]	0, 0.044[a]	0.000943, 0.0441[a]	0.00368, 0.0446[a]	0.000962, 0.0441[a]	0.00263, 0.0443[a]
95% CI LB	0[a]	0[a]	0.000877[a]	0[a]	0.000943[a]	0[a]	0[a]	0.000877[a]	0[a]	0[a]
95% CI UB	0.0444[a]	0.0451[a]	0.0449[a]	0.0443[a]	0.0455[a]	0.044[a]	0.0443[a]	0.0453[a]	0.0443[a]	0.0446[a]
N	51[a]	55[a]	57[a]	53[a]	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	98[a]	96.4[a]	91.2[a]	98.1[a]	92.5[a]	100[a]	98.1[a]	93[a]	98.1[a]	94.7[a]
Max	0.05[a]	0.06[a]	0.05[a]	0.05[a]	0.06[a]	< MDL[a]	0.05[a]	0.06[a]	0.05[a]	0.05[a]
MATES V										
Average		0.0253	0.0333	0.0311	0.0333	0.0356	0.0274	0.0315	0.0298	0.0326
95% CI LB		0.0233	0.0308	0.029	0.031	0.032	0.0251	0.0292	0.0277	0.0295
95% CI UB		0.0274	0.0359	0.033	0.0355	0.0388	0.0296	0.0338	0.0315	0.0356
N	0	60	61	61	60	59	56	53	60	58
% < MDL		55	49.2	49.2	53.3	47.5	55.4	54.7	51.7	51.7
Max		0.04	0.06	0.05	0.06	0.07	0.04	0.05	0.04	0.06

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

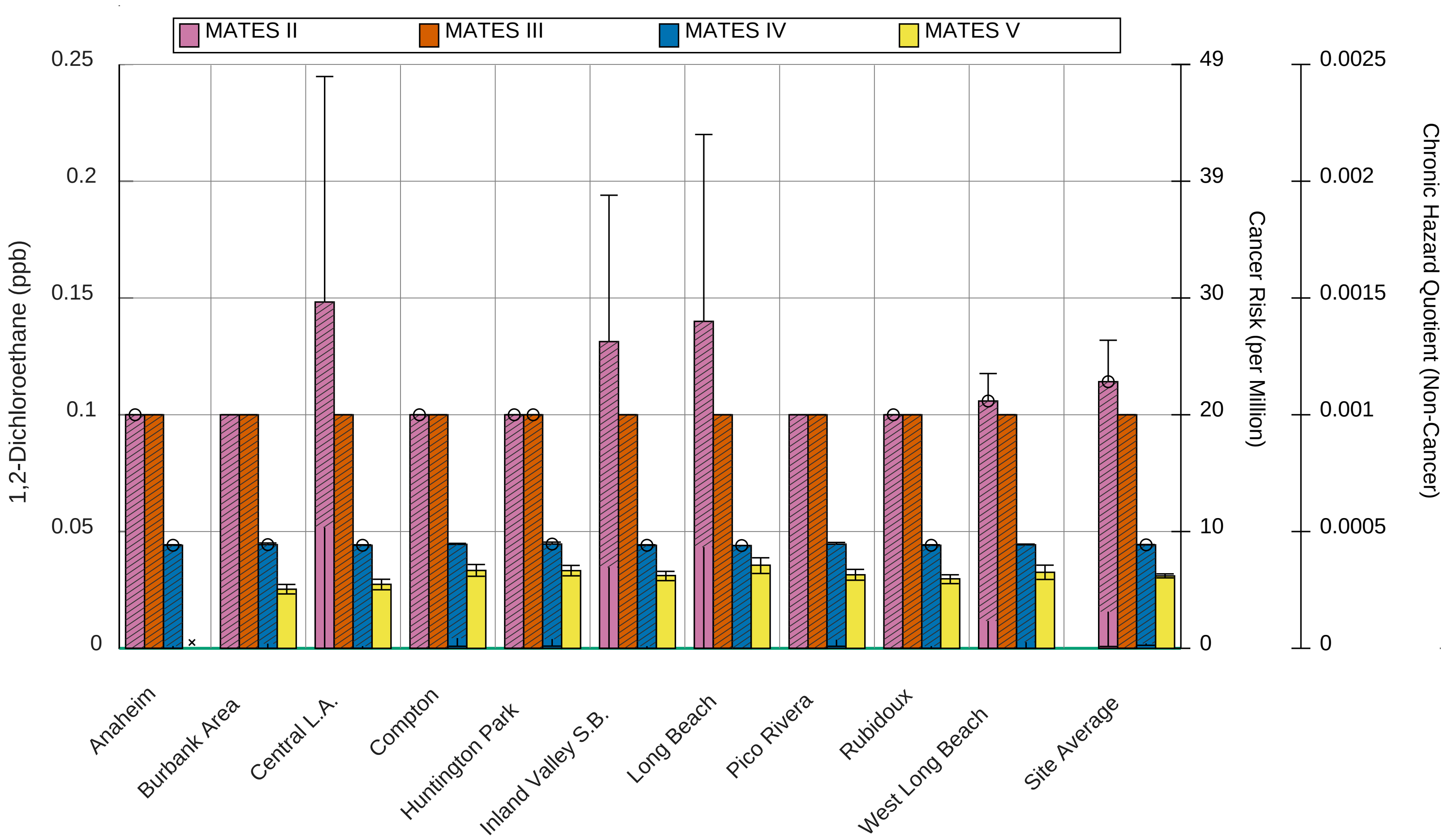


Figure IV-35. Annual Average Concentrations of 1,2-Dichloroethane in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

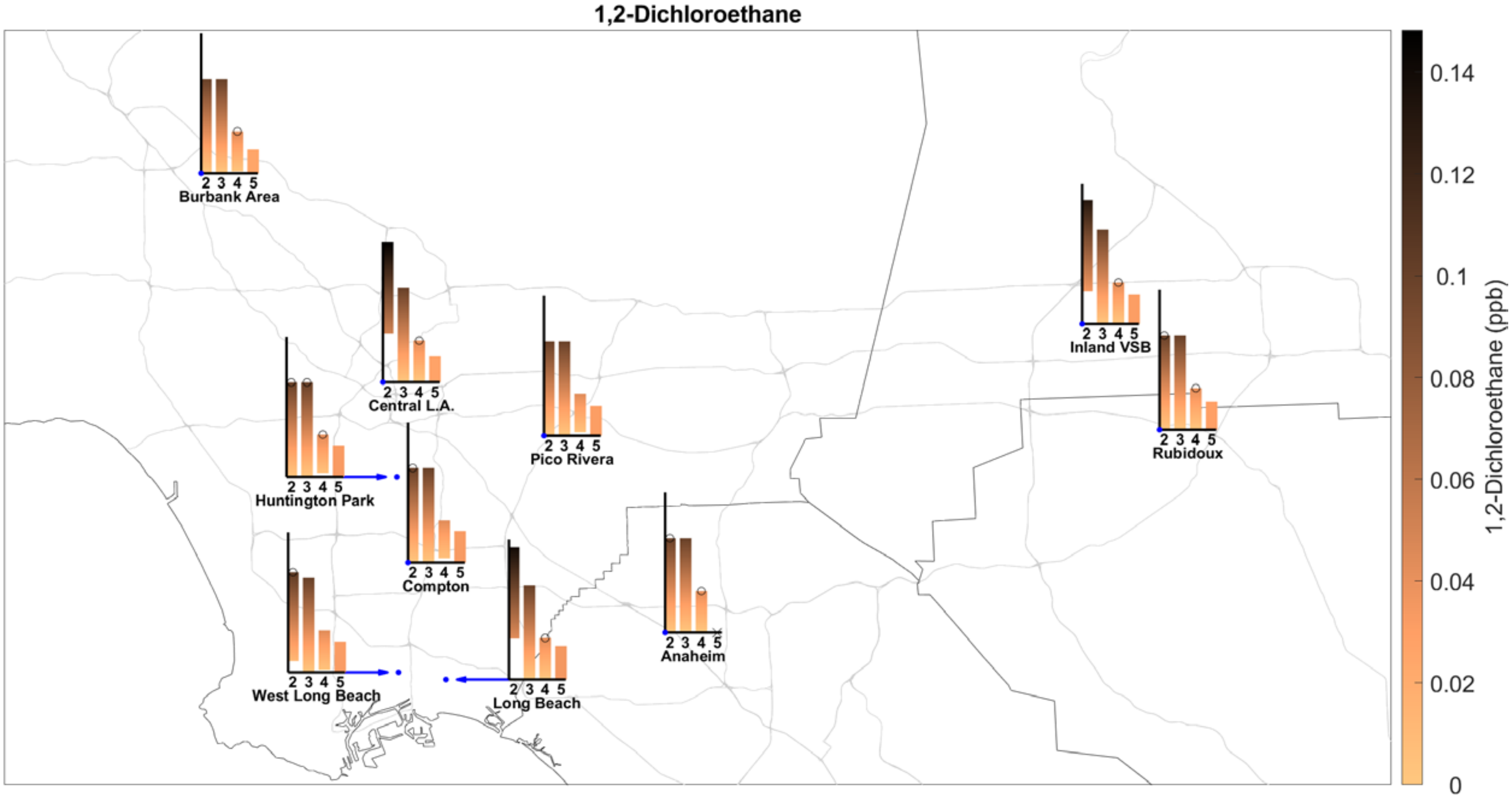


Figure IV-36. Geographic distribution of 1,2-Dichloroethane from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

1,1-Dichloroethene (VDC)

Table IV-21. Ambient Concentrations (ppb) of 1,1-Dichloroethene (VDC) from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.1[a]	0, 0.133[a]	0, 0.1[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.1[a]	0.183[a]	0.1[a]
N	26[a]	28[a]	21[a]	30[a]	23[a]	30[a]	29[a]	29[a]	24[a]	17[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

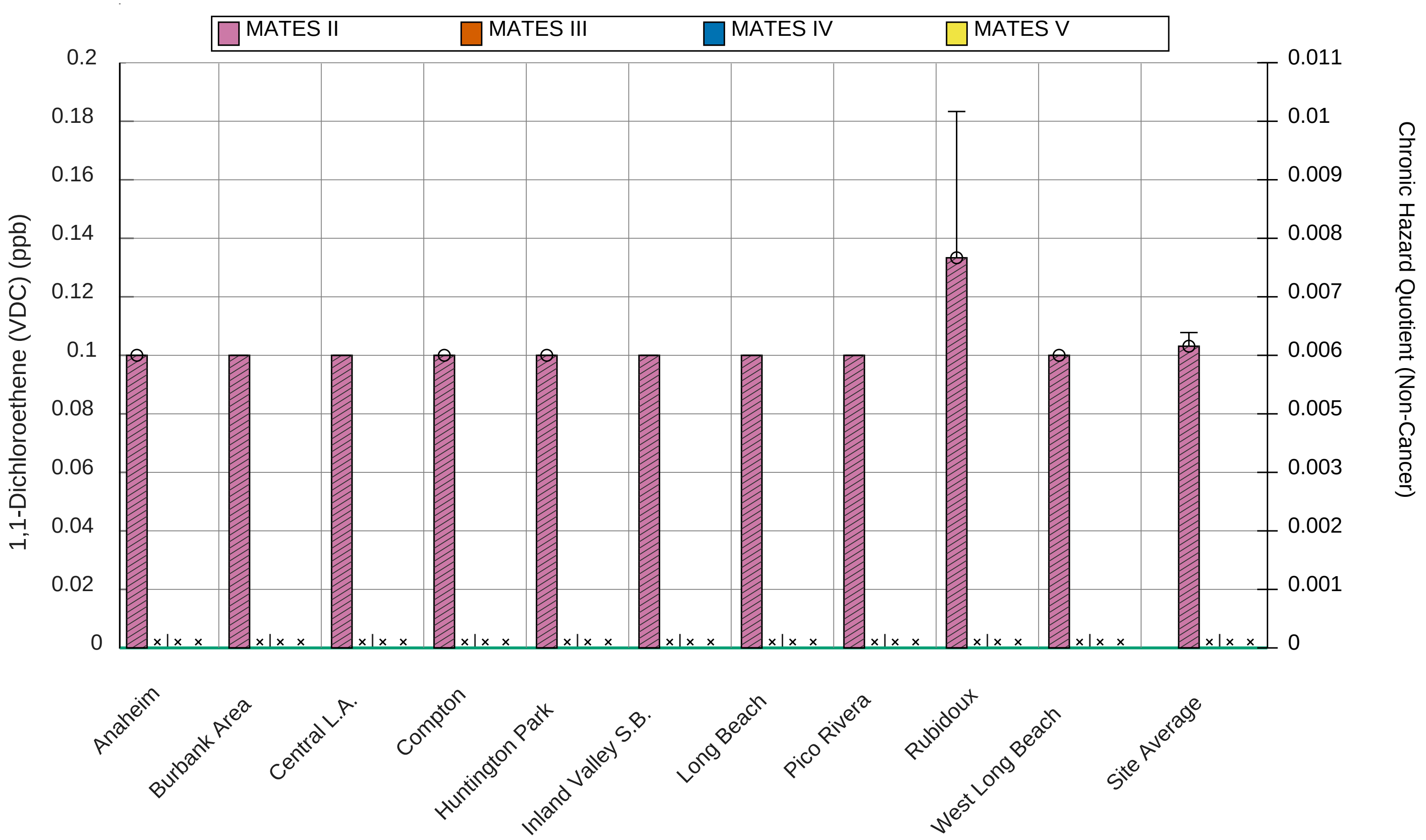


Figure IV-37. Annual Average Concentrations of 1,1-Dichloroethene (VDC) in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

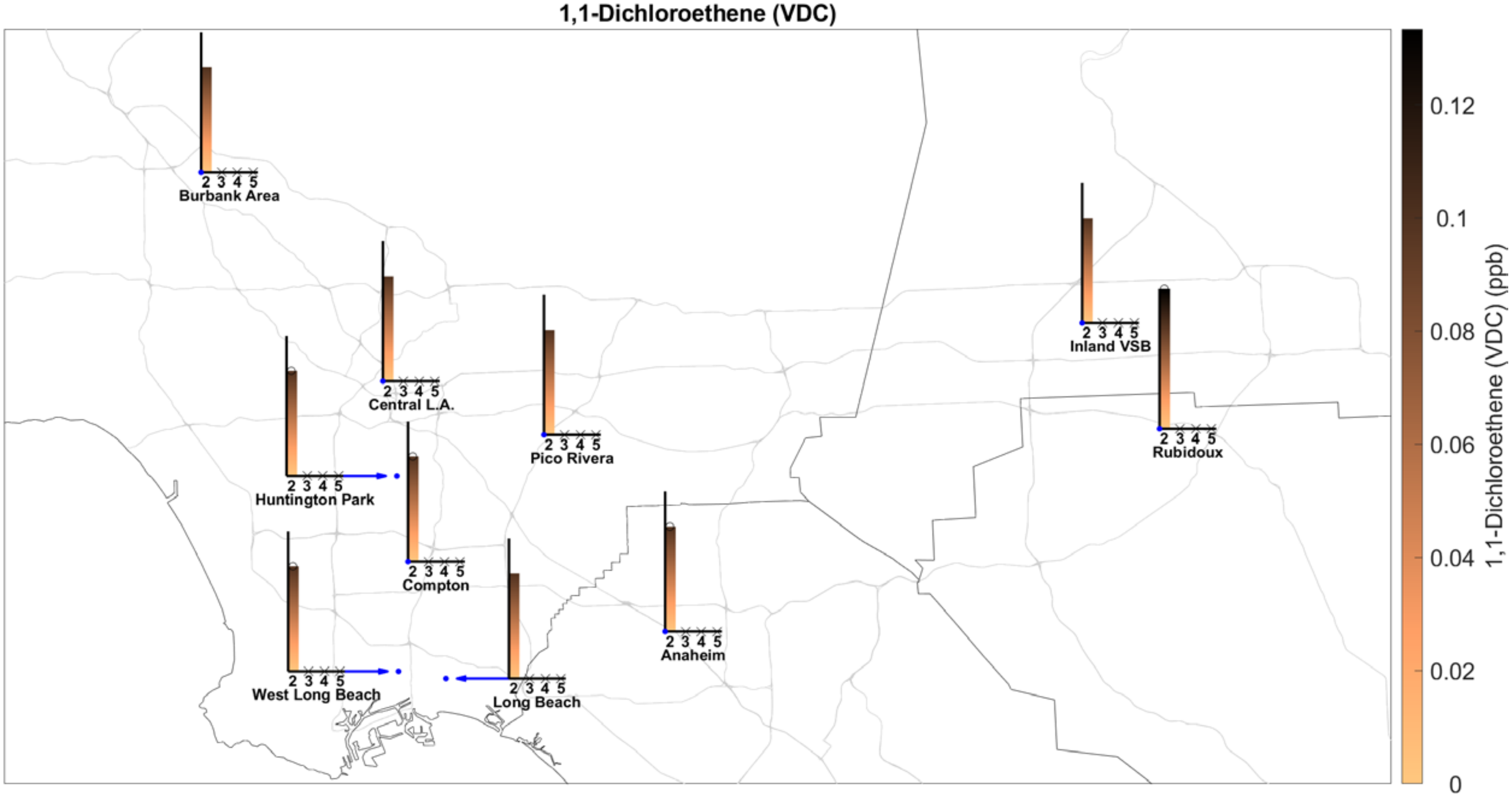


Figure IV-38. Geographic distribution of 1,1-Dichloroethene (VDC) from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

1,2-Dichloropropane

Table IV-22. Ambient Concentrations (ppb) of 1,2-Dichloropropane from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]
N	233[a]	241[a]	237[a]	232[a]	100[a]	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES IV										
Average	0.000588, 0.0222[a]	0, 0.022[a]	0, 0.022[a]	0, 0.022[a]	0, 0.022[a]	0, 0.022[a]	0.000566, 0.0222[a]	0, 0.022[a]	0.00712, 0.0253[a]	0, 0.022[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0.00317[a]	0[a]
95% CI UB	0.0225[a]	0.022[a]	0.022[a]	0.022[a]	0.022[a]	0.022[a]	0.0225[a]	0.022[a]	0.0278[a]	0.022[a]
N	51[a]	55[a]	57[a]	53[a]	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	98[a]	100[a]	100[a]	100[a]	100[a]	100[a]	98.1[a]	100[a]	82.7[a]	100[a]
Max	0.03[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	0.03[a]	< MDL[a]	0.06[a]	< MDL[a]
MATES V										
Average		0, 0.0255[a]	0.000656, 0.0256[a]	0, 0.0256[a]	0.0005, 0.0258[a]	0.000678, 0.0258[a]	0, 0.0257[a]	0.00302, 0.0266[a]	0.00133, 0.0262[a]	0, 0.0255[a]
95% CI LB		0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0.000755[a]	0[a]	0[a]
95% CI UB		0.0268[a]	0.0267[a]	0.0267[a]	0.0272[a]	0.0269[a]	0.027[a]	0.0281[a]	0.028[a]	0.0267[a]
N	0	60[a]	61[a]	61[a]	60[a]	59[a]	56[a]	53[a]	60[a]	58[a]
% < MDL		100[a]	96.7[a]	100[a]	98.3[a]	96.6[a]	100[a]	88.7[a]	96.7[a]	100[a]
Max		< MDL[a]	0.02[a]	< MDL[a]	0.03[a]	0.02[a]	< MDL[a]	0.05[a]	0.06[a]	< MDL[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

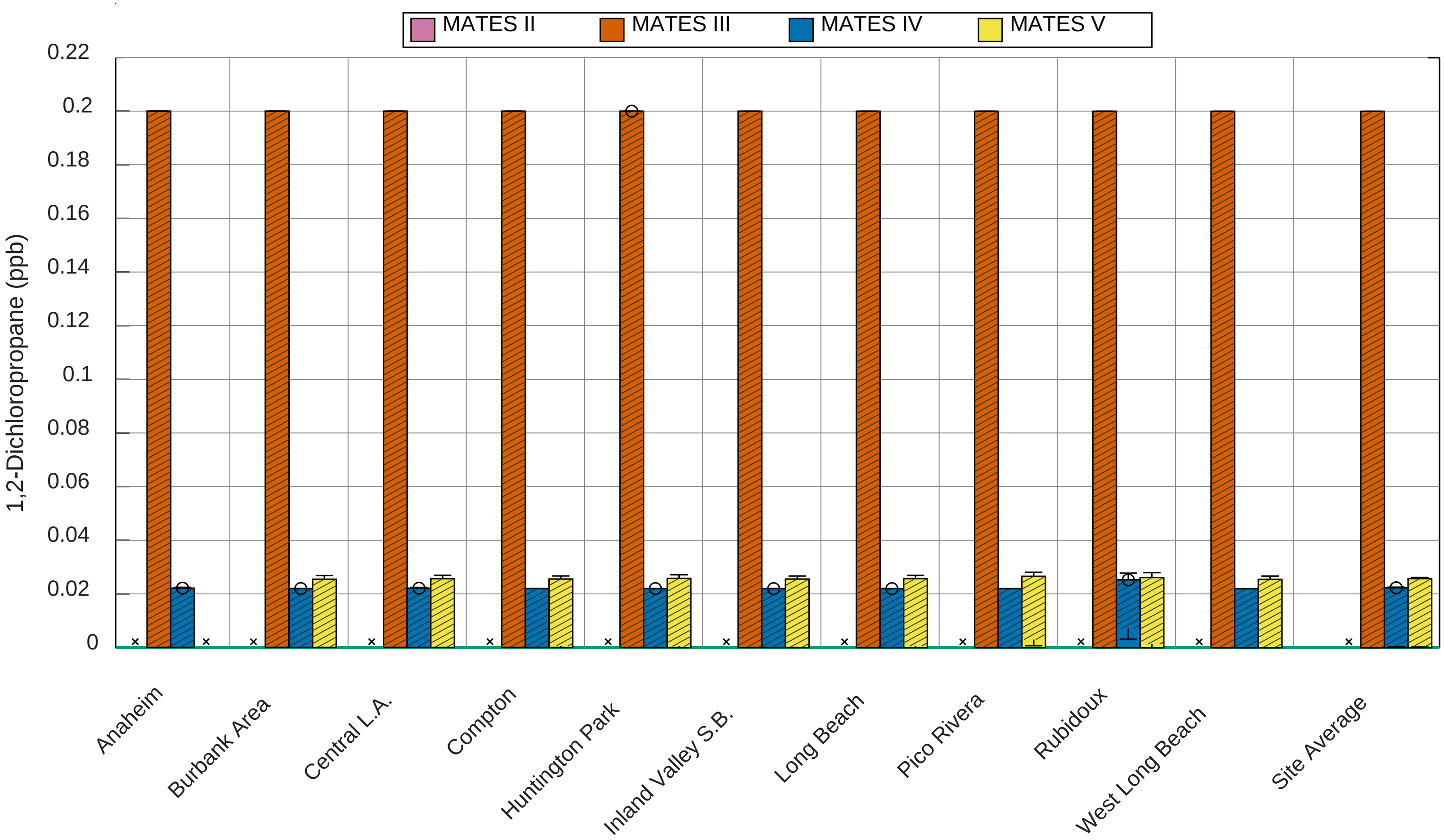


Figure IV-39. Annual Average Concentrations of 1,2-Dichloropropane in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

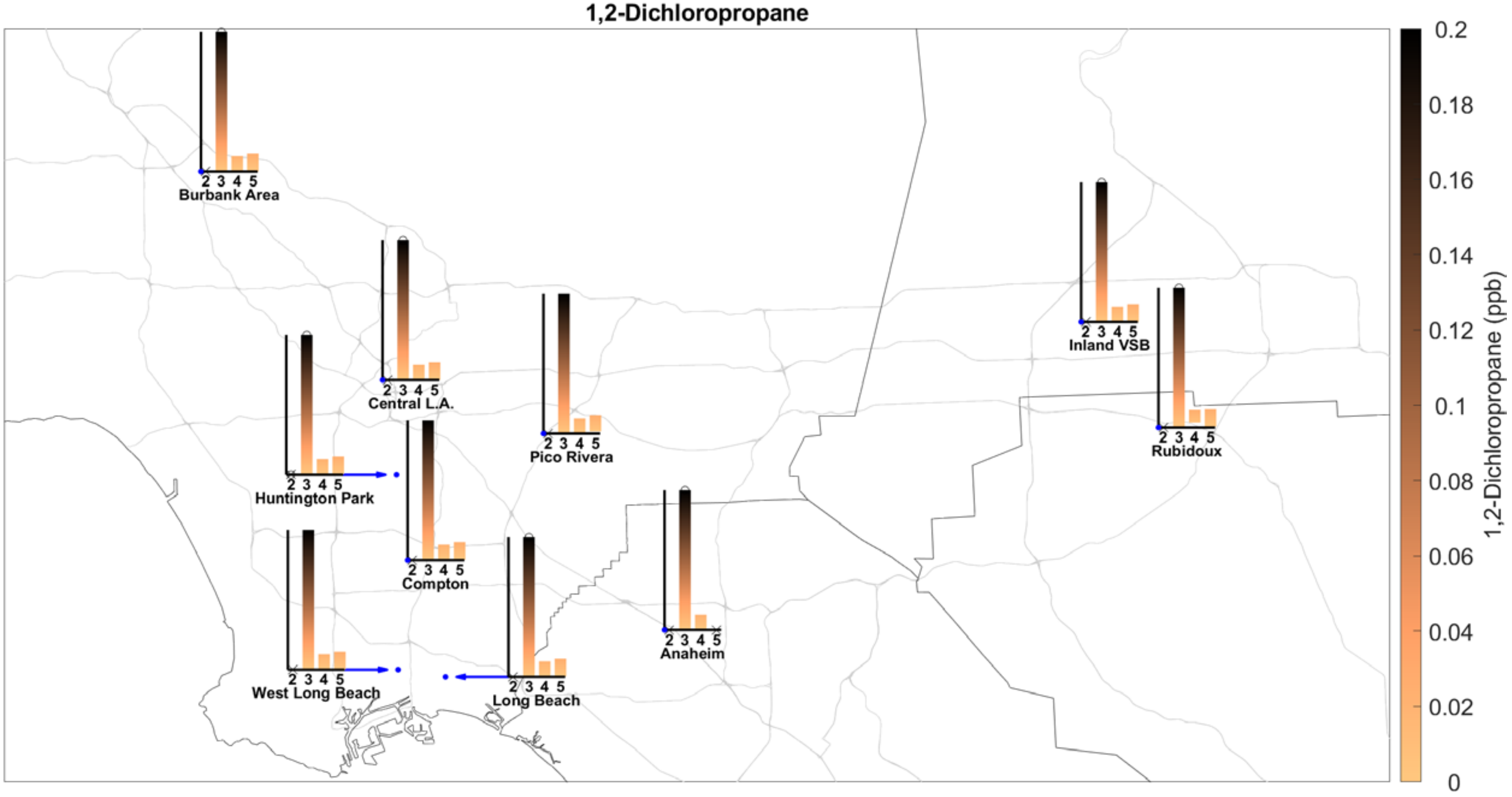


Figure IV-40. Geographic distribution of 1,2-Dichloropropane from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Ethyl Benzene

Table IV-23. Ambient Concentrations (ppb) of Ethyl Benzene from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.388	0.527	0.835	0.321	0.804	0.327	0.421	0.386	0.332	0.469
95% CI LB	0.305	0.439	0.662	0.271	0.642	0.264	0.349	0.317	0.268	0.342
95% CI UB	0.48	0.623	1.03	0.369	0.981	0.388	0.493	0.451	0.393	0.607
N	51	57	42	59	45	58	56	54	44	35
% < MDL	47.1	38.6	28.6	52.5	26.7	46.6	42.9	44.4	47.7	40
Max	1.5	1.6	3.1	0.6	2.7	1.2	1.3	1.1	0.8	1.7
MATES III										
Average	0.21	0.345	0.405	0.223	0.357	0.217	0.254	0.256	0.197	0.248
95% CI LB	0.189	0.316	0.36	0.206	0.31	0.198	0.237	0.226	0.182	0.223
95% CI UB	0.231	0.375	0.453	0.239	0.406	0.238	0.275	0.287	0.212	0.276
N	233	241	237	232	100	238	238	121	234	235
% < MDL	30.5	3.3	6.8	18.5	0	23.1	6.7	9.1	26.1	23.4
Max	1.25	1.16	1.97	0.69	1.22	0.85	0.85	0.92	0.8	1.13
MATES IV										
Average	0.125	0.178	0.2	0.114	0.24	0.11	0.698	0.126	0.154	0.139
95% CI LB	0.0963	0.143	0.15	0.0972	0.183	0.092	0.53	0.106	0.128	0.109
95% CI UB	0.16	0.215	0.256	0.132	0.311	0.131	0.917	0.147	0.183	0.174
N	51	55	57	53	53	54	53	57	52	57
% < MDL	17.6	3.6	15.8	9.4	1.9	9.3	1.9	12.3	1.9	28.1
Max	0.63	0.58	0.81	0.42	1.43	0.32	4.75	0.35	0.43	0.73
MATES V										
Average		0.0753	0.149	0.103	0.125	0.0969	0.145	0.0982	0.107	0.111
95% CI LB		0.0668	0.116	0.0917	0.103	0.0767	0.107	0.082	0.0911	0.0889
95% CI UB		0.0846	0.186	0.115	0.15	0.119	0.198	0.116	0.127	0.134
N	0	57	58	58	57	55	54	50	57	54
% < MDL		5.3	0	1.7	0	0	1.9	0	1.8	0
Max		0.2	0.57	0.27	0.38	0.38	1.29	0.3	0.51	0.43

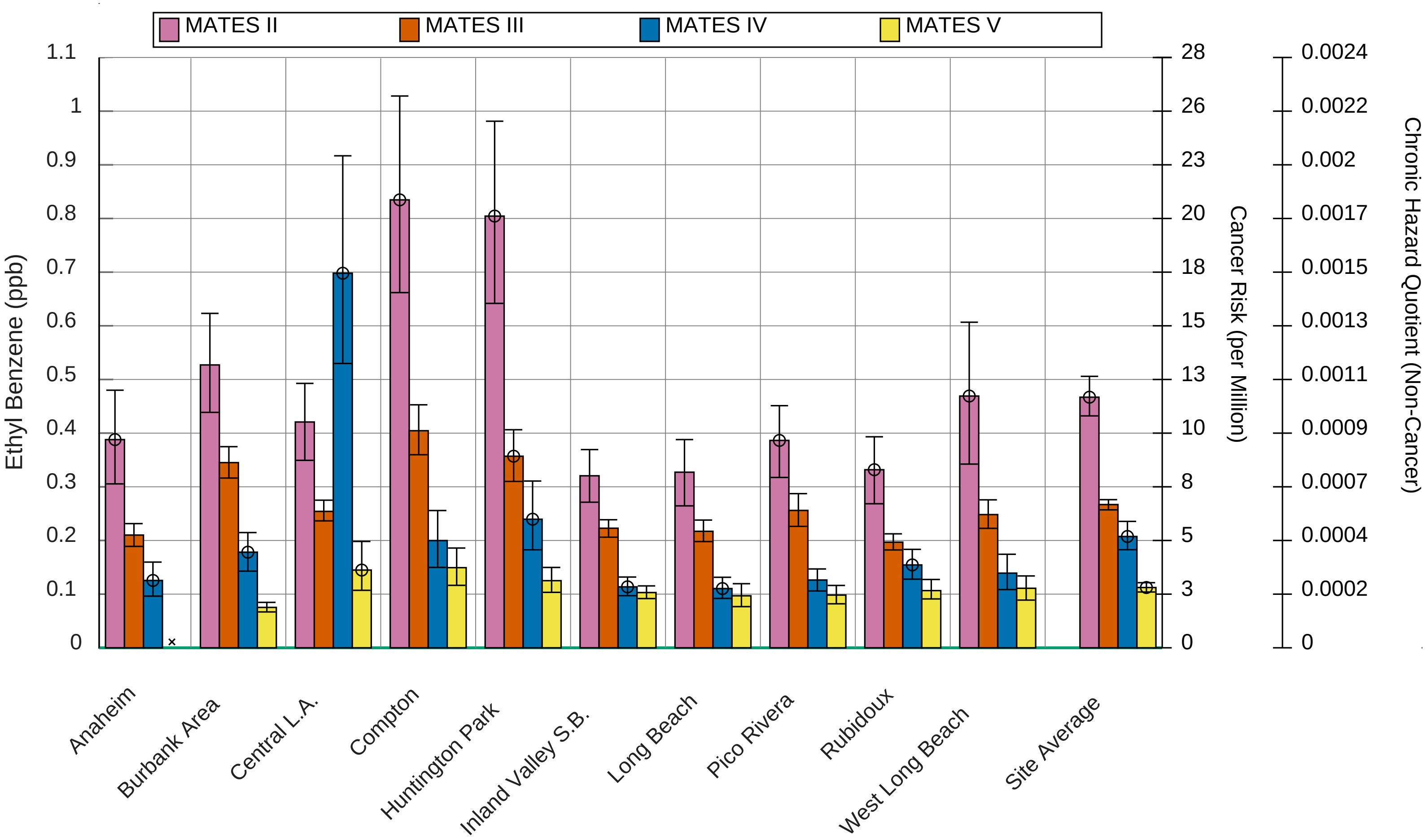


Figure IV-41. Annual Average Concentrations of Ethyl Benzene in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

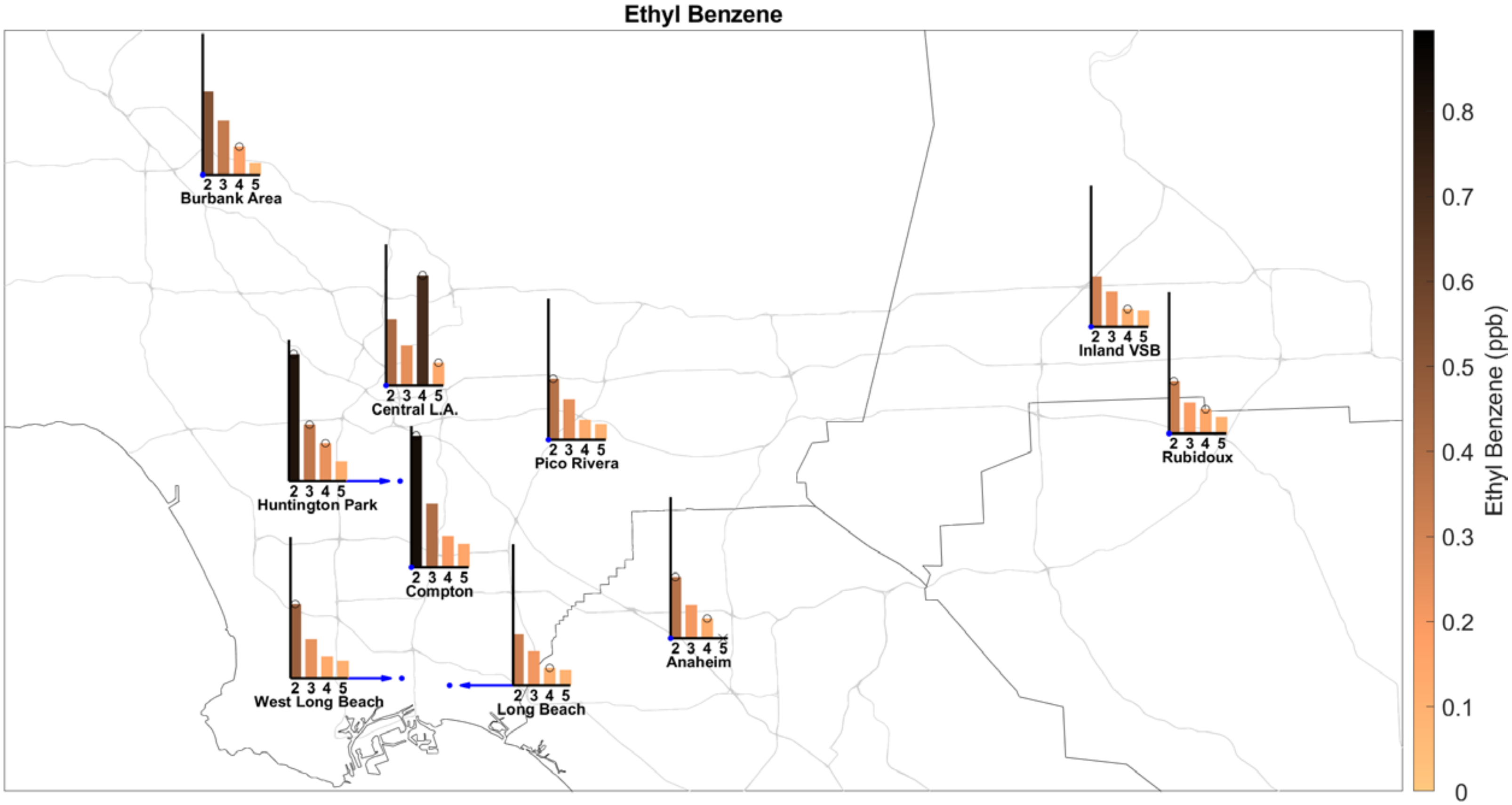


Figure IV-42. Geographic distribution of Ethyl Benzene from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Methylene Chloride

Table IV-24. Ambient Concentrations (ppb) of Methylene Chloride from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.604	0.941	0.777	0.592	1.07	0.501	0.809	0.856	0.556	0.631
95% CI LB	0.418	0.758	0.614	0.455	0.625	0.353	0.626	0.652	0.443	0.437
95% CI UB	0.845	1.14	0.956	0.758	1.76	0.693	1.03	1.12	0.68	0.849
N	51	57	42	59	45	57	56	54	44	35
% < MDL	47.1	24.6	35.7	42.4	37.8	49.1	32.1	27.8	38.6	40
Max	5	3.3	3	3.6	13	4.6	5.2	5.8	2.1	2.7
MATES III										
Average	0.232	0.35	0.342	0.189	0.312	1.05	0.368	0.29	0.265	0.21
95% CI LB	0.212	0.317	0.276	0.176	0.255	0.219	0.341	0.251	0.246	0.188
95% CI UB	0.254	0.388	0.445	0.201	0.384	2.29	0.397	0.34	0.287	0.232
N	233	241	237	232	100	238	238	121	234	235
% < MDL	14.6	3.3	5.1	20.3	4	21	1.3	5	8.1	33.2
Max	0.99	2.81	10.3	0.59	2.97	110	1.37	2.47	0.91	1.42
MATES IV										
Average	0.635	0.238	0.171	0.283	0.238	0.913	0.313	0.168	2	0.478
95% CI LB	0.26	0.202	0.15	0.184	0.195	0.207	0.263	0.15	1.23	0.167
95% CI UB	1.25	0.276	0.193	0.406	0.289	2.29	0.371	0.188	2.93	1.05
N	51	55	57	53	53	54	53	57	52	57
% < MDL	0	0	0	1.9	1.9	1.9	3.8	0	0	7
Max	13.8	0.86	0.44	2.56	1.05	36.8	1.16	0.45	17.1	13.6
MATES V										
Average		0.164	0.193	0.188	0.172	0.165	0.436	0.162	1.02	0.157
95% CI LB		0.151	0.162	0.164	0.151	0.143	0.321	0.145	0.718	0.138
95% CI UB		0.179	0.231	0.217	0.196	0.187	0.586	0.182	1.37	0.179
N	0	59	60	60	59	58	54	52	59	57
% < MDL		0	0	0	0	0	0	0	0	0
Max		0.33	0.97	0.67	0.47	0.43	2.24	0.41	5.92	0.39

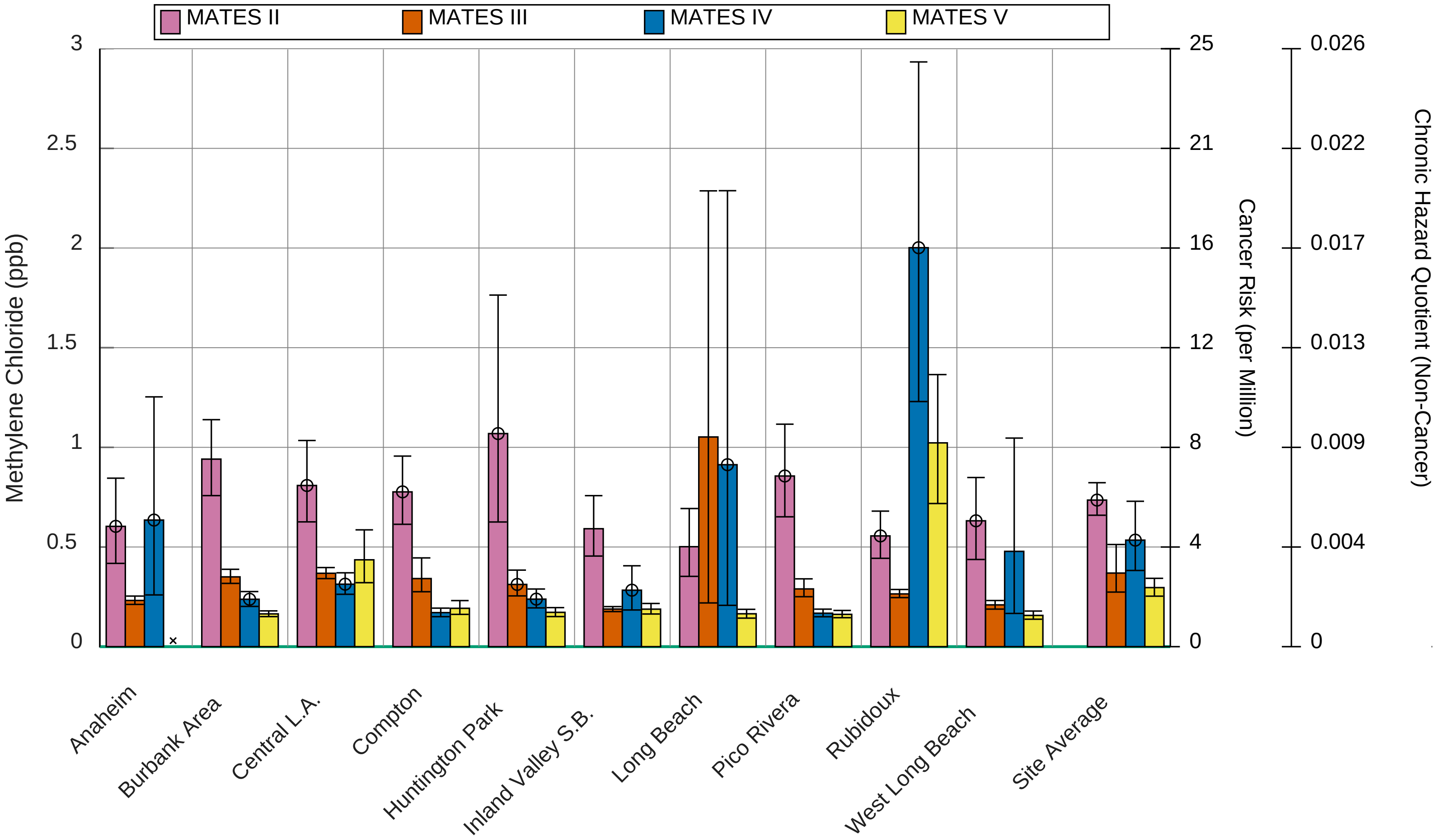


Figure IV-43. Annual Average Concentrations of Methylene Chloride in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

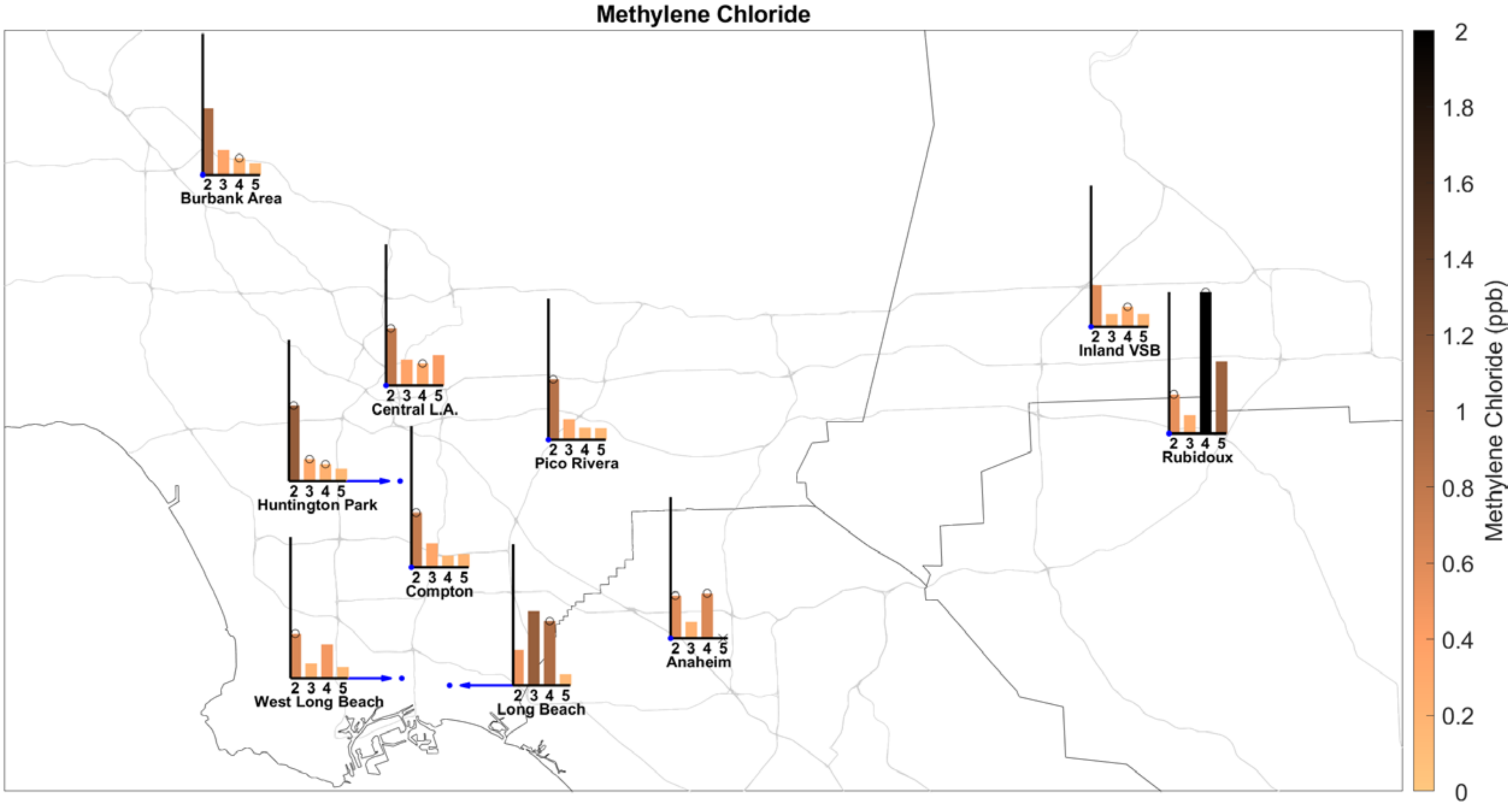


Figure IV-44. Geographic distribution of Methylene Chloride from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Methyl tertiary-butyl ether (MTBE)

Table IV-25. Ambient Concentrations (ppb) of Methyl tertiary-butyl ether (MTBE) from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	0, 0.3[a]	0.0204, 0.318[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]	0, 0.3[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.3[a]	0.348[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]	0.3[a]
N	233[a]	241[a]	237[a]	232[a]	100[a]	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	100[a]	99.2[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	3.35[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES IV										
Average	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]
N	51[a]	55[a]	57[a]	53[a]	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES V										
Average		0, 0.0329[a]	0, 0.0334[a]	0, 0.0334[a]	0, 0.0338[a]	0, 0.0342[a]	0, 0.0339[a]	0.00098, 0.0347[a]	0.000175, 0.0335[a]	0.000179, 0.0332[a]
95% CI LB		0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB		0.0378[a]	0.0382[a]	0.0382[a]	0.0384[a]	0.0391[a]	0.0391[a]	0.0398[a]	0.0384[a]	0.0379[a]
N	0	58[a]	59[a]	59[a]	58[a]	57[a]	54[a]	51[a]	57[a]	56[a]
% < MDL		100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	98[a]	98.2[a]	98.2[a]
Max		< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	0.05[a]	0.01[a]	0.01[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

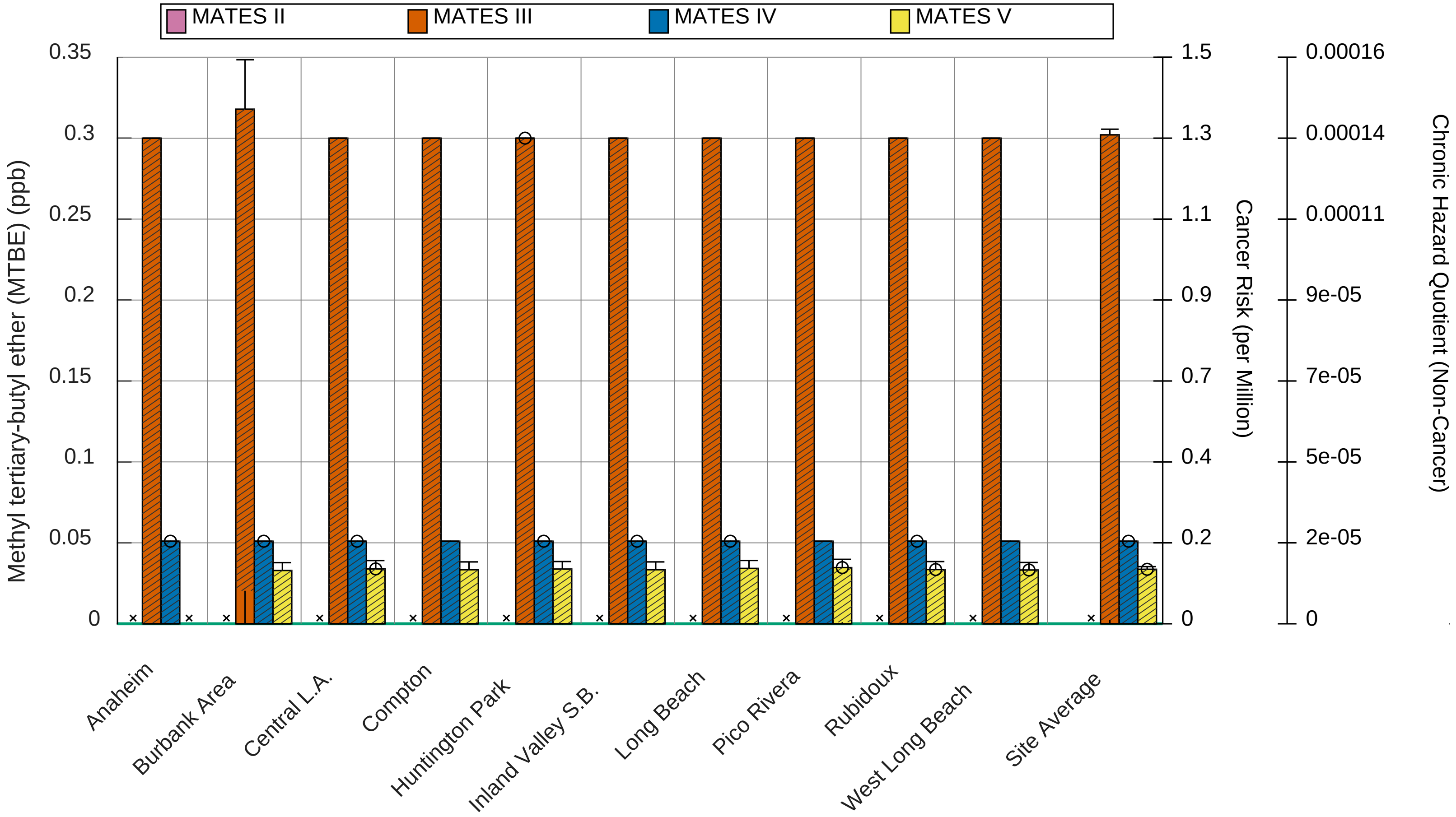


Figure IV-45. Annual Average Concentrations of Methyl tertiary-butyl ether (MTBE) in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean 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.

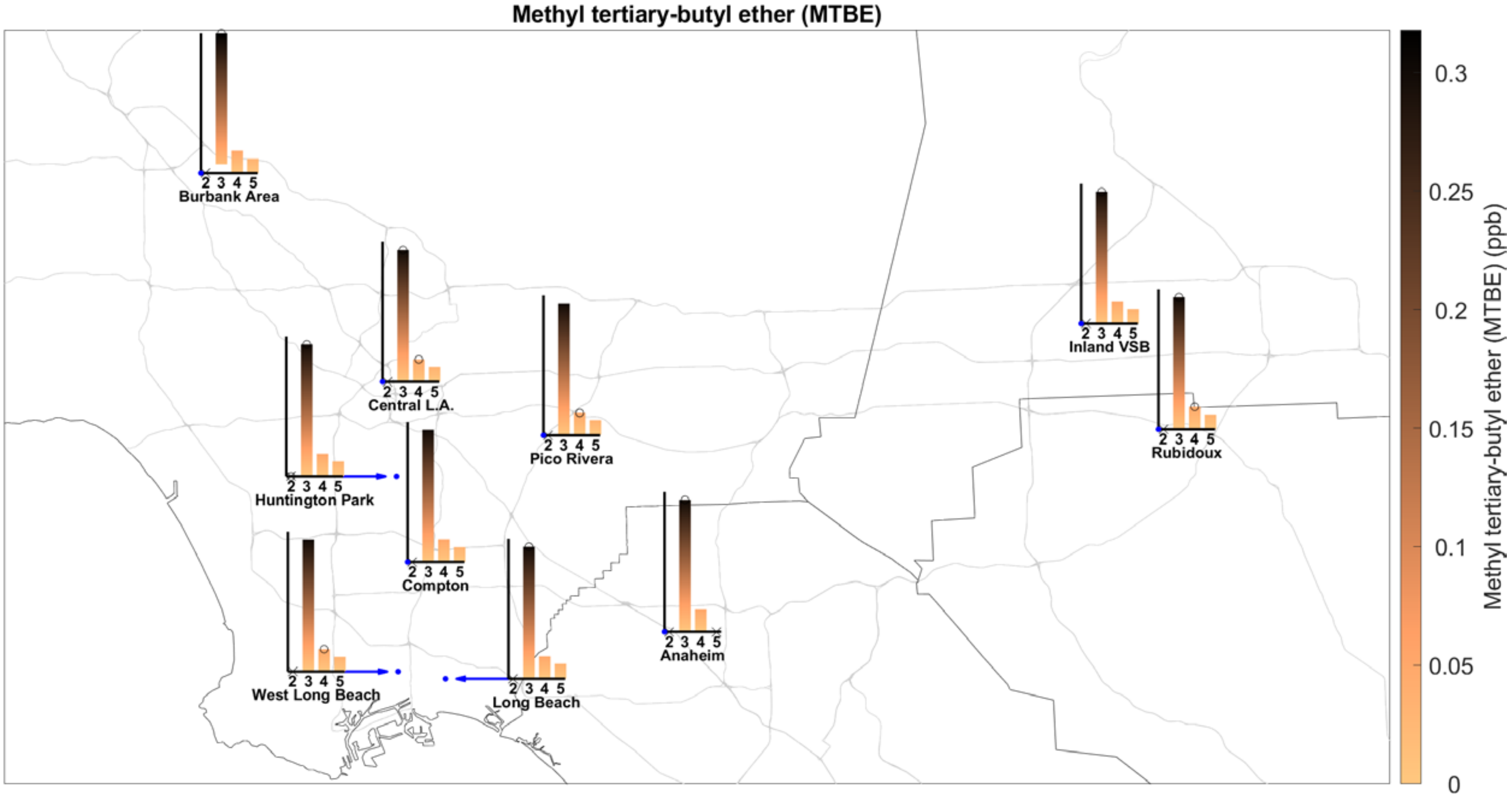


Figure IV-46. Geographic distribution of Methyl tertiary-butyl ether (MTBE) from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Non Methane Organic Carbon

Table IV-26. Ambient Concentrations (ppbC) of Non Methane Organic Carbon from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	168	243	233	214	252	178	415	179	154	199
95% CI LB	135	201	185	183	208	158	295	152	136	165
95% CI UB	206	287	286	253	300	200	583	206	175	238
N	51	55	57	53	53	54	53	57	52	57
% < MDL	0	0	0	0	1.9	0	1.9	0	0	0
Max	715	733	810	940	836	417	3730	447	361	596
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

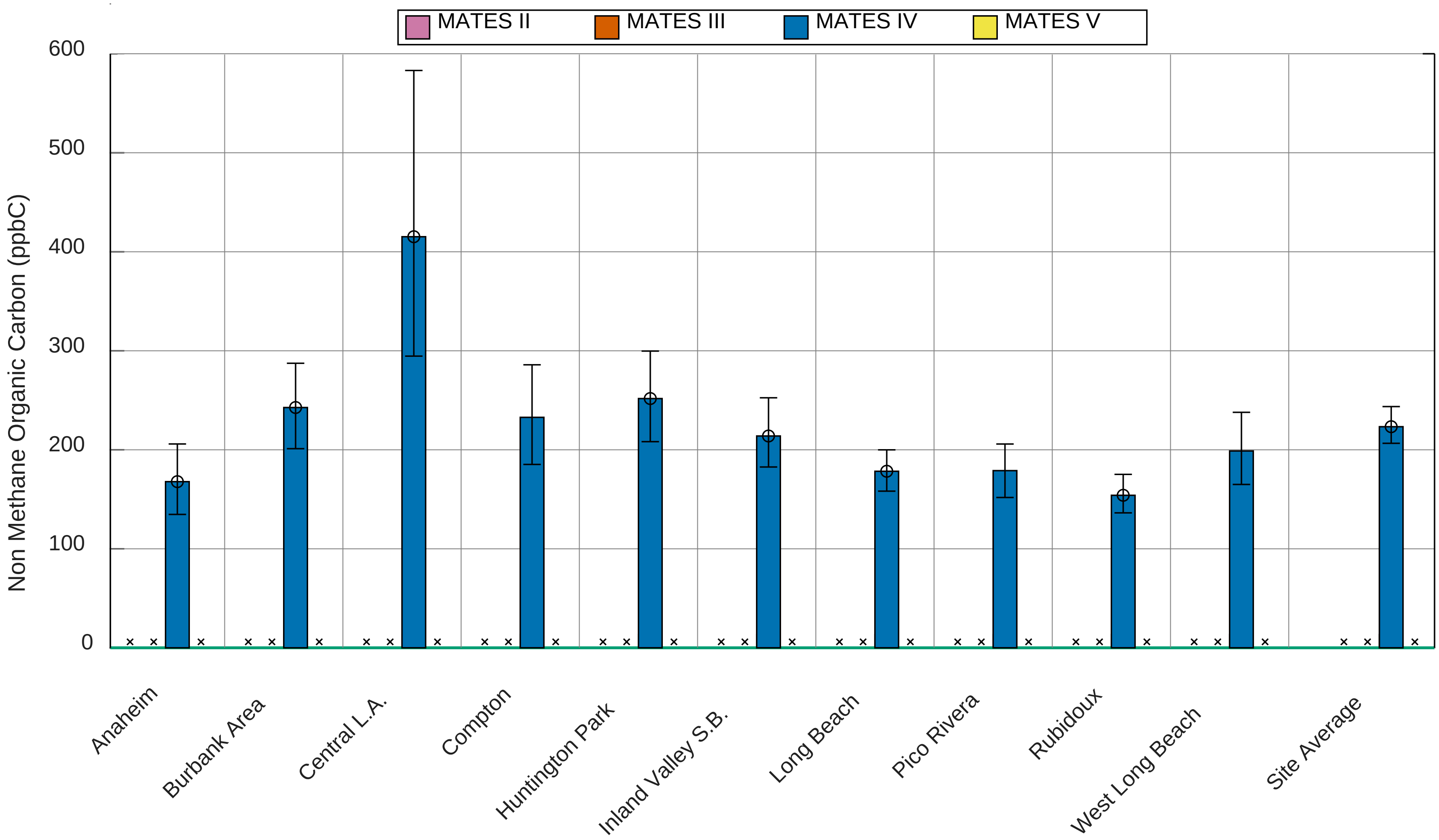


Figure IV-47. Annual Average Concentrations of Non Methane Organic Carbon in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with 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.

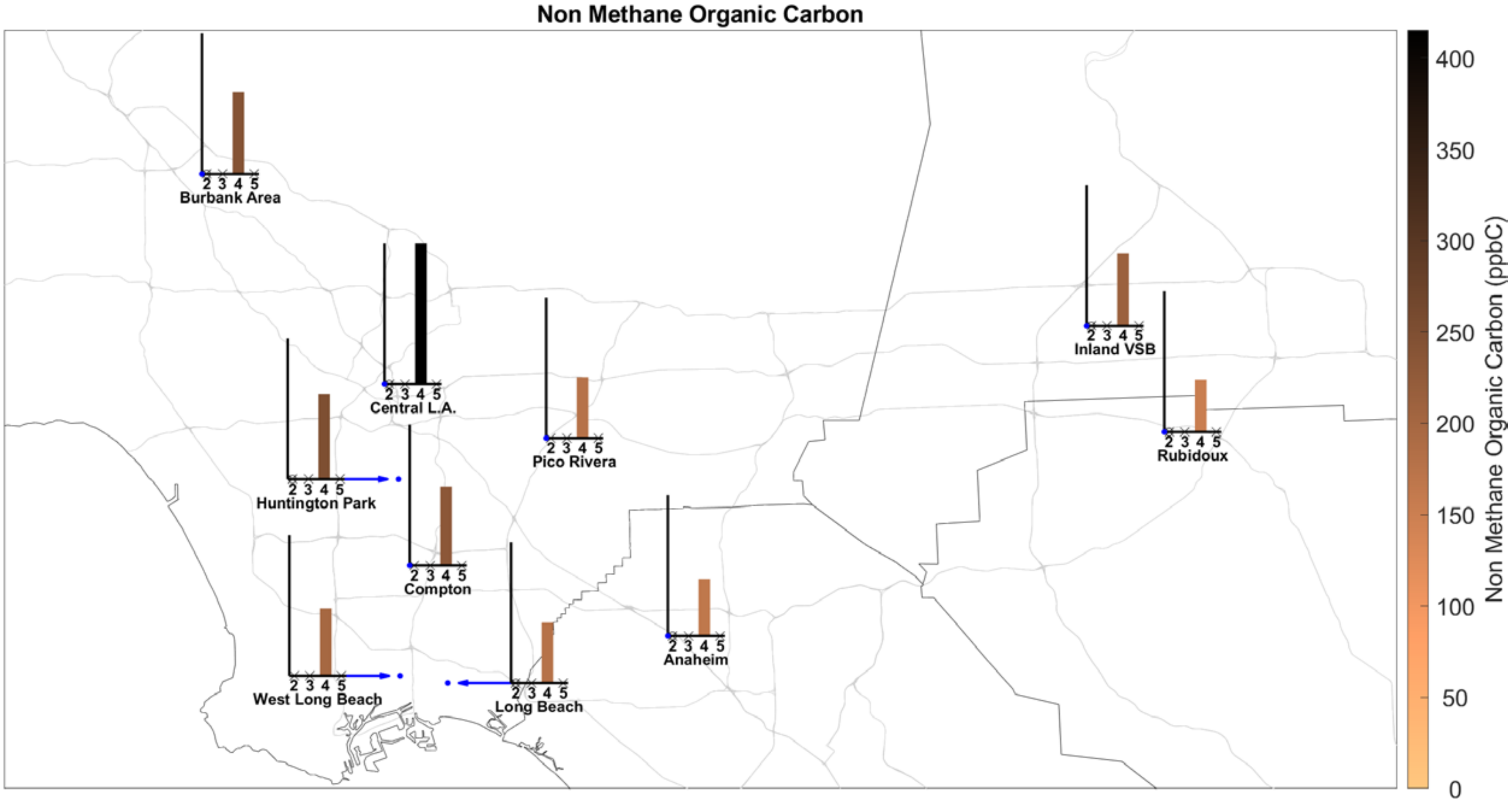


Figure IV-48. Geographic distribution of Non Methane Organic Carbon from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Perchloroethylene

Table IV-27. Ambient Concentrations (ppb) of Perchloroethylene from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.321	0.53	0.397	0.18	0.396	0.172	0.245	0.245	0.169	0.238
95% CI LB	0.217	0.406	0.315	0.15	0.3	0.126	0.205	0.201	0.136	0.161
95% CI UB	0.449	0.671	0.488	0.212	0.507	0.222	0.286	0.294	0.201	0.333
N	49	56	40	59	44	57	55	50	45	33
% < MDL	14.3	5.4	0	8.5	2.3	21.1	7.3	12	11.1	18.2
Max	2.6	2	1.3	0.6	1.9	0.79	0.8	0.9	0.5	1.3
MATES III										
Average	0.0209, 0.108[a]	0.128	0.153	0.00672, 0.101[a]	0.123	0.0119, 0.103[a]	0.0185, 0.105[a]	0.0172, 0.106[a]	0.00244, 0.1[a]	0.0103, 0.103[a]
95% CI LB	0.0133[a]	0.12	0.139	0.00336[a]	0.113	0.00702[a]	0.0126[a]	0.00905[a]	0.00047[a]	0.00596[a]
95% CI UB	0.113[a]	0.138	0.17	0.102[a]	0.136	0.106[a]	0.107[a]	0.109[a]	0.101[a]	0.104[a]
N	233[a]	241	237	232[a]	100	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	87.1[a]	66	60.3	94.4[a]	73	91.6[a]	86.6[a]	88.4[a]	97.9[a]	92.3[a]
Max	0.46[a]	0.79	1.21	0.17[a]	0.5	0.22[a]	0.21[a]	0.22[a]	0.15[a]	0.19[a]
MATES IV										
Average	0.0159, 0.072[a]	0.0182, 0.0725[a]	0.0184, 0.0743[a]	0.0749	0.0147, 0.0699[a]	0.0013, 0.0651[a]	0.00189, 0.0657[a]	0.00298, 0.0657[a]	0, 0.065[a]	0.00123, 0.0651[a]
95% CI LB	0.00549[a]	0.00745[a]	0.00693[a]	0.0683	0.00585[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.0785[a]	0.0783[a]	0.0848[a]	0.0831	0.0739[a]	0.0653[a]	0.067[a]	0.067[a]	0.065[a]	0.0653[a]
N	51[a]	55[a]	57[a]	53	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	86.3[a]	83.6[a]	86[a]	79.2	84.9[a]	98.1[a]	98.1[a]	96.5[a]	100[a]	98.2[a]
Max	0.17[a]	0.15[a]	0.26[a]	0.23	0.12[a]	0.07[a]	0.1[a]	0.1[a]	< MDL[a]	0.07[a]
MATES V										
Average		0.0305	0.0536	0.0558	0.0364	0.0324	0.0325	0.0367	0.0305	0.0326
95% CI LB		0.03	0.0427	0.043	0.0331	0.0307	0.0312	0.0331	0.03	0.0311
95% CI UB		0.0312	0.0678	0.0734	0.0398	0.0345	0.0342	0.0406	0.0312	0.0344
N	0	60	59	60	58	58	54	51	58	57
% < MDL		73.3	33.9	25	36.2	70.7	55.6	49	69	64.9
Max		0.04	0.34	0.46	0.09	0.07	0.05	0.07	0.04	0.06

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

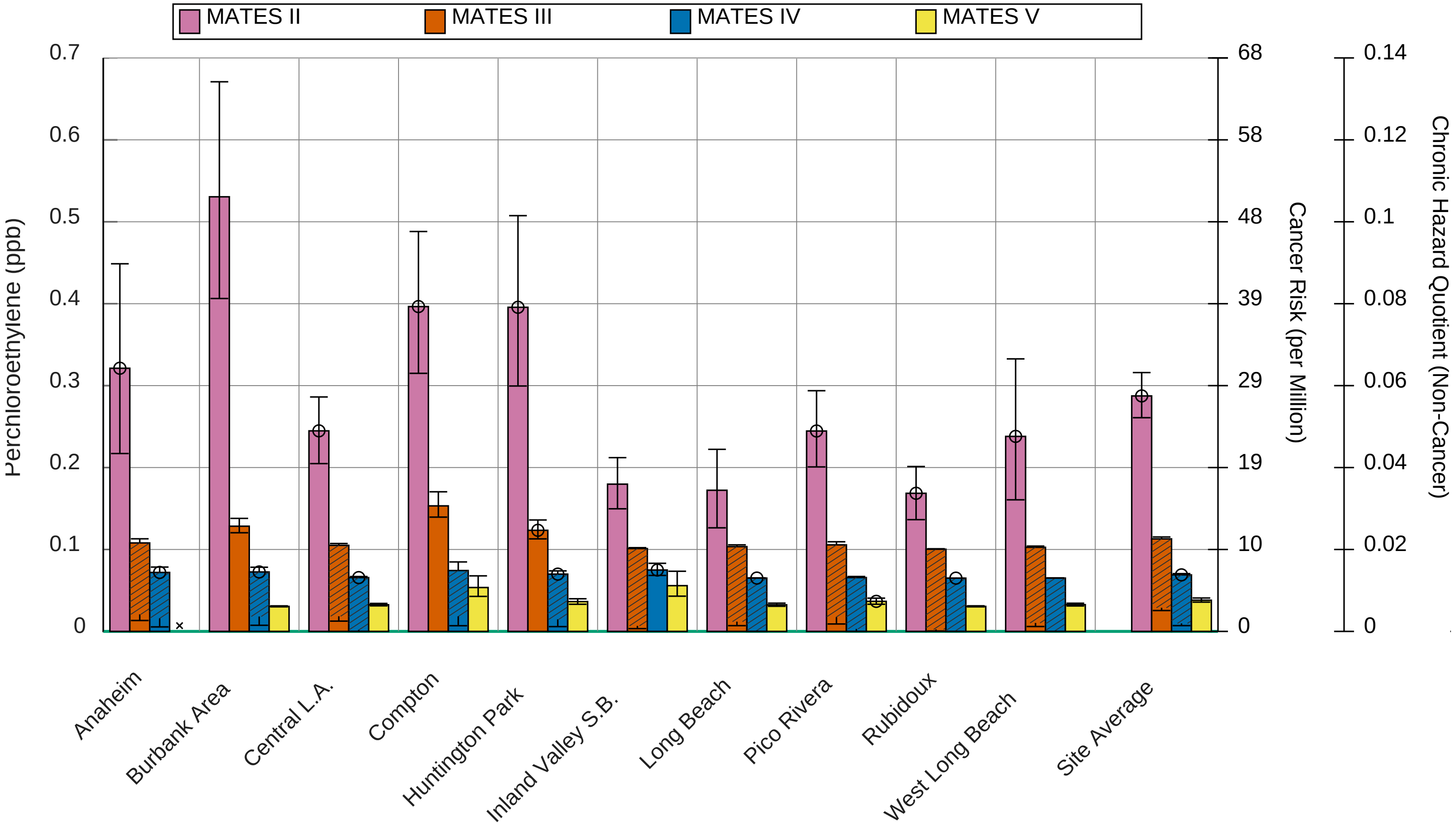


Figure IV-49. Annual Average Concentrations of Perchloroethylene in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

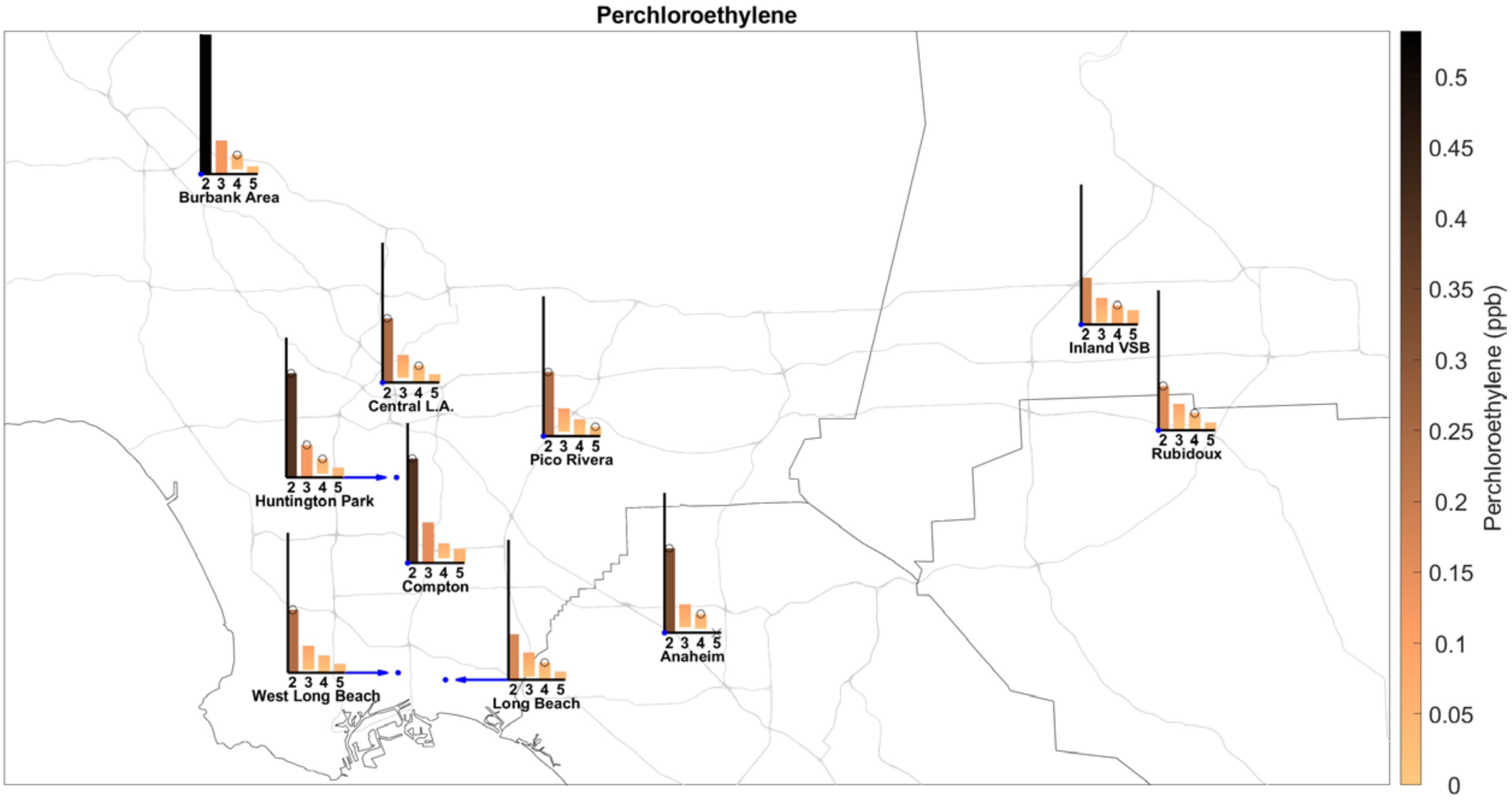


Figure IV-50. Geographic distribution of Perchloroethylene from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Styrene

Table IV-28. Ambient Concentrations (ppb) of Styrene from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.998	0.261	0.362	0.161	0.246	0.223	0.195	0.19	0.242	0.282
95% CI LB	0.426	0.147	0.267	0.137	0.183	0.162	0.137	0.152	0.179	0.171
95% CI UB	1.74	0.403	0.467	0.186	0.313	0.297	0.285	0.232	0.308	0.4
N	29	35	21	38	24	37	35	34	24	17
% < MDL	34.5	42.9	0	39.5	8.3	35.1	40	38.2	20.8	35.3
Max	8	1.8	1	0.4	0.6	1	1.4	0.5	0.6	0.9
MATES III										
Average	0.395	0.14	0.181	0.116	0.112	0.145	0.0294, 0.112[a]	0.0291, 0.109[a]	0.126	0.336
95% CI LB	0.31	0.129	0.161	0.11	0.107	0.132	0.0209[a]	0.0186[a]	0.118	0.288
95% CI UB	0.49	0.155	0.203	0.123	0.118	0.159	0.118[a]	0.115[a]	0.135	0.391
N	233	241	237	232	100	238	238[a]	121[a]	234	235
% < MDL	63.9	74.7	53.6	72.8	73	71.4	82.8[a]	80.2[a]	74.8	37.4
Max	3.78	0.805	1.33	0.39	0.27	0.78	0.41[a]	0.265[a]	0.62	3.69
MATES IV										
Average	0.112	0.0958	0.11	0.00189, 0.0696[a]	0.0877	0.0146, 0.076[a]	0.0175, 0.0735[a]	0.0131, 0.0724[a]	0.0748	0.108
95% CI LB	0.0835	0.0805	0.0858	0[a]	0.0771	0.00407[a]	0.00802[a]	0.00504[a]	0.0711	0.0911
95% CI UB	0.15	0.114	0.139	0.0708[a]	0.101	0.085[a]	0.0783[a]	0.0751[a]	0.0792	0.126
N	51	55	57	53[a]	53	54[a]	53[a]	57[a]	52	57
% < MDL	74.5	74.5	71.9	98.1[a]	77.4	88.9[a]	81.1[a]	86[a]	78.8	64.9
Max	0.85	0.33	0.49	0.1[a]	0.25	0.26[a]	0.16[a]	0.105[a]	0.14	0.32
MATES V										
Average		0.0547	0.0896	0.0636	0.0805	0.0652	0.0643	0.0876	0.0822	0.109
95% CI LB		0.0488	0.0681	0.0544	0.0599	0.0533	0.0537	0.0788	0.0704	0.0834
95% CI UB		0.0614	0.117	0.0745	0.109	0.0777	0.0772	0.0987	0.0959	0.138
N	0	59	60	60	59	58	55	52	60	57
% < MDL		54.2	40	43.3	49.2	60.3	54.5	13.5	28.3	38.6
Max		0.15	0.68	0.31	0.68	0.3	0.28	0.25	0.32	0.62

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

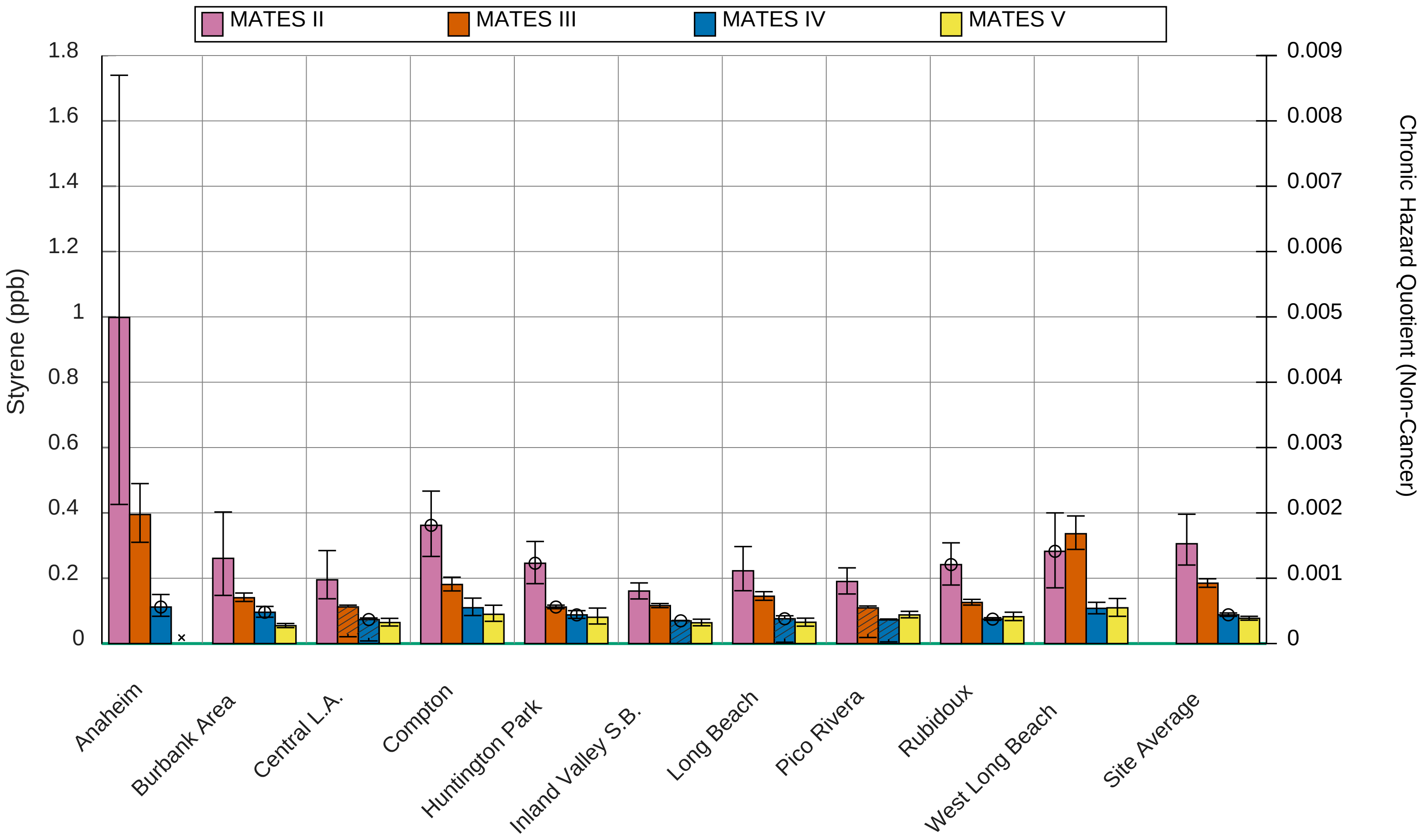


Figure IV-51. Annual Average Concentrations of Styrene in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

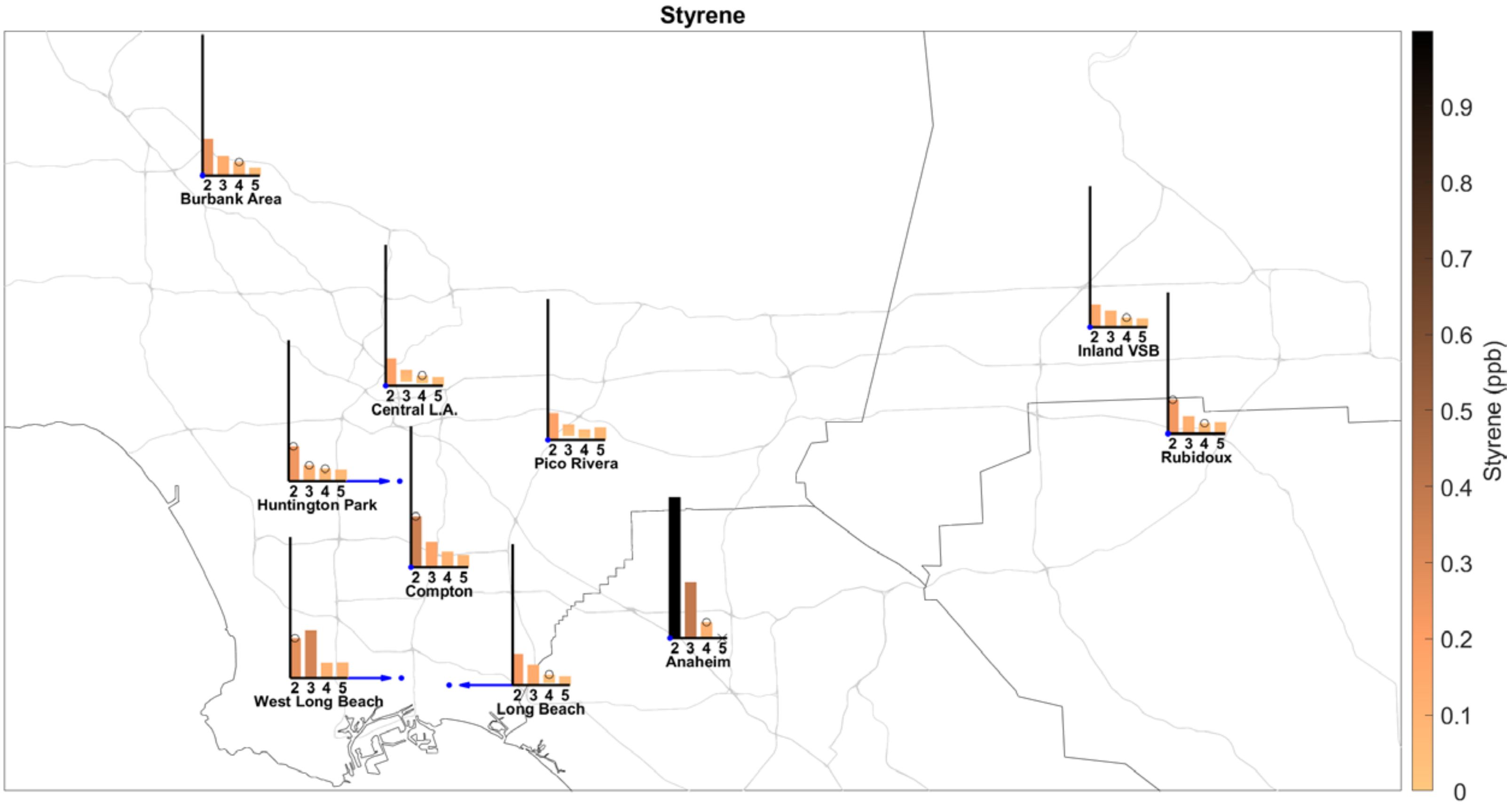


Figure IV-52. Geographic distribution of Styrene from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Toluene

Table IV-29. Ambient Concentrations (ppb) of Toluene from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	2.77	4.17	5.08	2.42	5.79	2.1	2.95	3.13	2.78	3.65
95% CI LB	2.18	3.49	3.93	2.04	4.76	1.73	2.48	2.6	2.25	2.64
95% CI UB	3.42	4.9	6.32	2.8	6.91	2.51	3.42	3.7	3.3	4.78
N	49	56	40	56	44	56	53	53	42	34
% < MDL	2	1.8	0	1.8	2.3	1.8	1.9	3.8	2.4	2.9
Max	8.8	11.6	20	7.6	15.1	6.1	7.4	8.8	7.5	15
MATES III										
Average	1.5	2.58	2.82	1.71	2.84	1.5	1.82	1.98	1.51	1.76
95% CI LB	1.35	2.38	2.51	1.58	2.51	1.36	1.69	1.74	1.4	1.57
95% CI UB	1.66	2.8	3.14	1.83	3.2	1.64	1.96	2.23	1.63	1.97
N	233	241	237	232	100	238	238	121	234	235
% < MDL	0	0	0	0.4	0	0	0	0	0	0
Max	8.42	8.94	13.2	5.55	8.68	5.58	6.11	6.95	5.5	8.44
MATES IV										
Average	0.875	1.32	1.42	0.837	1.61	0.741	1.11	0.966	0.813	0.892
95% CI LB	0.669	1.07	1.06	0.715	1.31	0.61	0.937	0.798	0.685	0.689
95% CI UB	1.12	1.57	1.82	0.97	1.95	0.886	1.3	1.15	0.96	1.12
N	51	55	57	53	53	54	53	57	52	57
% < MDL	0	0	0	0	0	0	1.9	0	0	0
Max	4.6	3.78	6.15	2.92	5.67	2.33	3.76	2.81	2.71	3.58
MATES V										
Average		0.905	1.04	0.681	0.895	0.613	0.607	0.686	0.641	0.71
95% CI LB		0.802	0.785	0.595	0.724	0.476	0.517	0.544	0.529	0.57
95% CI UB		1.01	1.3	0.777	1.08	0.763	0.704	0.872	0.764	0.87
N	0	60	61	61	60	59	56	53	60	58
% < MDL		0	0	0	0	0	0	0	0	0
Max		1.85	4.2	1.78	2.88	2.27	1.62	3.64	2.4	2.37

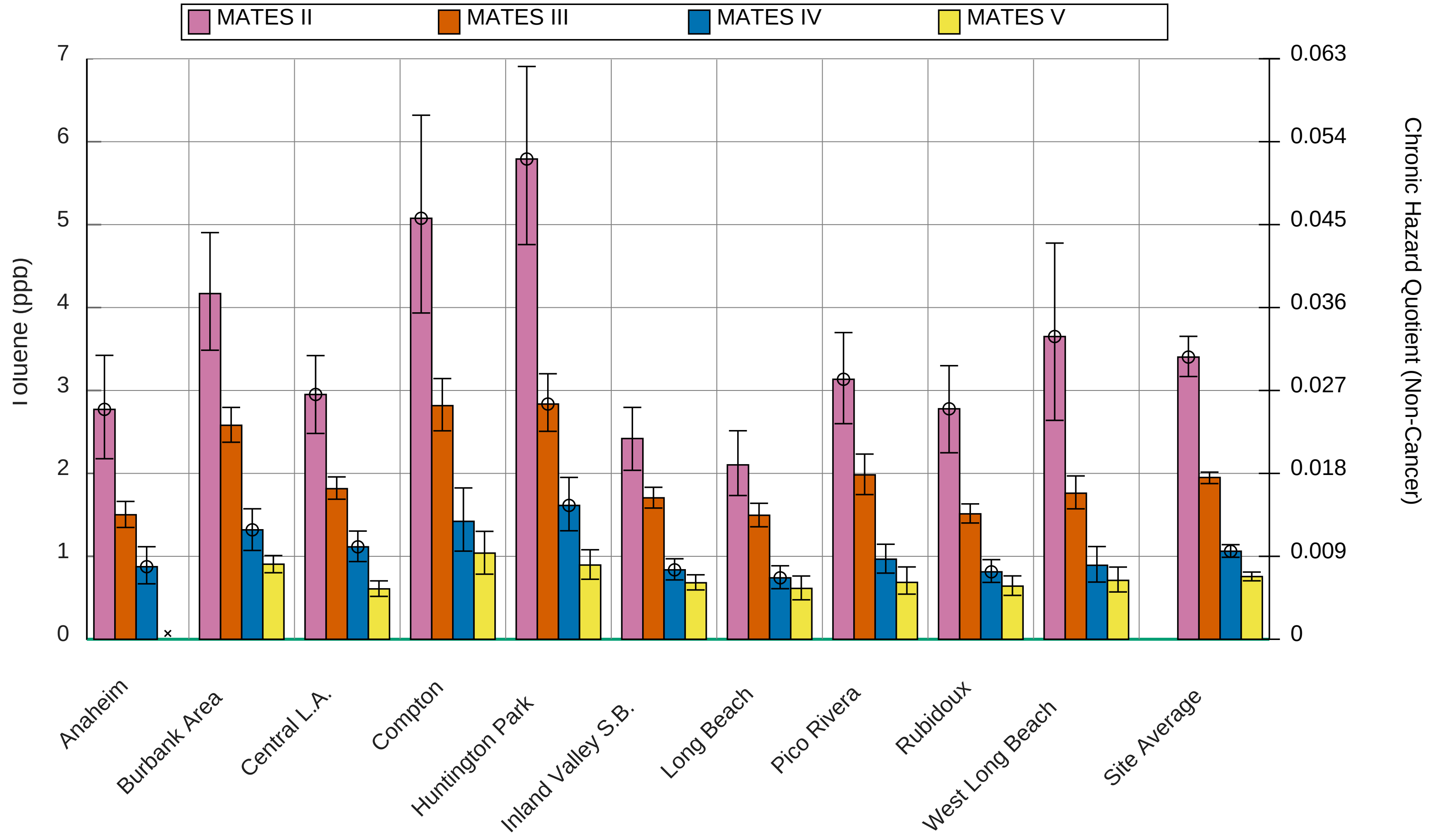


Figure IV-53. Annual Average Concentrations of Toluene in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

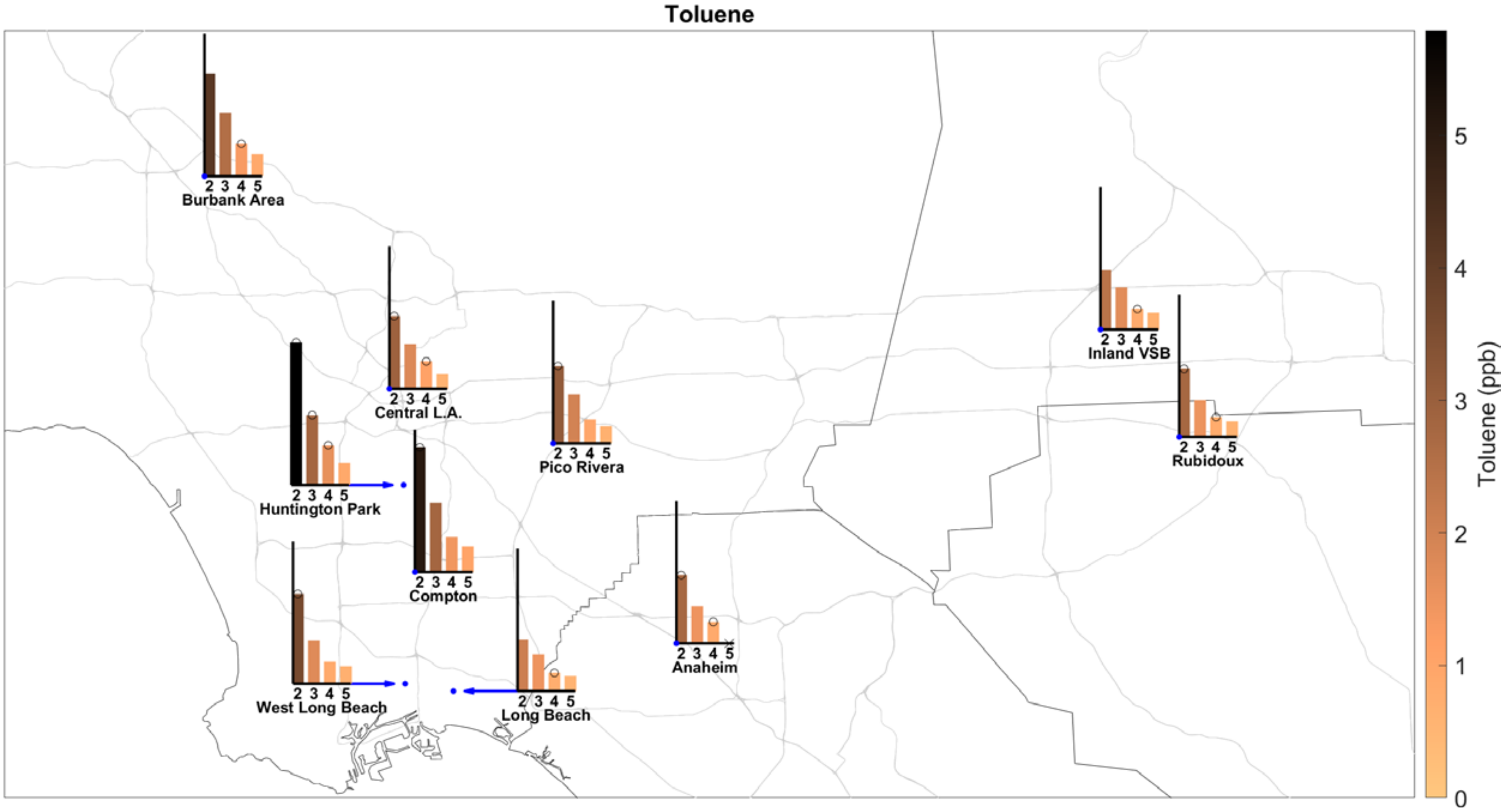


Figure IV-54. Geographic distribution of Toluene from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Trichloroethylene

Table IV-30. Ambient Concentrations (ppb) of Trichloroethylene from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.131	0.0459	0.0621	0.0277	0.0422	0.0317	0.265	0.0387	0.0248	0.0621
95% CI LB	0.106	0.0352	0.0423	0.0252	0.0336	0.0263	0.202	0.0316	0.0224	0.0324
95% CI UB	0.159	0.0585	0.0876	0.0723	0.0521	0.0737	0.332	0.0459	0.0751	0.111
N	51	57	42	60	45	59	57	54	45	35
% < MDL	23.5	52.6	57.1	80	53.3	74.6	14	59.3	80	54.3
Max	0.57	0.29	0.36	0.07	0.13	0.15	1.3	0.1	0.06	0.8
MATES III										
Average	0.0012, 0.1[a]	0.00546, 0.101[a]	0.000886, 0.1[a]	0, 0.1[a]	0.0012, 0.1[a]	0, 0.1[a]	0.00559, 0.102[a]	0.00446, 0.1[a]	0, 0.1[a]	0.00294, 0.101[a]
95% CI LB	0[a]	0.00249[a]	0[a]	0[a]	0[a]	0[a]	0.00206[a]	0.000909[a]	0[a]	0.000426[a]
95% CI UB	0.101[a]	0.102[a]	0.1[a]	0.1[a]	0.101[a]	0.1[a]	0.104[a]	0.101[a]	0.1[a]	0.104[a]
N	233[a]	241[a]	237[a]	232[a]	100[a]	238[a]	238[a]	121[a]	234[a]	235[a]
% < MDL	99.1[a]	95.4[a]	99.2[a]	100[a]	99[a]	100[a]	96.2[a]	95.9[a]	100[a]	98.3[a]
Max	0.18[a]	0.15[a]	0.11[a]	< MDL[a]	0.12[a]	< MDL[a]	0.33[a]	0.115[a]	< MDL[a]	0.36[a]
MATES IV										
Average	0, 0.072[a]	0, 0.072[a]	0, 0.072[a]	0, 0.072[a]	0, 0.072[a]	0, 0.072[a]	0.00679, 0.0734[a]	0, 0.072[a]	0, 0.072[a]	0, 0.072[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0.00151[a]	0[a]	0[a]	0[a]
95% CI UB	0.072[a]	0.072[a]	0.072[a]	0.072[a]	0.072[a]	0.072[a]	0.0749[a]	0.072[a]	0.072[a]	0.072[a]
N	51[a]	55[a]	57[a]	53[a]	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	92.5[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	0.1[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES V										
Average		0.00283, 0.0282[a]	0.0141	0.00377, 0.0286[a]	0.0149	0.0124	0.00429, 0.0299[a]	0.0109	0.0108	0.0178
95% CI LB		0.000667[a]	0.0115	0.00131[a]	0.0121	0.0103	0.00125[a]	0.0095	0.00965	0.0133
95% CI UB		0.0319[a]	0.0316	0.0323[a]	0.0291	0.0325	0.0338[a]	0.0317	0.0324	0.0297
N	0	60[a]	61	61[a]	60	59	56[a]	53	60	58
% < MDL		90[a]	70.5	82[a]	70	72.9	85.7[a]	73.6	80	69
Max		0.05[a]	0.06	0.05[a]	0.07	0.05	0.05[a]	0.05	0.05	0.14

[a]More than 80% of data are < MDL. Values based on zero and MDL substitutions.

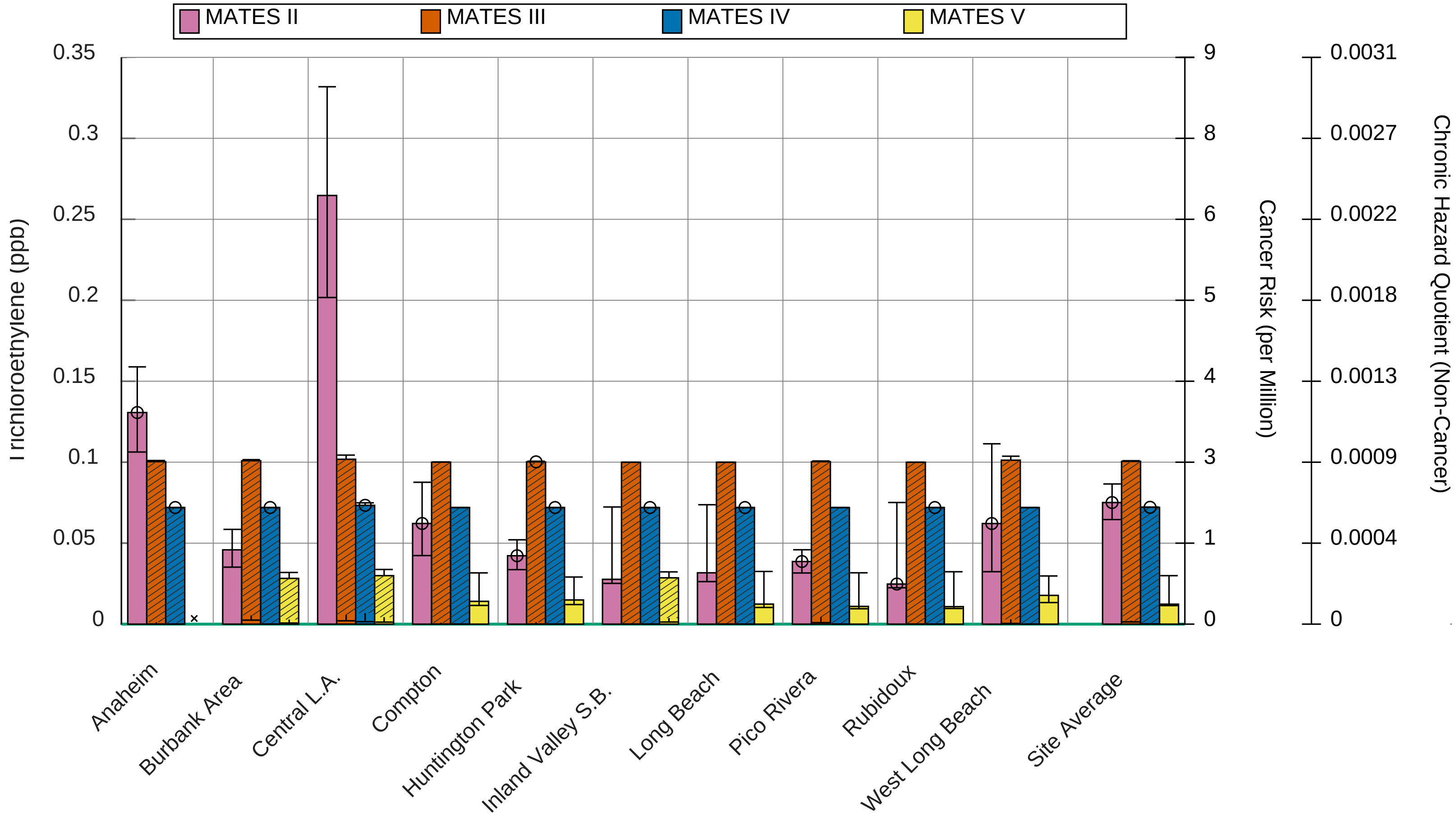


Figure IV-55. Annual Average Concentrations of Trichloroethylene in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

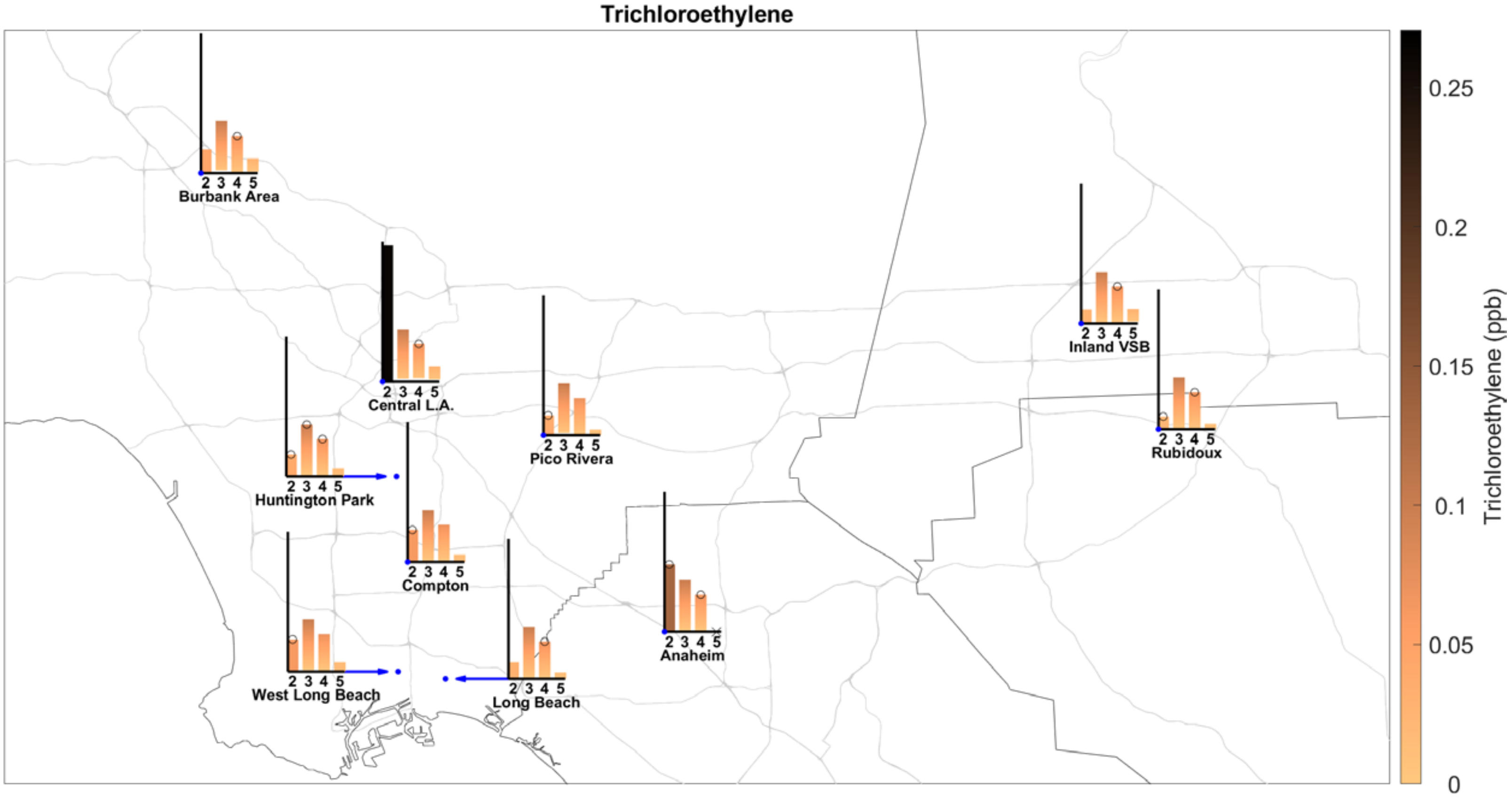


Figure IV-56. Geographic distribution of Trichloroethylene from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Vinyl Chloride

Table IV-31. Ambient Concentrations (ppb) of Vinyl Chloride from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.242[a]	0, 0.2[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.304[a]	0.2[a]
N	26[a]	28[a]	21[a]	30[a]	23[a]	30[a]	29[a]	29[a]	24[a]	17[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES III										
Average	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]	0, 0.2[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]	0.2[a]
N	233[a]	241[a]	237[a]	232[a]	100[a]	238[a]	238[a]	121[a]	234[a]	234[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES IV										
Average	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]	0, 0.051[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]	0.051[a]
N	51[a]	55[a]	57[a]	53[a]	53[a]	54[a]	53[a]	57[a]	52[a]	57[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES V										
Average		0.000667, 0.0275[a]	0.00082, 0.0282[a]	0.000328, 0.028[a]	0.000167, 0.0283[a]	0.00119, 0.0288[a]	0.000357, 0.0282[a]	0.000943, 0.0292[a]	0.000167, 0.0283[a]	0.00069, 0.0279[a]
95% CI LB		0.000167[a]	0.000164[a]	0[a]	0[a]	0.000339[a]	0[a]	0.000189[a]	0[a]	0.000172[a]
95% CI UB		0.0312[a]	0.0316[a]	0.0315[a]	0.0318[a]	0.0322[a]	0.0316[a]	0.0328[a]	0.0318[a]	0.0314[a]
N	0	60[a]	61[a]	61[a]	60[a]	59[a]	56[a]	53[a]	60[a]	58[a]
% < MDL		93.3[a]	93.4[a]	96.7[a]	98.3[a]	89.8[a]	96.4[a]	92.5[a]	98.3[a]	93.1[a]
Max		0.01[a]	0.02[a]	0.01[a]	0.01[a]	0.02[a]	0.01[a]	0.02[a]	0.01[a]	0.01[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

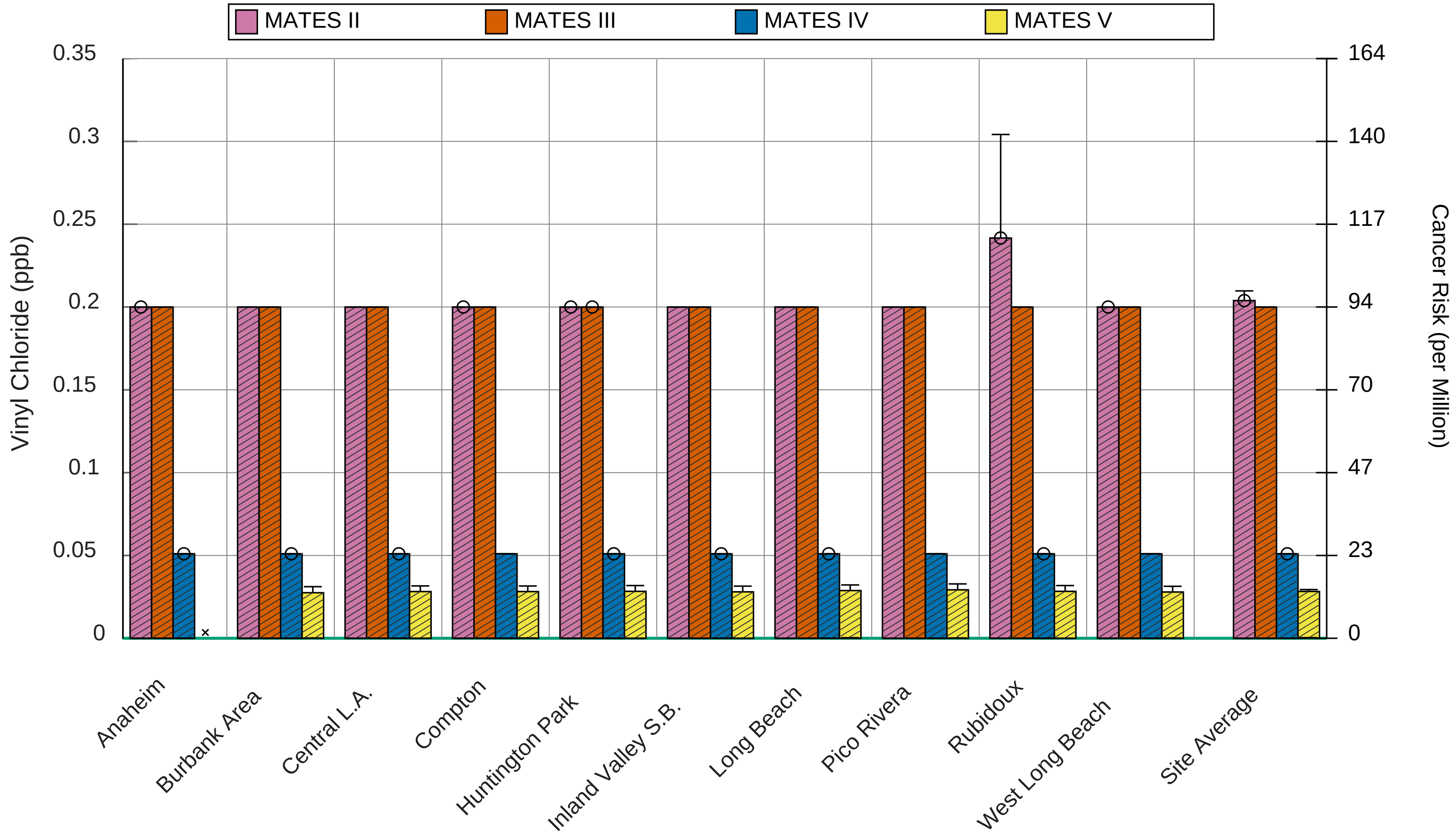


Figure IV-57. Annual Average Concentrations of Vinyl Chloride in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

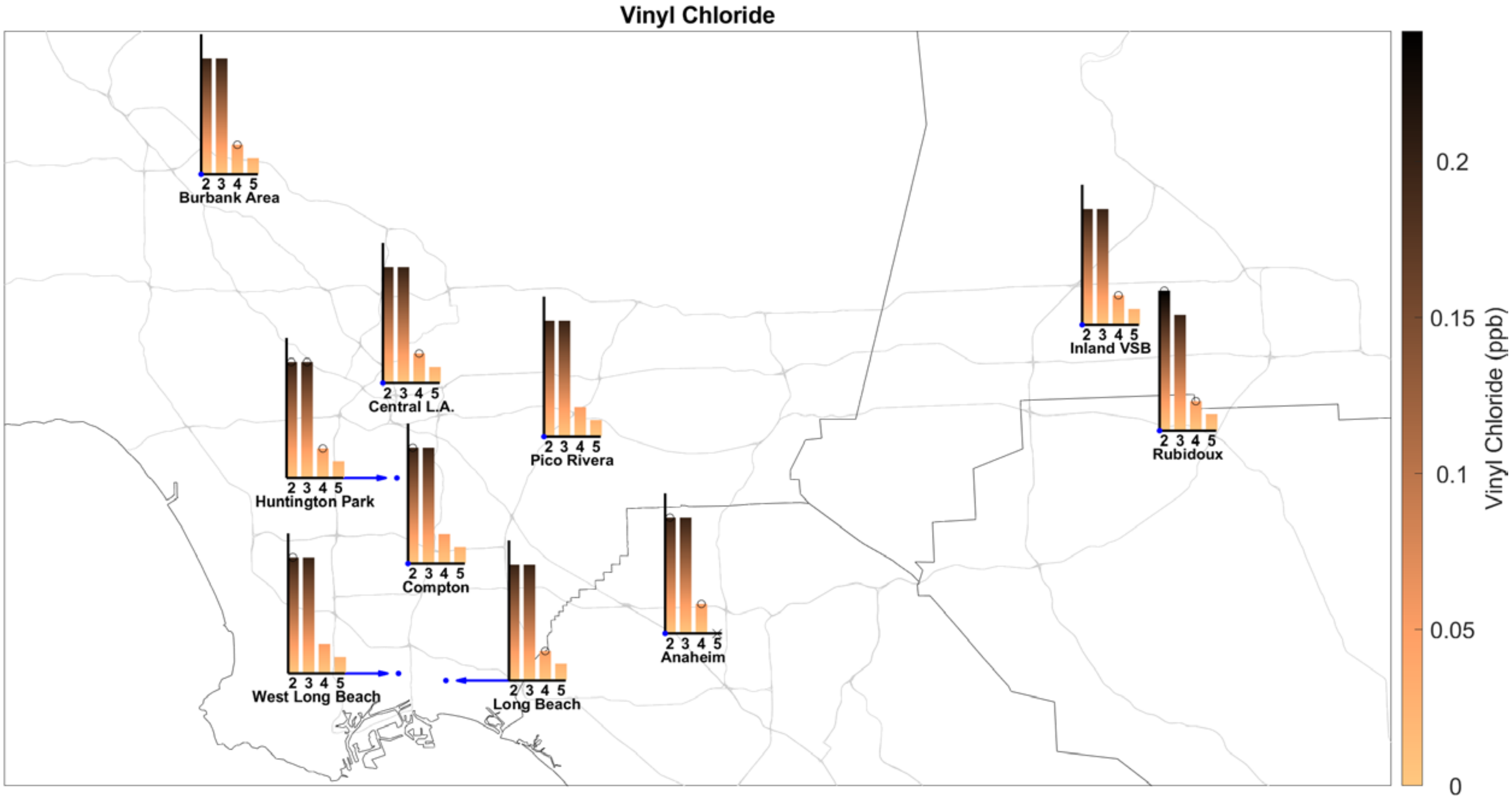


Figure IV-58. Geographic distribution of Vinyl Chloride from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Xylene (m-, p-)

Table IV-32. Ambient Concentrations (ppb) of Xylene (m-, p-) from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1.36	1.81	2.98	0.949	3.02	1.02	1.4	1.38	1.16	1.78
95% CI LB	1.06	1.45	2.32	0.816	2.45	0.833	1.17	1.14	0.951	1.27
95% CI UB	1.7	2.2	3.66	1.09	3.62	1.24	1.67	1.65	1.39	2.34
N	50	56	41	58	44	57	55	54	42	35
% < MDL	22	16.1	17.1	31	2.3	31.6	20	18.5	21.4	20
Max	6.1	6	8.8	2.5	8.9	3.2	3.8	4.3	3.3	7.2
MATES III										
Average	0.724	1.3	1.51	0.753	1.42	0.764	0.939	0.97	0.65	0.822
95% CI LB	0.647	1.19	1.34	0.697	1.24	0.69	0.874	0.862	0.598	0.732
95% CI UB	0.806	1.42	1.69	0.81	1.61	0.846	1.01	1.09	0.704	0.917
N	233	241	237	232	100	238	238	121	234	235
% < MDL	0	0	0	2.6	0	0	0	0	0.4	0.4
Max	4.03	4.91	7.85	2.4	4.58	3.03	3.04	3.74	2.5	4.53
MATES IV										
Average	0.404	0.606	0.672	0.348	0.865	0.34	2.42	0.394	0.379	0.435
95% CI LB	0.297	0.482	0.49	0.292	0.631	0.277	1.86	0.324	0.316	0.328
95% CI UB	0.528	0.744	0.877	0.413	1.17	0.41	3.15	0.467	0.451	0.558
N	51	55	57	53	53	54	53	57	52	57
% < MDL	3.9	0	1.8	3.8	1.9	0	1.9	1.8	0	5.3
Max	2.31	2.19	3.06	1.42	6.62	1.09	16.2	1.08	1.03	2.53
MATES V										
Average		0.204	0.484	0.302	0.383	0.293	0.492	0.294	0.27	0.343
95% CI LB		0.181	0.363	0.26	0.306	0.223	0.341	0.235	0.226	0.267
95% CI UB		0.229	0.619	0.35	0.469	0.373	0.715	0.355	0.321	0.43
N	0	57	58	58	57	56	54	50	57	55
% < MDL		1.8	1.7	1.7	0	1.8	0	0	1.8	0
Max		0.48	2.01	1.04	1.26	1.39	5.1	0.98	0.84	1.52

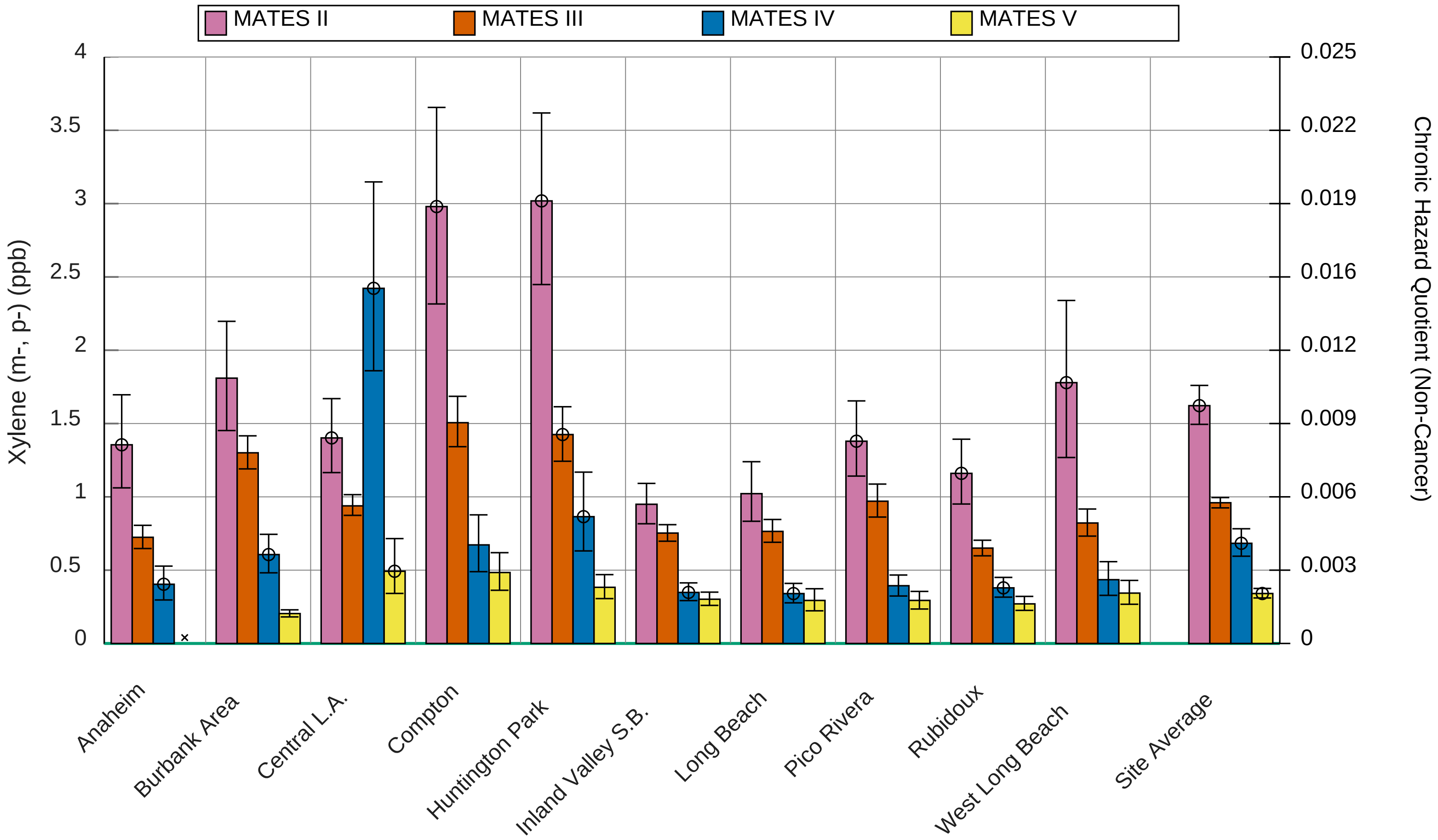


Figure IV-59. Annual Average Concentrations of Xylene (m-, p-) in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

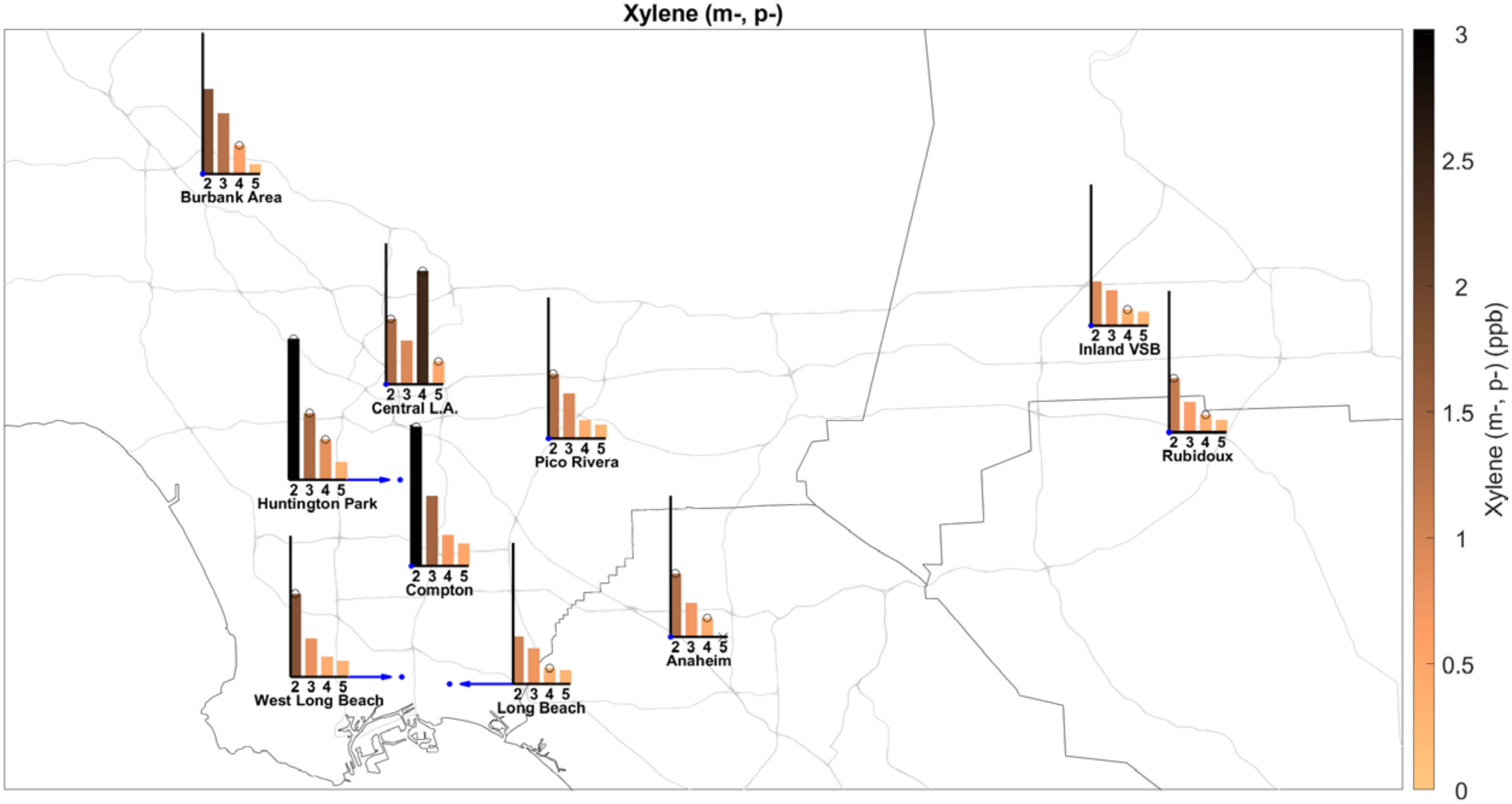


Figure IV-60. Geographic distribution of Xylene (m-, p-) from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Xylene (o-)

Table IV-33. Ambient Concentrations (ppb) of Xylene (o-) from the VOCs analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.498	0.635	0.901	0.353	0.927	0.384	0.526	0.519	0.431	0.59
95% CI LB	0.389	0.525	0.697	0.299	0.758	0.315	0.443	0.439	0.353	0.437
95% CI UB	0.618	0.756	1.12	0.407	1.11	0.456	0.612	0.604	0.509	0.75
N	51	56	42	56	44	56	55	54	42	35
% < MDL	19.6	7.1	11.9	16.1	0	19.6	10.9	9.3	16.7	22.9
Max	1.7	2.1	2.9	0.9	2.3	1.1	1.3	1.5	1	1.7
MATES III										
Average	0.269	0.356	0.436	0.243	0.363	0.265	0.274	0.266	0.24	0.283
95% CI LB	0.248	0.325	0.389	0.23	0.315	0.249	0.257	0.243	0.229	0.26
95% CI UB	0.292	0.391	0.488	0.256	0.415	0.283	0.294	0.291	0.253	0.307
N	233	241	237	232	100	238	238	121	234	235
% < MDL	73	49	45.6	65.9	40	69.7	58	60.3	72.6	68.1
Max	1.69	1.45	2.26	0.82	1.32	0.83	0.94	0.965	1.1	1.28
MATES IV										
Average	0.131	0.174	0.203	0.101	0.238	0.101	0.505	0.114	0.13	0.133
95% CI LB	0.0989	0.136	0.144	0.0877	0.168	0.0844	0.384	0.0966	0.109	0.101
95% CI UB	0.173	0.217	0.273	0.116	0.333	0.121	0.656	0.135	0.153	0.171
N	51	55	57	53	53	54	53	57	52	57
% < MDL	51	18.2	36.8	35.8	15.1	48.1	1.9	33.3	28.8	49.1
Max	0.79	0.72	1.01	0.3	2.03	0.34	3.17	0.34	0.35	0.86
MATES V										
Average		0.083	0.176	0.117	0.142	0.109	0.187	0.111	0.123	0.127
95% CI LB		0.0742	0.136	0.102	0.115	0.083	0.132	0.0908	0.103	0.1
95% CI UB		0.0927	0.218	0.134	0.172	0.139	0.264	0.134	0.15	0.159
N	0	57	58	58	57	56	54	50	57	55
% < MDL		1.8	0	0	0	0	0	0	0	0
Max		0.2	0.81	0.43	0.5	0.55	1.81	0.38	0.63	0.62

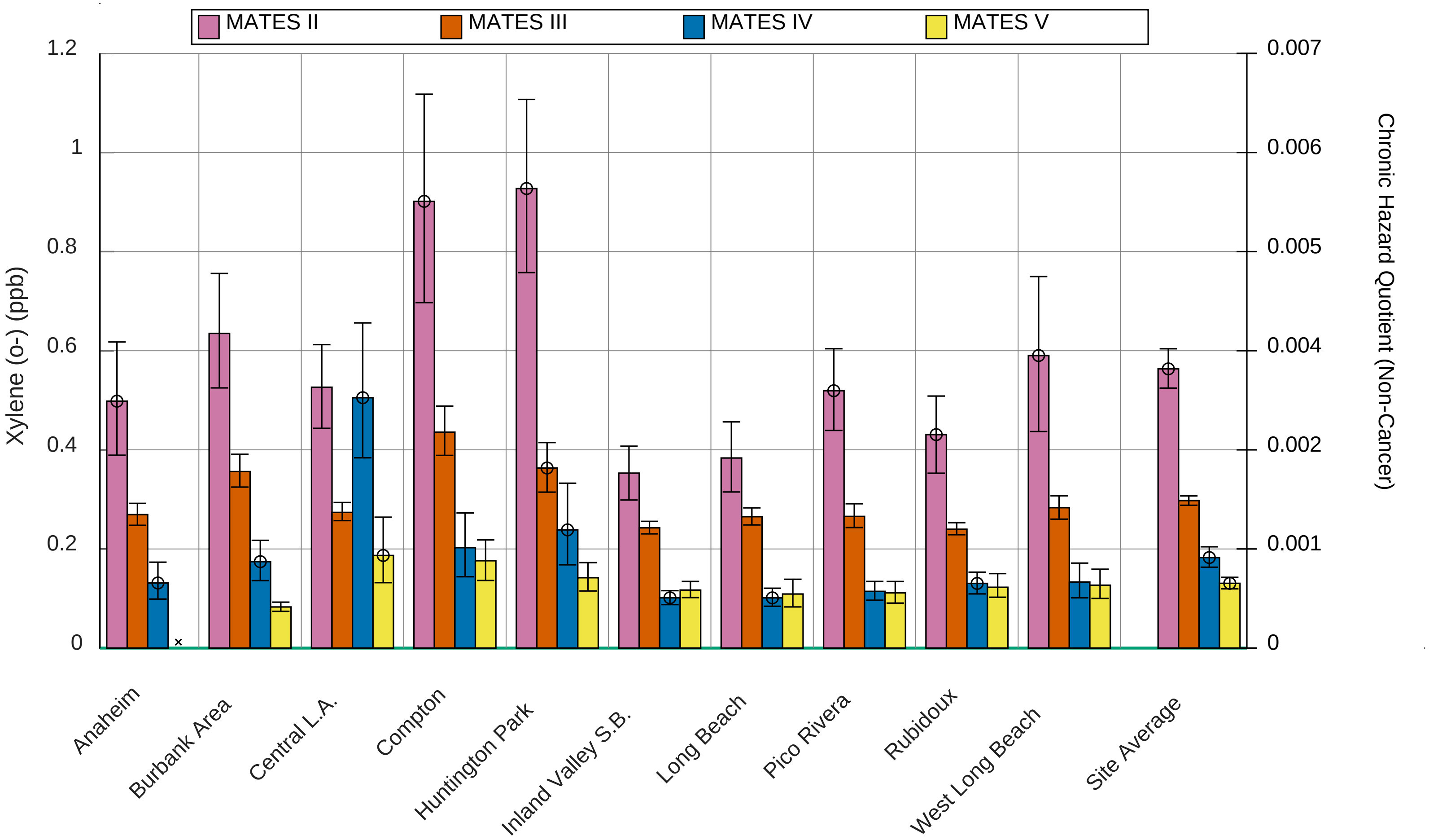


Figure IV-61. Annual Average Concentrations of Xylene (o-) in the VOCs Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

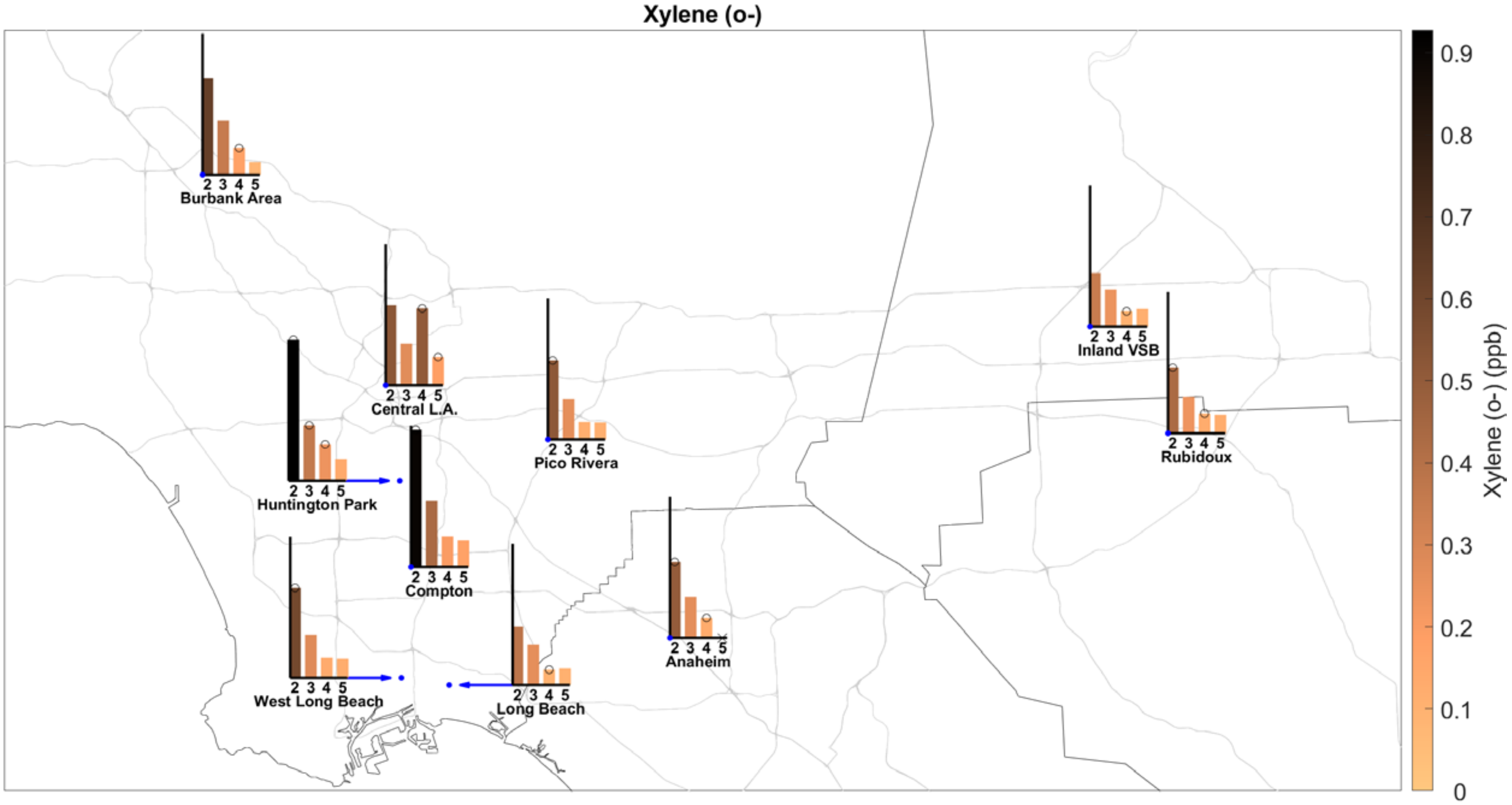


Figure IV-62. Geographic distribution of Xylene (o-) from the VOCs Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

TSP Hexavalent Chromium Analysis

Hexavalent Chromium

Table IV-34. Ambient Concentrations (ng/m^3) of Hexavalent Chromium from the TSP Hexavalent Chromium analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.174	0.209	0.244	0.148	0.219	0.16	0.156	0.135	0.255	0.182
95% CI LB	0.135	0.166	0.188	0.127	0.171	0.136	0.131	0.111	0.207	0.145
95% CI UB	0.217	0.257	0.304	0.171	0.271	0.186	0.185	0.162	0.306	0.227
N	51	52	40	53	48	58	55	51	48	41
% < MDL	54.9	51.9	42.5	66	52.1	63.8	67.3	64.7	39.6	43.9
Max	0.7	0.6	1.1	0.44	0.82	0.39	0.41	0.41	0.8	0.71
MATES III										
Average	0.14	0.157	0.251	0.187	0.188	0.155	0.164	0.158	0.403	0.208
95% CI LB	0.127	0.144	0.22	0.172	0.16	0.14	0.15	0.14	0.338	0.185
95% CI UB	0.153	0.171	0.286	0.203	0.218	0.172	0.177	0.178	0.474	0.233
N	238	237	231	230	118	237	240	121	234	232
% < MDL	17.2	15.6	9.1	7	8.5	13.5	10	7.4	13.2	14.2
Max	0.68	0.75	1.77	0.69	0.91	1.07	0.79	0.69	3.55	1.16
MATES IV										
Average	0.0266	0.0398	0.112	0.0443	0.105	0.0434	0.0686	0.049	0.0409	0.0338
95% CI LB	0.022	0.0319	0.0814	0.0373	0.0606	0.034	0.0538	0.0408	0.0324	0.0278
95% CI UB	0.0316	0.0492	0.154	0.0519	0.178	0.054	0.0864	0.0585	0.0513	0.0408
N	60	57	60	58	55	60	59	61	59	58
% < MDL	1.7	0	0	1.7	0	1.7	0	0	1.7	1.7
Max	0.09	0.19	0.85	0.12	1.8	0.2	0.39	0.17	0.25	0.14
MATES V										
Average	0.038	0.0322	0.0607	0.0385	0.0567	0.0336	0.0434	0.0349	0.0264	0.0346
95% CI LB	0.0312	0.0281	0.0533	0.0341	0.0462	0.0286	0.0375	0.0313	0.0235	0.0299
95% CI UB	0.0468	0.0367	0.0683	0.0432	0.0689	0.0392	0.0499	0.0389	0.0297	0.0397
N	60	58	60	59	61	59	59	61	59	59
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	0.24	0.1	0.16	0.1	0.24	0.13	0.16	0.09	0.06	0.11

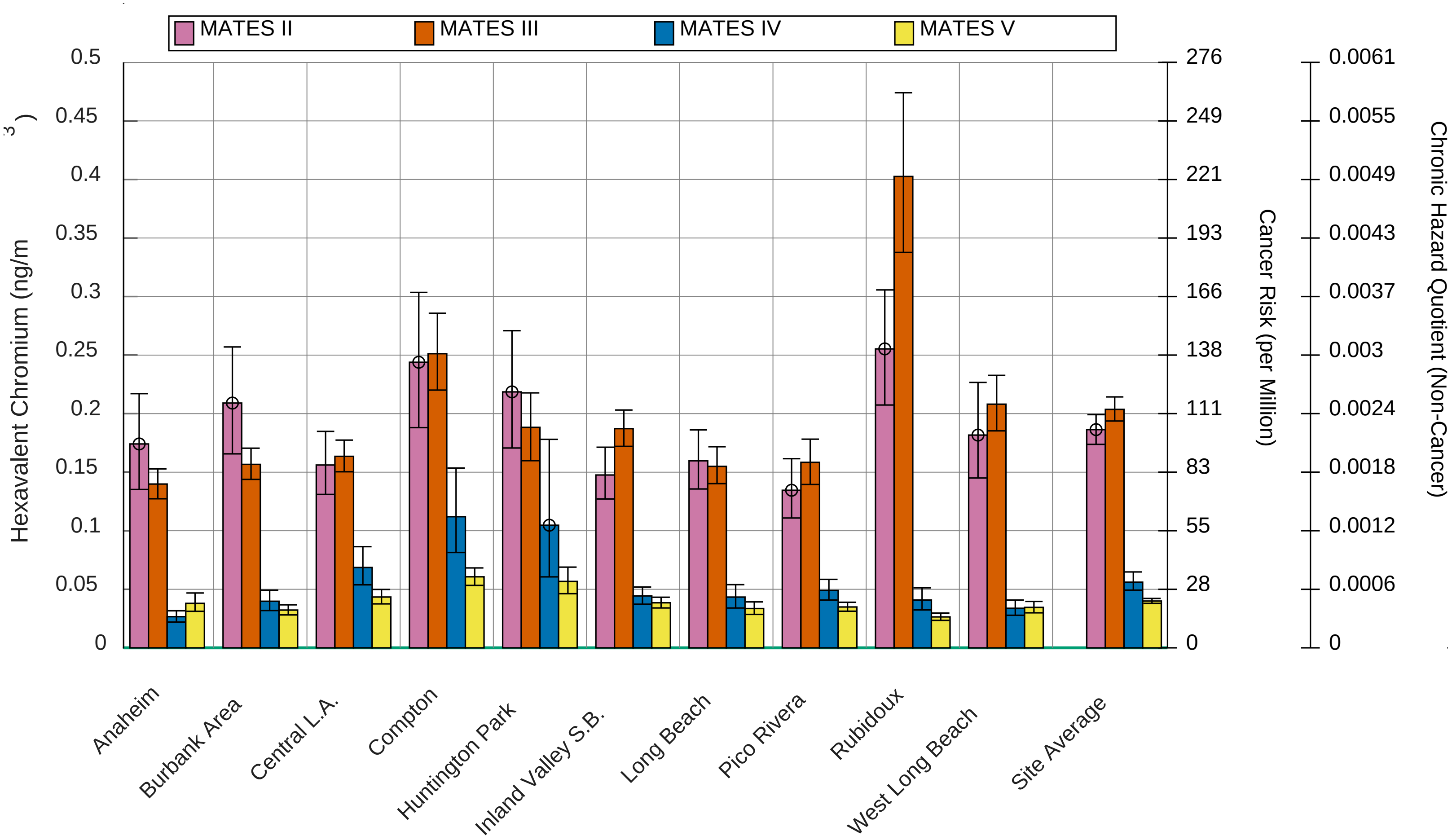


Figure IV-63. Annual Average Concentrations of Hexavalent Chromium in the TSP Hexavalent Chromium Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the 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.

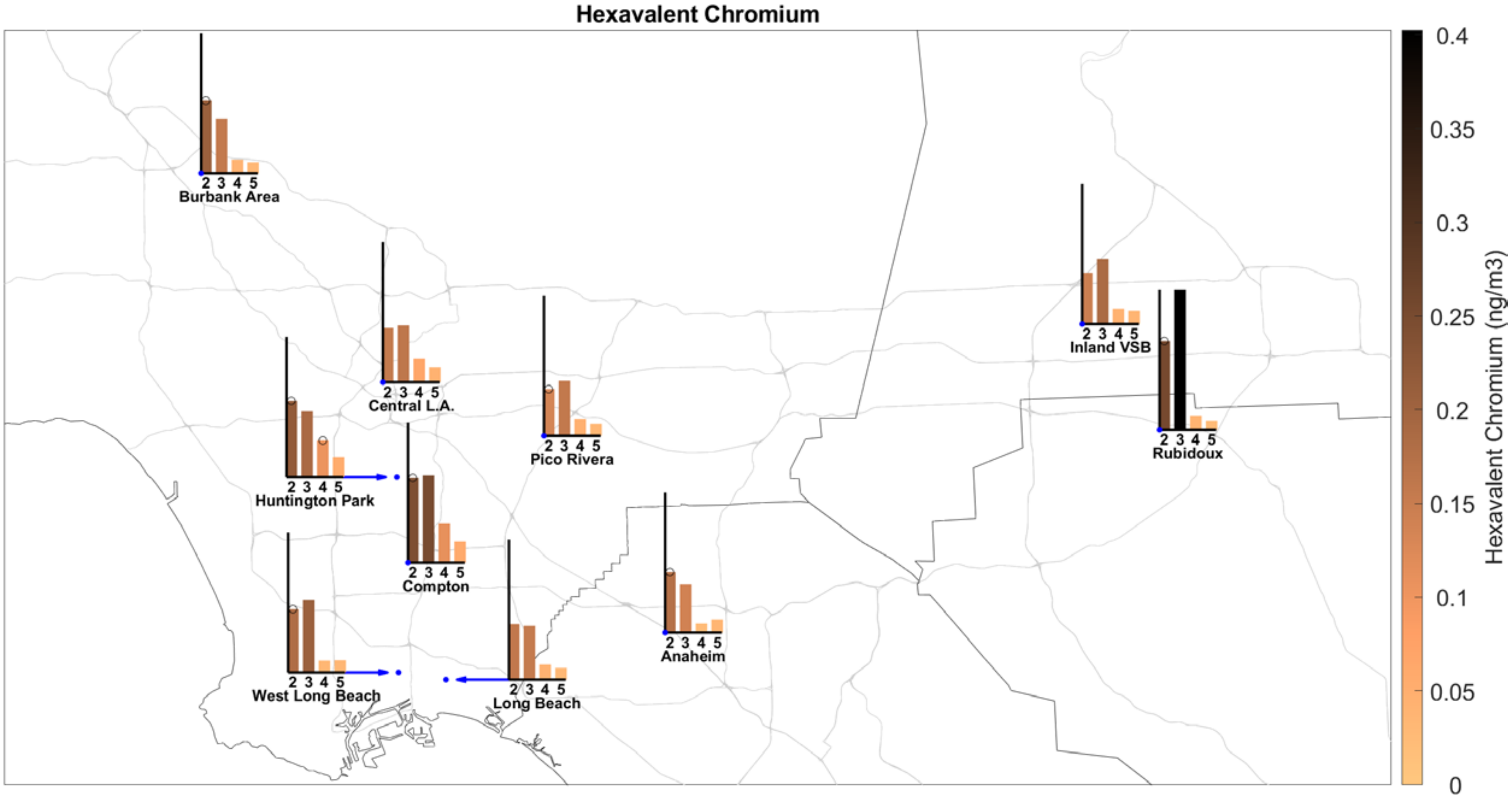


Figure IV-64. Geographic distribution of Hexavalent Chromium from the TSP Hexavalent Chromium Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

TSP Metals Analysis

Aluminum

Table IV-35. Ambient Concentrations (ng/m^3) of Aluminum from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1280	1160	1420	1800	1130	937	1020	1090	2330	1290
95% CI LB	1020	988	1110	1460	961	776	839	899	1990	1080
95% CI UB	1570	1340	1740	2170	1330	1110	1200	1270	2680	1550
N	45	47	39	41	42	56	51	41	41	39
% < MDL	4.4	4.3	7.7	7.3	4.8	7.1	9.8	9.8	2.4	2.6
Max	4160	2960	4480	4930	3170	2840	3030	2620	5670	3580
MATES III										
Average	3060	3340	3530	5770	3020	3160	3460	3230	7180	4110
95% CI LB	2800	3100	3280	5330	2720	2940	3250	2930	6710	3770
95% CI UB	3330	3590	3800	6220	3380	3380	3670	3580	7670	4440
N	232	218	228	224	116	230	229	118	237	227
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	11800	13100	10700	17200	13700	11600	8210	14900	18000	14600
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

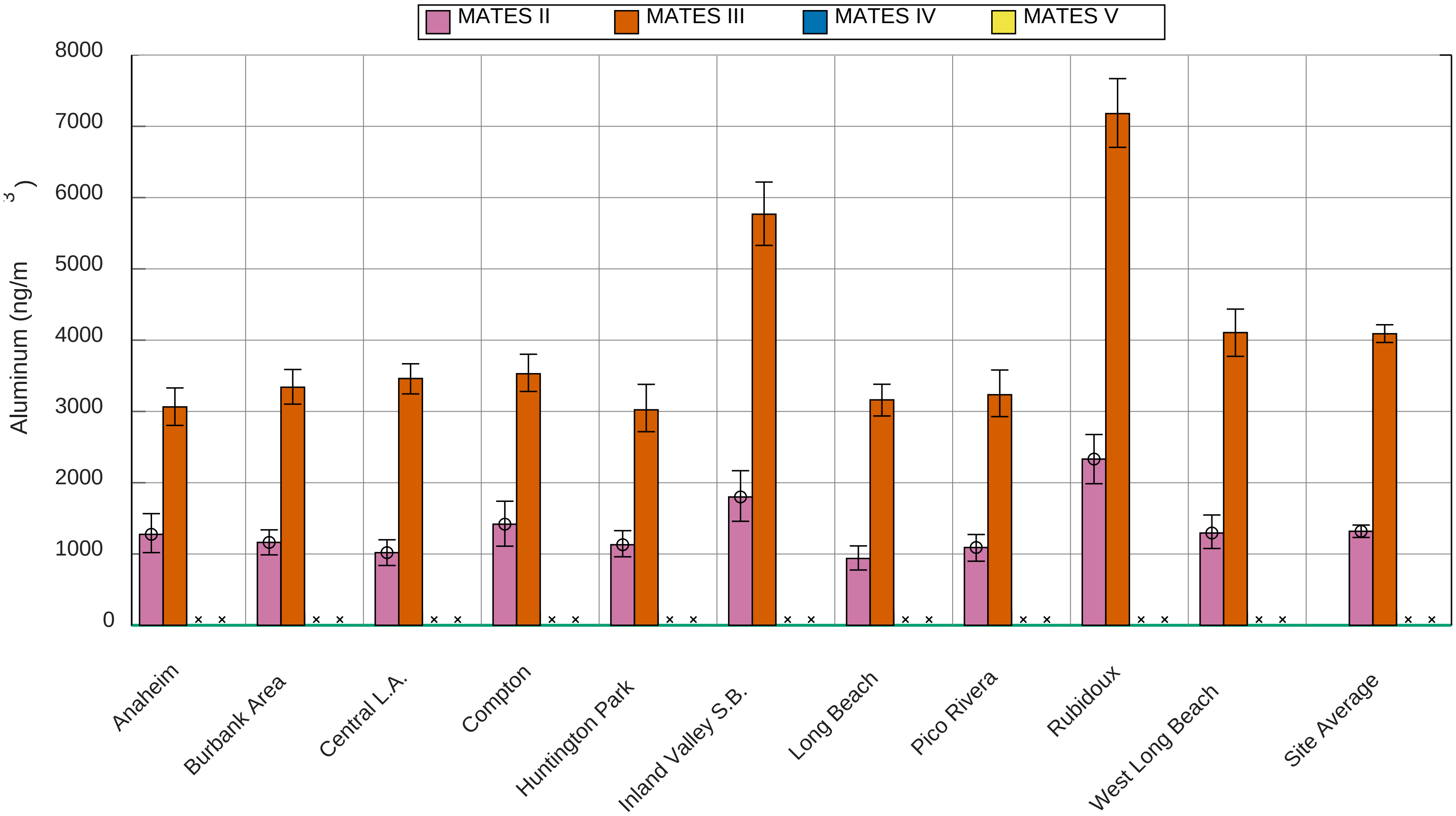


Figure IV-65. Annual Average Concentrations of Aluminum in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

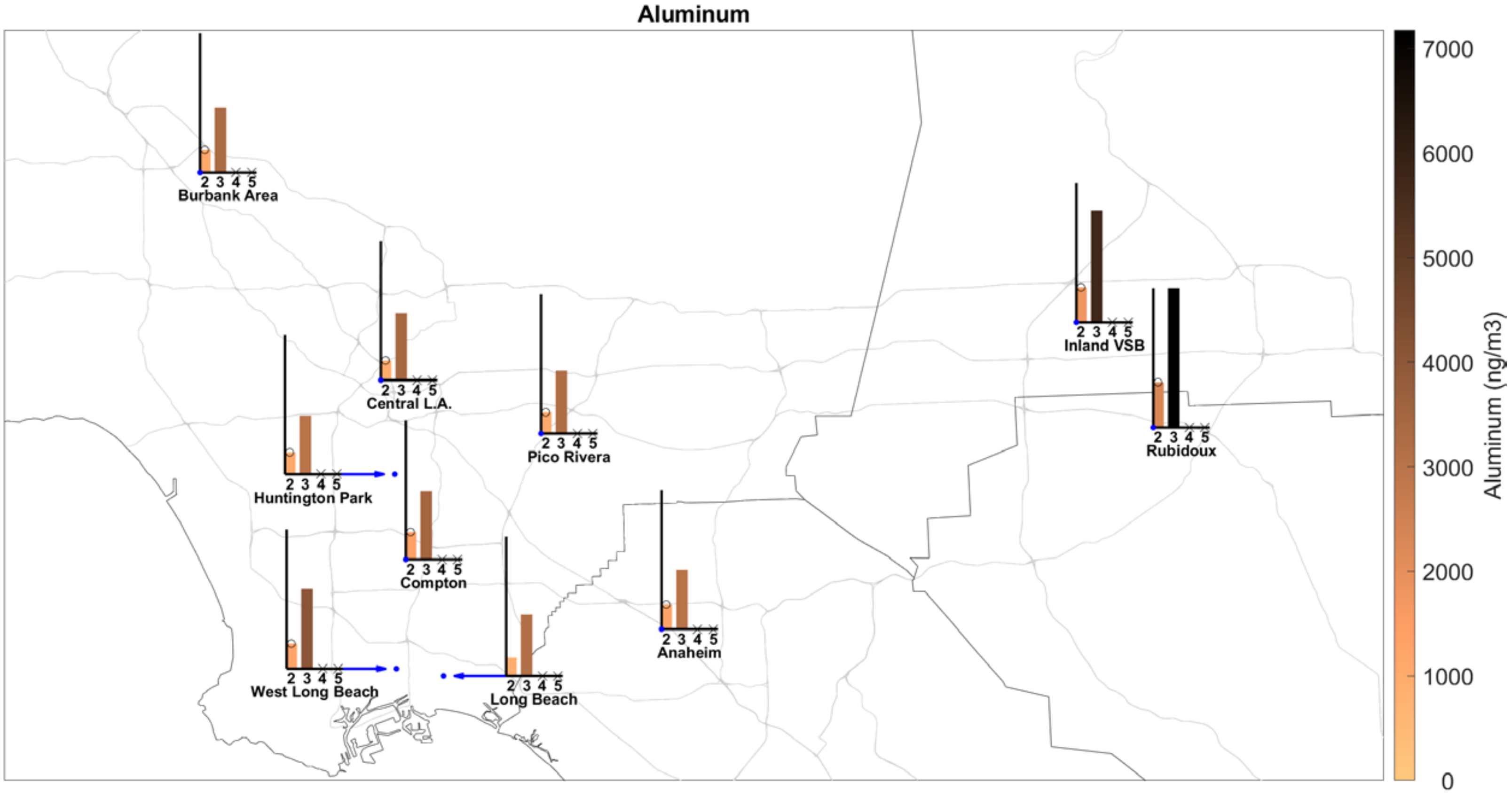


Figure IV-66. Geographic distribution of Aluminum from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Antimony

Table IV-36. Ambient Concentrations (ng/m^3) of Antimony from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.978, 13.5[a]	6.74	1.67, 12.6[a]	0.366, 12.7[a]	1.21, 13.2[a]	0.339, 12.2[a]	1.53, 12.2[a]	34.5	0.415, 12.8[a]	6.9
95% CI LB	0.2[a]	6.58	0.59[a]	0[a]	0.31[a]	0[a]	0.706[a]	15	0[a]	6.38
95% CI UB	15.2[a]	13.8	14.5[a]	14.6[a]	15[a]	13.7[a]	13.9[a]	70.2	14.6[a]	14.6
N	45[a]	47	39[a]	41[a]	42[a]	56[a]	51[a]	41	41[a]	39
% < MDL	88.9[a]	78.7	82.1[a]	95.1[a]	85.7[a]	96.4[a]	80.4[a]	78	95.1[a]	79.5
Max	15[a]	10	16[a]	8[a]	13[a]	10[a]	13[a]	547	11[a]	12
MATES III										
Average	1.35, 3.03[a]	4.18	1.14, 2.82[a]	0.58, 2.39[a]	1.1, 2.72[a]	1.05, 2.74[a]	3.54	3.16	0.687, 2.44[a]	0.653, 2.4[a]
95% CI LB	0.835[a]	3.69	0.752[a]	0.23[a]	0.646[a]	0.686[a]	3.19	2.77	0.336[a]	0.411[a]
95% CI UB	3.64[a]	4.7	3.19[a]	2.9[a]	3.12[a]	3.07[a]	3.88	3.57	2.87[a]	2.63[a]
N	232[a]	218	228[a]	224[a]	116[a]	230[a]	229	118	237[a]	227[a]
% < MDL	84.1[a]	59.6	83.8[a]	90.6[a]	81[a]	84.3[a]	67.2	66.9	87.8[a]	87.2[a]
Max	53.7[a]	20.4	31.9[a]	53[a]	15.2[a]	16.8[a]	17.7	11.5	46.5[a]	17.2[a]
MATES IV										
Average	2.45	5.07	3.97	4.5	4.95	3.28	6.06	6.09	3.98	2.76
95% CI LB	1.92	4.16	3.11	3.99	4.01	2.55	5	5.08	3.24	2.19
95% CI UB	3.04	6.09	4.92	5.03	5.9	4.1	7.22	7.3	4.94	3.43
N	60	58	59	56	55	59	59	60	58	58
% < MDL	1.7	0	0	0	0	1.7	0	0	0	0
Max	11.4	21.4	13.9	9.01	16.6	11.8	19	30.4	23.7	11.4
MATES V										
Average	4.49	3.54	4.76	5.37	4.43	3.26	5.41	5.3	4.84	3.48
95% CI LB	3.43	3.06	3.67	4.65	3.38	2.47	4.57	4.42	4.09	2.64
95% CI UB	5.71	4.06	5.93	6.13	5.5	4.14	6.29	6.29	5.66	4.43
N	61	58	61	59	61	60	60	60	60	59
% < MDL	0	0	0	0	11.5	0	1.7	0	0	0
Max	23.1	7.95	20.2	15.4	16.7	13	15.5	16.9	14.2	16.4

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

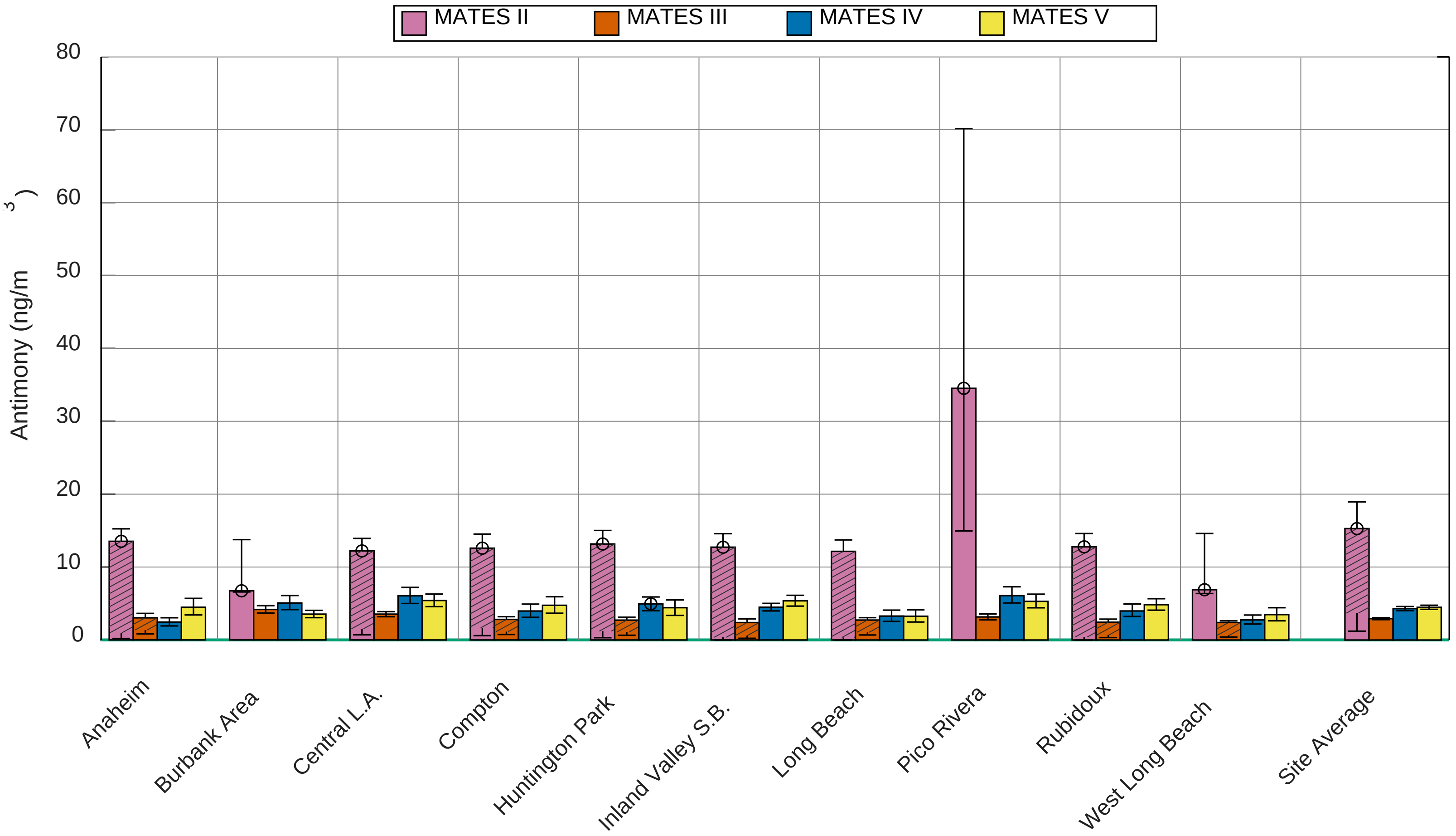


Figure IV-67. Annual Average Concentrations of Antimony in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

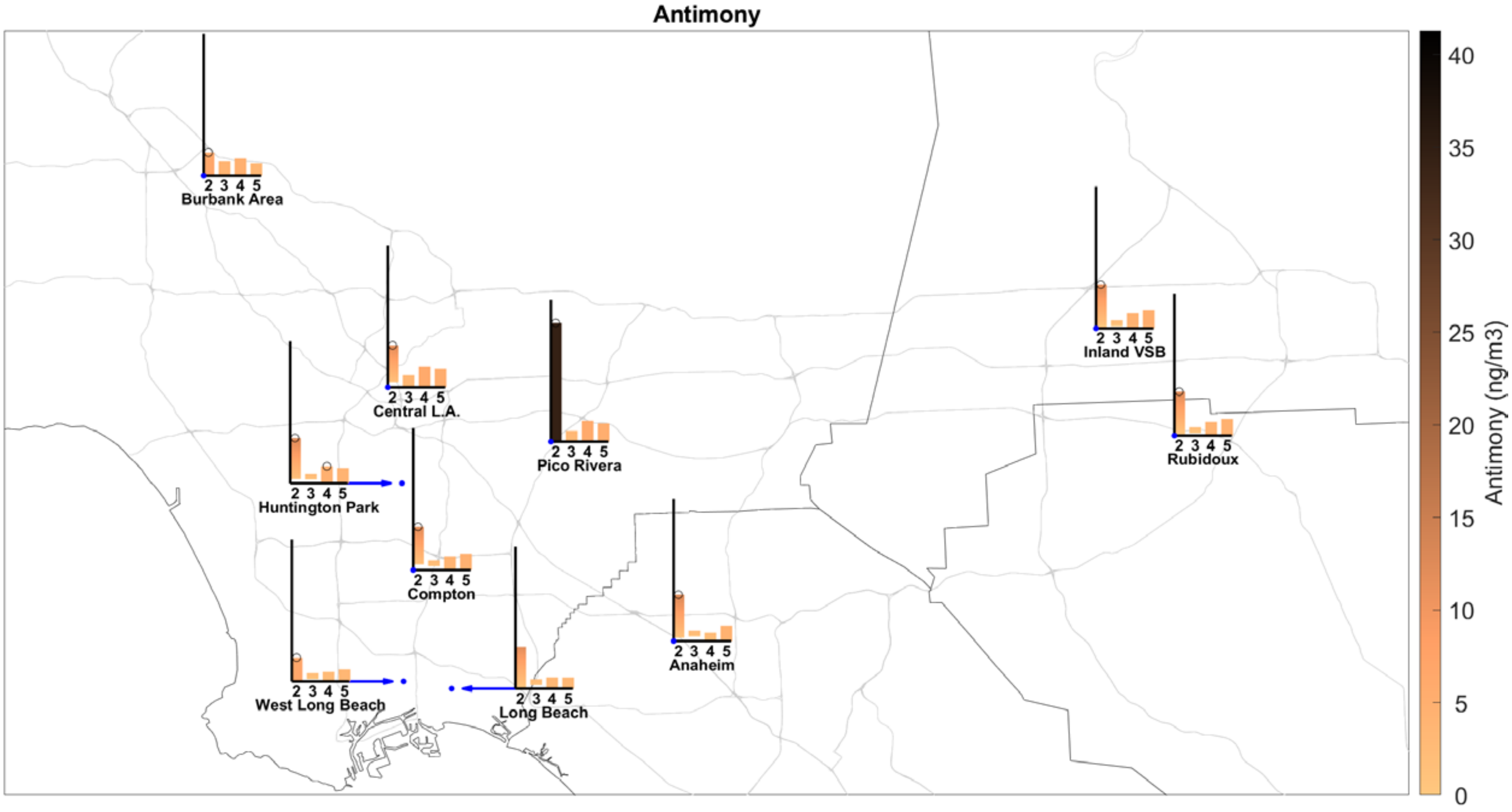


Figure IV-68. Geographic distribution of Antimony from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Arsenic

Table IV-37. Ambient Concentrations (ng/m^3) of Arsenic from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 3.56[a]	0, 3.43[a]	0.308, 3.54[a]	0.293, 3.59[a]	0.238, 3.55[a]	0, 3.46[a]	0, 3.45[a]	0.0732, 3.63[a]	0.171, 3.54[a]	0, 3.49[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	3.69[a]	3.57[a]	3.69[a]	3.76[a]	3.69[a]	3.59[a]	3.59[a]	3.78[a]	3.68[a]	3.64[a]
N	45[a]	47[a]	39[a]	41[a]	42[a]	56[a]	51[a]	41[a]	41[a]	39[a]
% < MDL	100[a]	100[a]	92.3[a]	92.7[a]	92.9[a]	100[a]	100[a]	97.6[a]	95.1[a]	100[a]
Max	< MDL[a]	< MDL[a]	4[a]	5[a]	4[a]	< MDL[a]	< MDL[a]	3[a]	4[a]	< MDL[a]
MATES III										
Average	0.212, 1.06[a]	1.16	1.17	1.22	1.42	1.13	1.2	1.36	1.16	1.15
95% CI LB	0.149[a]	1.12	1.11	1.15	1.26	1.08	1.13	1.24	1.11	1.1
95% CI UB	1.08[a]	1.2	1.24	1.3	1.62	1.18	1.26	1.51	1.21	1.22
N	232[a]	218	228	224	116	230	229	118	237	227
% < MDL	84.5[a]	68.8	73.7	67.9	61.2	77	71.2	66.1	71.3	72.7
Max	2.31[a]	3.43	5.77	7.23	6.47	4.2	4.95	4.97	4.3	4.98
MATES IV										
Average	0.238	0.447	0.502	0.909	0.557	0.396	0.637	0.566	0.757	0.497
95% CI LB	0.207	0.393	0.418	0.794	0.467	0.338	0.538	0.503	0.6	0.418
95% CI UB	0.271	0.502	0.596	1.03	0.653	0.458	0.745	0.629	0.993	0.583
N	60	58	59	56	55	59	59	60	58	58
% < MDL	16.7	3.4	5.1	0	0	5.1	0	3.3	0	3.4
Max	0.52	0.96	2.08	2.35	1.67	1.02	2.1	1.19	6.33	1.46
MATES V										
Average	0.36	0.459	0.441	0.885	0.413	0.376	0.412	0.663	0.663	0.466
95% CI LB	0.311	0.396	0.365	0.745	0.342	0.311	0.356	0.571	0.578	0.388
95% CI UB	0.414	0.524	0.528	1.04	0.489	0.452	0.477	0.759	0.743	0.561
N	61	58	61	59	61	60	60	60	60	59
% < MDL	1.6	0	0	0	14.8	0	1.7	0	0	0
Max	1.03	1.13	1.58	3.16	1.12	1.64	1.58	1.51	1.46	2.12

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

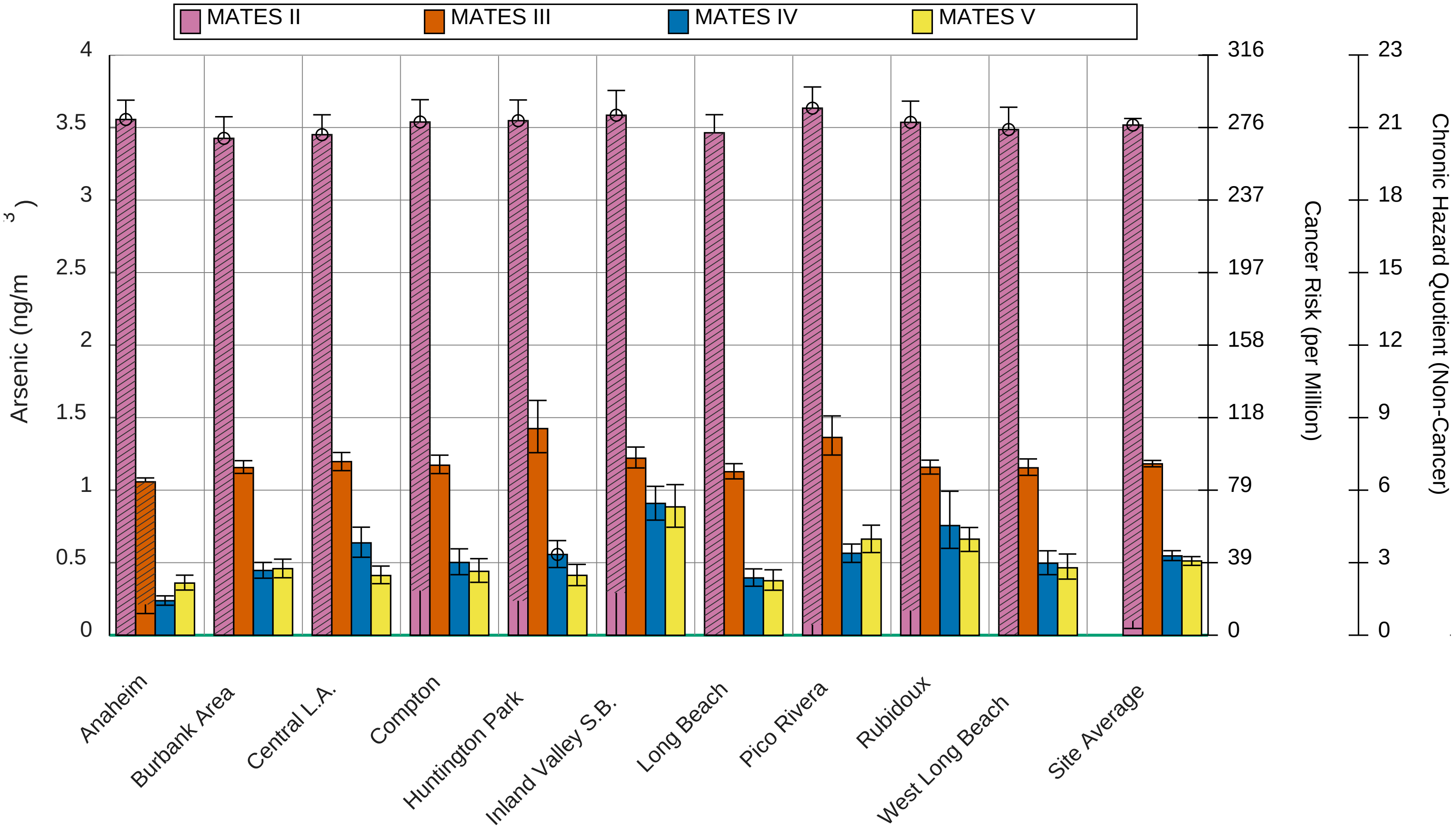


Figure IV-69. Annual Average Concentrations of Arsenic in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

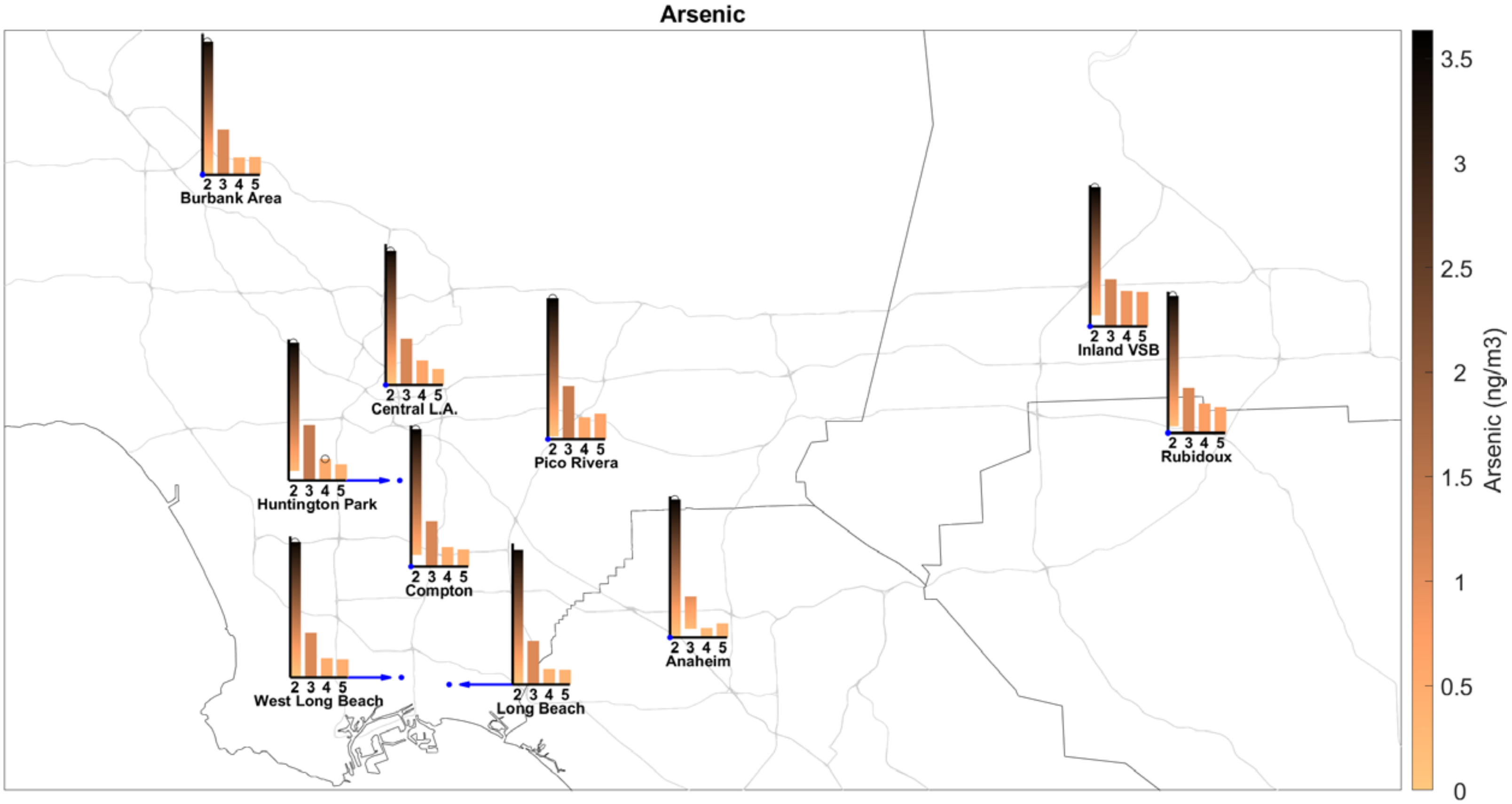


Figure IV-70. Geographic distribution of Arsenic from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

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), see Figure IV-71. 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.

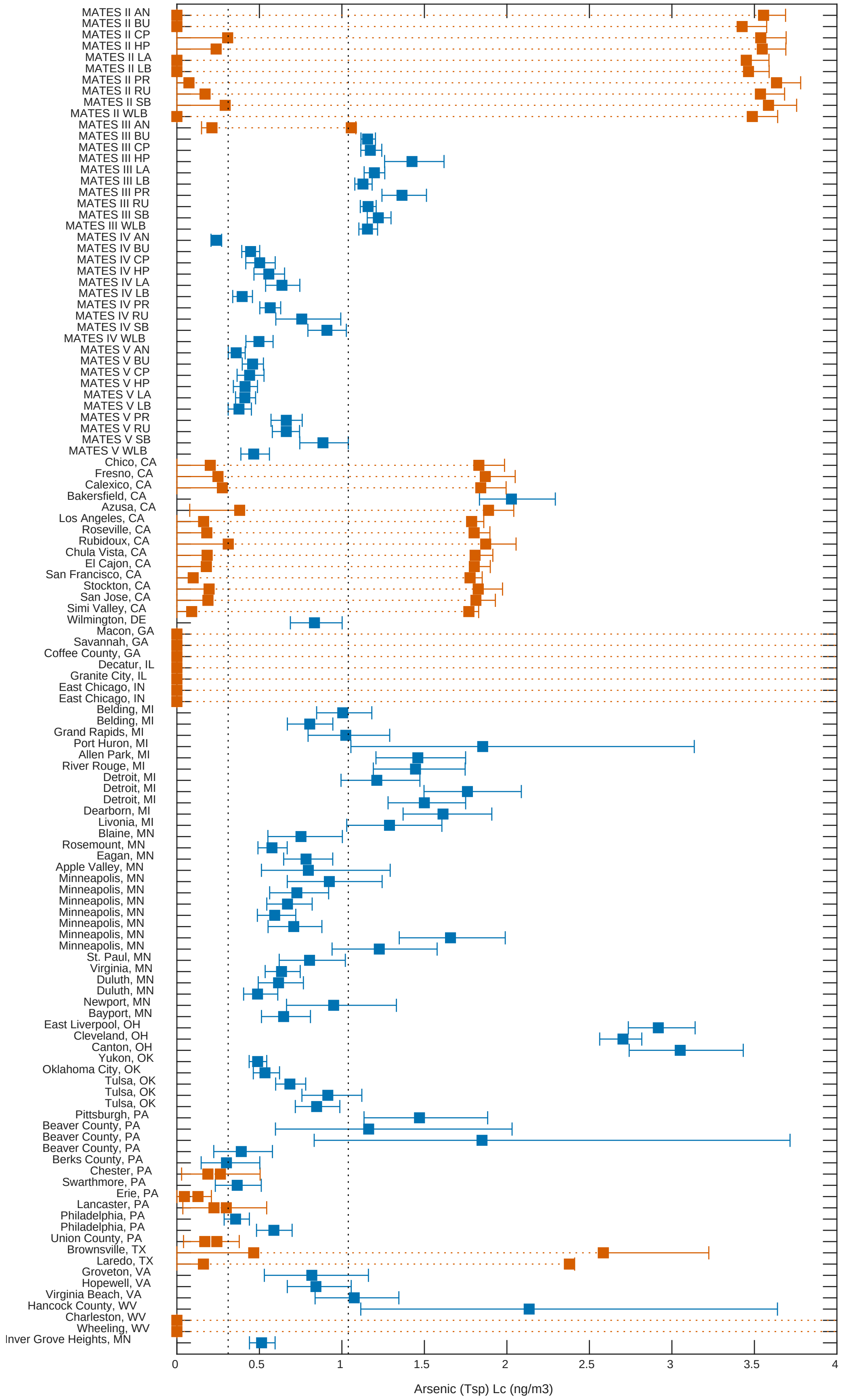


Figure IV-71. Comparison of MATES TSP Arsenic data with TSP Arsenic data from the Ambient Monitoring Archive (AMA) for 2017 (https://www3.epa.gov/ttn/amtic/toxdat.html#data). The 2-letter abbreviations for the MATES stations are the same as those shown in Table IV-1. For the AMA data, the city or county is followed by the 2-letter state abbreviation. Blue data are the KM mean and corresponding error bars. The red-orange data have more than 80% below detection limit. For these data, the zero-substituted mean with its lower bound bootstrap 95% confidence interval, a dotted line between the zero-substituted mean and the MDL-substituted mean, and then the upper 95% confidence interval corresponding to the MDL substituted mean are shown. Note that some of the upper-bound estimates go well off the right-side of the plot. Vertical dotted lines mark the minimum and maximum 95% confidence intervals for TSP arsenic KM means from MATES V.

Barium

Table IV-38. Ambient Concentrations (ng/m^3) of Barium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	55.8	55	65.8	56.1	89.8	42.3	59.2	52.1	56.7	54.5
95% CI LB	42.3	46.1	51.3	45.5	58.7	35.1	50	39.5	46.3	43.9
95% CI UB	72.6	65.3	81.6	67.3	131	49.7	69.3	68.3	67.4	66.1
N	45	47	39	41	42	56	51	41	41	39
% < MDL	42.2	27.7	23.1	29.3	19	41.1	25.5	41.5	29.3	30.8
Max	237	161	212	176	602	127	197	286	152	170
MATES III										
Average	55	77	63.1	74.6	81.4	55.7	89	73.7	78.9	56.9
95% CI LB	49.3	70.8	57.4	63.3	72.9	51	82.4	66.4	70.3	51.6
95% CI UB	61.5	83.3	69.1	92.8	90.9	60.2	95.9	81.4	91.6	62.6
N	232	218	228	224	116	230	229	118	237	227
% < MDL	10.3	3.2	4.4	5.4	0.9	5.7	2.6	0.8	5.1	11
Max	457	366	268	1830	300	214	353	210	1280	218
MATES IV										
Average	29.4	57.3	46.3	69.7	55.6	43.4	67.1	61.1	58.5	57
95% CI LB	23.3	47.8	38.3	56.5	46.5	36.3	55.3	52.3	46.6	47.7
95% CI UB	36.6	68.1	54.1	85.5	66	51.3	79.8	70.7	73.6	67.6
N	60	58	59	56	55	59	59	60	58	58
% < MDL	1.7	0	0	0	0	0	0	0	0	0
Max	159	216	139	306	158	115	216	162	371	159
MATES V										
Average	48.6	46.4	57.7	75	50.7	40	60.6	67.9	60	54.6
95% CI LB	39.5	39.6	45.7	64.1	40.1	32.2	50.8	58.3	51.1	44.1
95% CI UB	59	52.9	71.1	86.2	61.5	49.8	71.1	78.1	69.9	66.5
N	55	51	54	55	56	55	53	55	53	54
% < MDL	0	0	0	0	1.8	0	1.9	0	0	0
Max	218	109	215	189	171	154	185	179	160	225

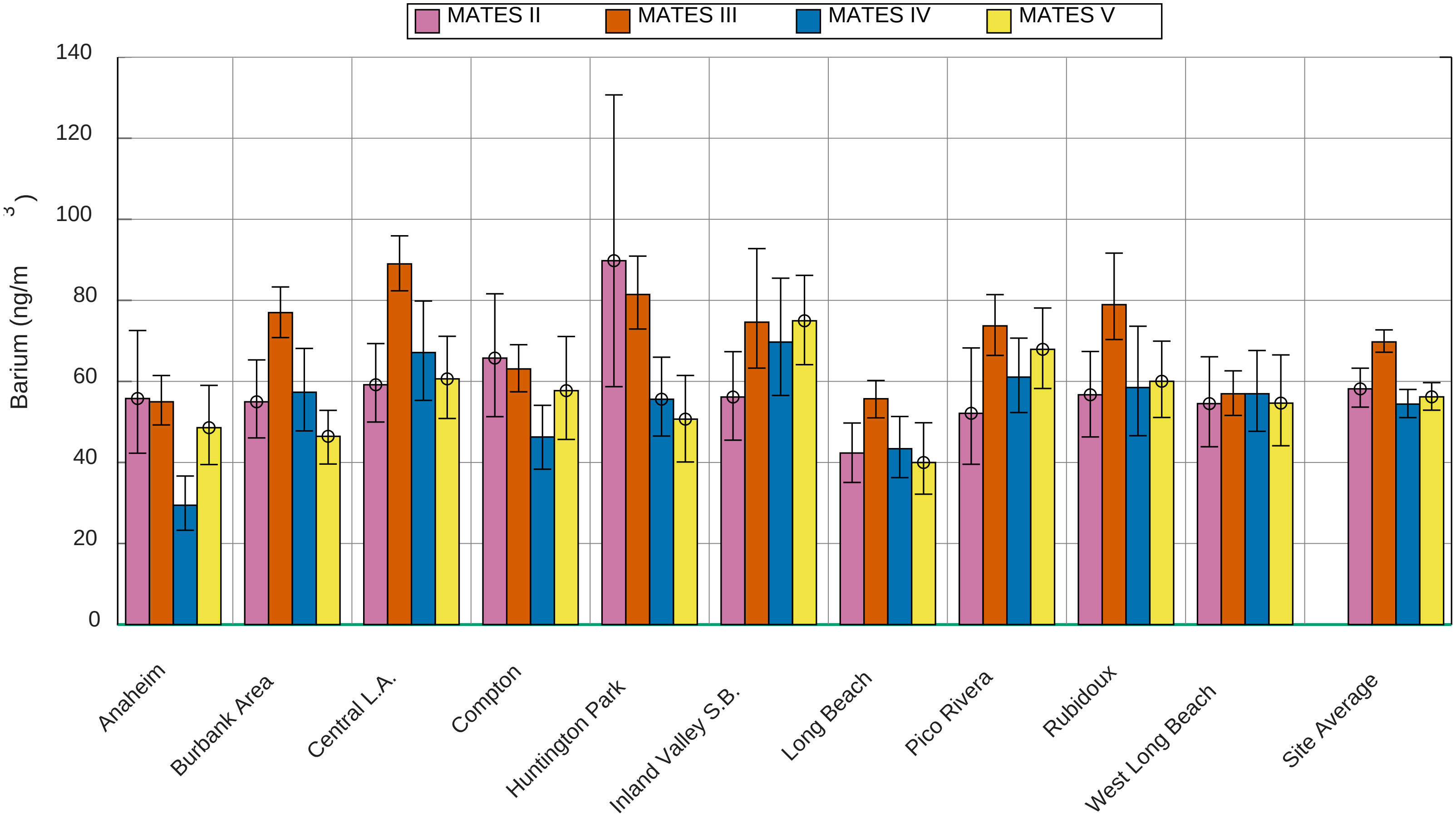


Figure IV-72. Annual Average Concentrations of Barium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

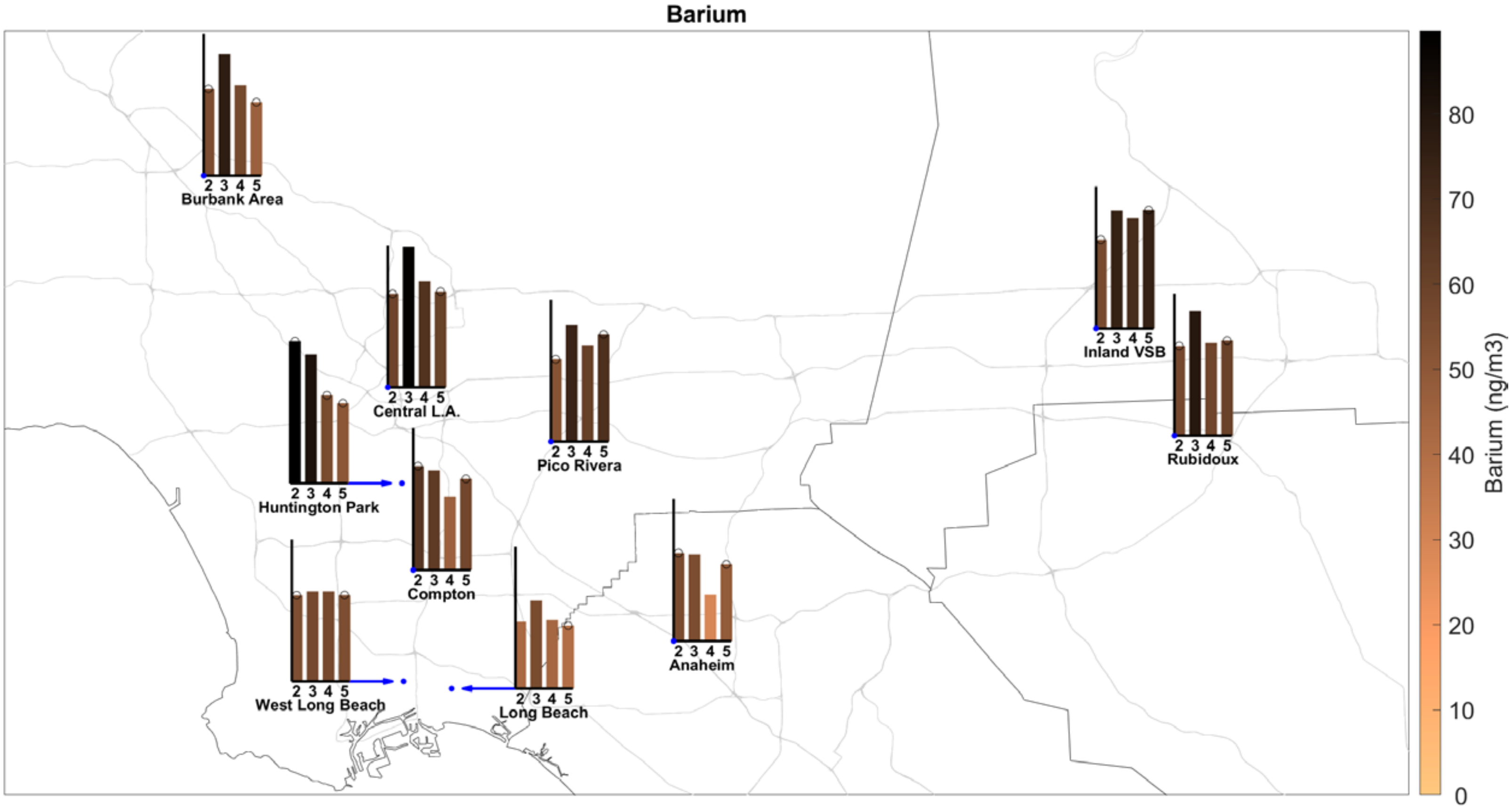


Figure IV-73. Geographic distribution of Barium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Beryllium

Table IV-39. Ambient Concentrations (ng/m^3) of Beryllium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	0.00633, 0.089[a]	0, 0.087[a]	0.00153, 0.0871[a]	0.005, 0.0874[a]	0, 0.087[a]	0, 0.087[a]	0, 0.087[a]	0, 0.087[a]	0.00397, 0.0895[a]	0.00155, 0.0871[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.0922[a]	0.087[a]	0.0872[a]	0.0879[a]	0.087[a]	0.087[a]	0.087[a]	0.087[a]	0.0944[a]	0.0872[a]
N	60[a]	58[a]	59[a]	56[a]	55[a]	59[a]	59[a]	60[a]	58[a]	58[a]
% < MDL	95[a]	100[a]	98.3[a]	94.6[a]	100[a]	100[a]	100[a]	100[a]	98.3[a]	98.3[a]
Max	0.15[a]	< MDL[a]	0.09[a]	0.1[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	0.23[a]	0.09[a]
MATES V										
Average	0.0077, 0.0411[a]	0.00931, 0.0417[a]	0.00705, 0.0431[a]	0.06	0.00328, 0.0407[a]	0.00483, 0.0422[a]	0.0045, 0.0412[a]	0.0483	0.0499	0.0105, 0.0431[a]
95% CI LB	0.00361[a]	0.00431[a]	0.00197[a]	0.0517	0.000656[a]	0.000667[a]	0.001[a]	0.0447	0.046	0.00458[a]
95% CI UB	0.0426[a]	0.044[a]	0.0469[a]	0.0695	0.042[a]	0.0465[a]	0.0428[a]	0.0527	0.0547	0.0478[a]
N	61[a]	58[a]	61[a]	59	61[a]	60[a]	60[a]	60	60	59[a]
% < MDL	83.6[a]	81[a]	90.2[a]	40.7	93.4[a]	93.3[a]	91.7[a]	58.3	46.7	81.4[a]
Max	0.07[a]	0.09[a]	0.13[a]	0.18	0.07[a]	0.15[a]	0.08[a]	0.11	0.14	0.15[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

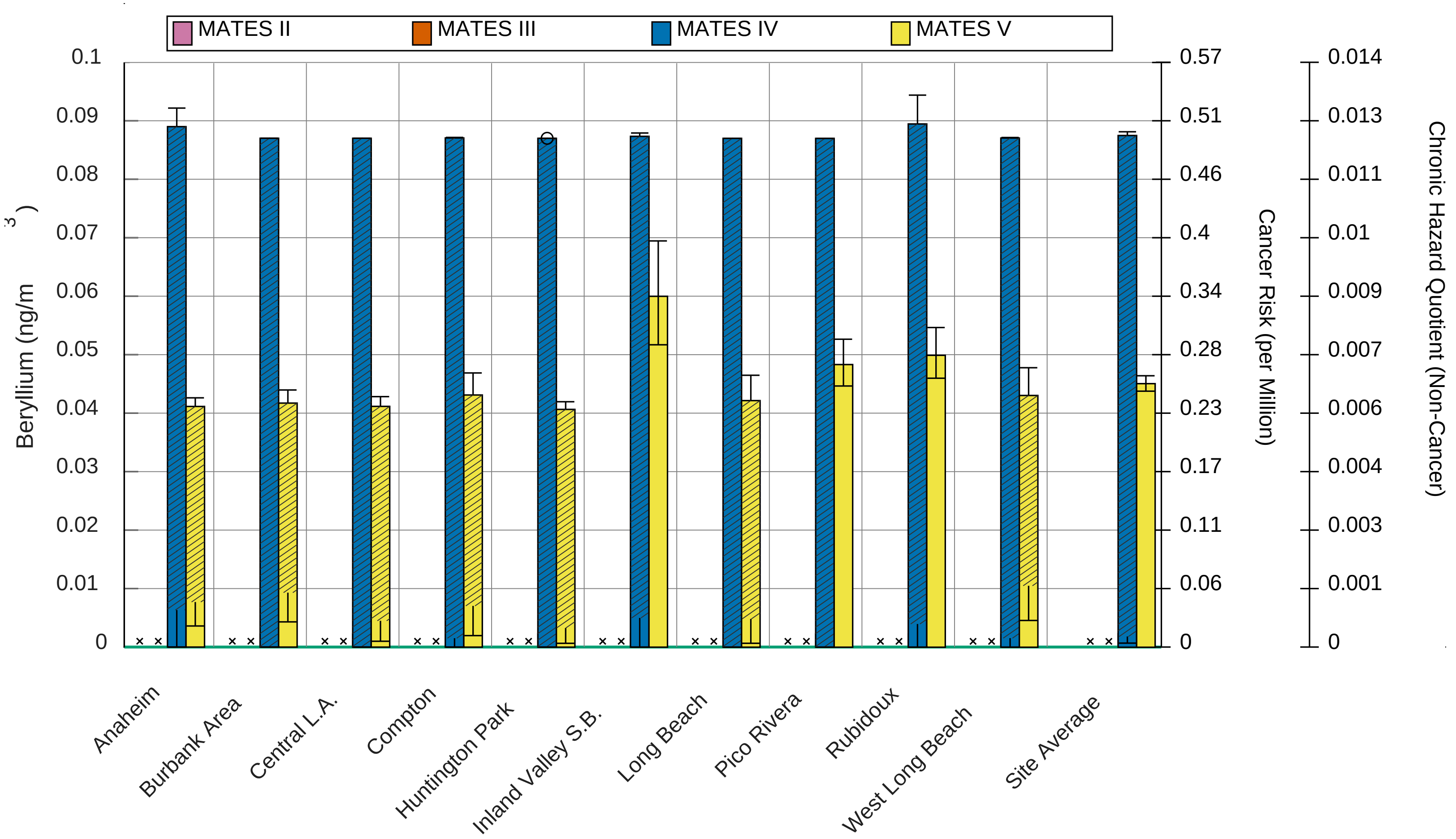


Figure IV-74. Annual Average Concentrations of Beryllium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

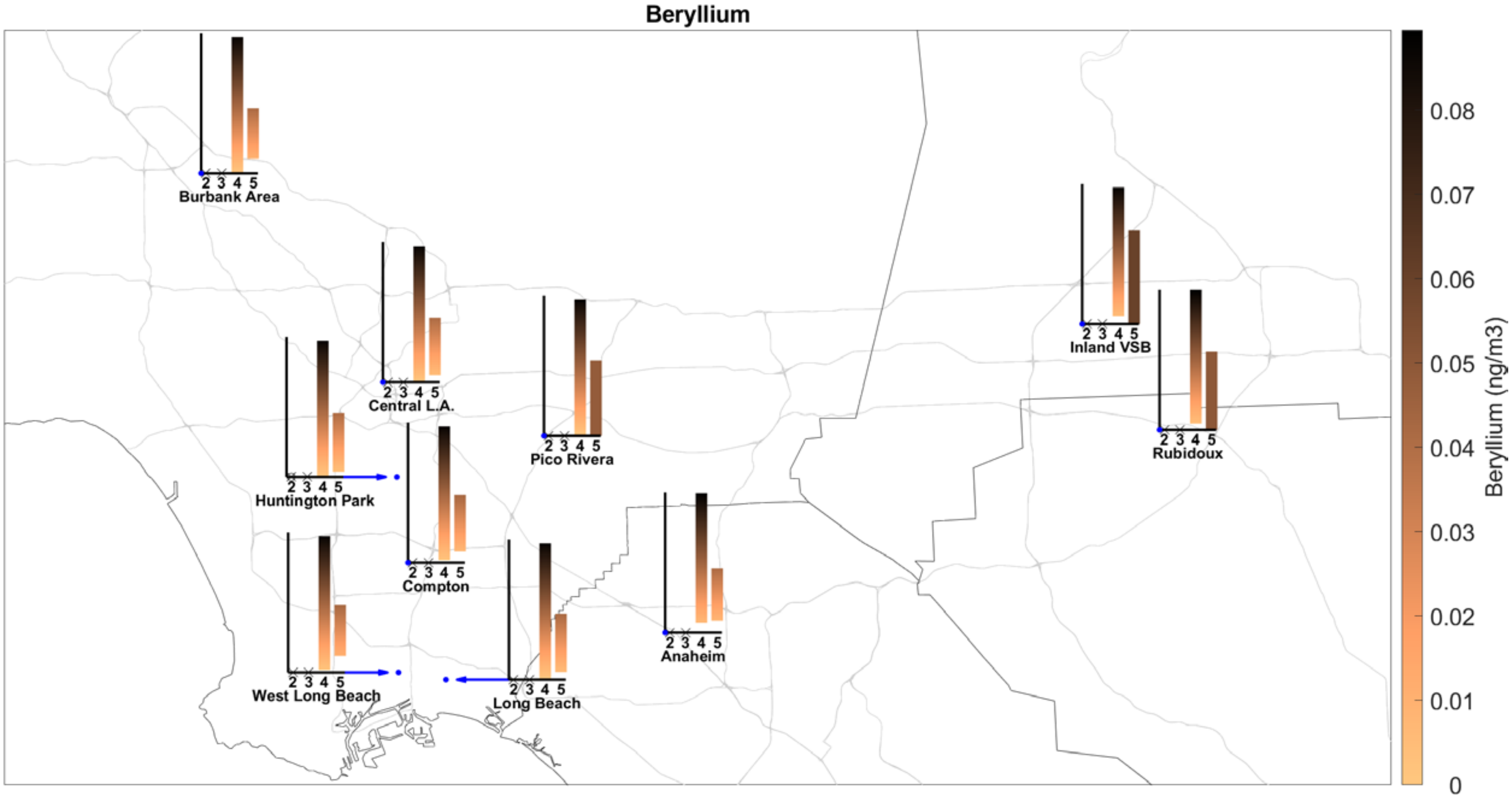


Figure IV-75. Geographic distribution of Beryllium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Bromine

Table IV-40. Ambient Concentrations (ng/m^3) of Bromine from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	11.7	10.4	12.5	10.3	13.8	12	10.7	11.3	13.2	13.3
95% CI LB	9.99	8.98	10.7	8.42	12	10.4	9.31	9.73	11	11.4
95% CI UB	13.6	12	14.4	12.1	15.5	13.7	12.2	12.9	15.3	15.1
N	45	47	39	41	42	56	51	41	41	39
% < MDL	2.2	0	0	4.9	0	0	3.9	2.4	4.9	0
Max	28	30.1	35.1	28.4	29	37.5	22.4	23.9	29.1	28.8
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

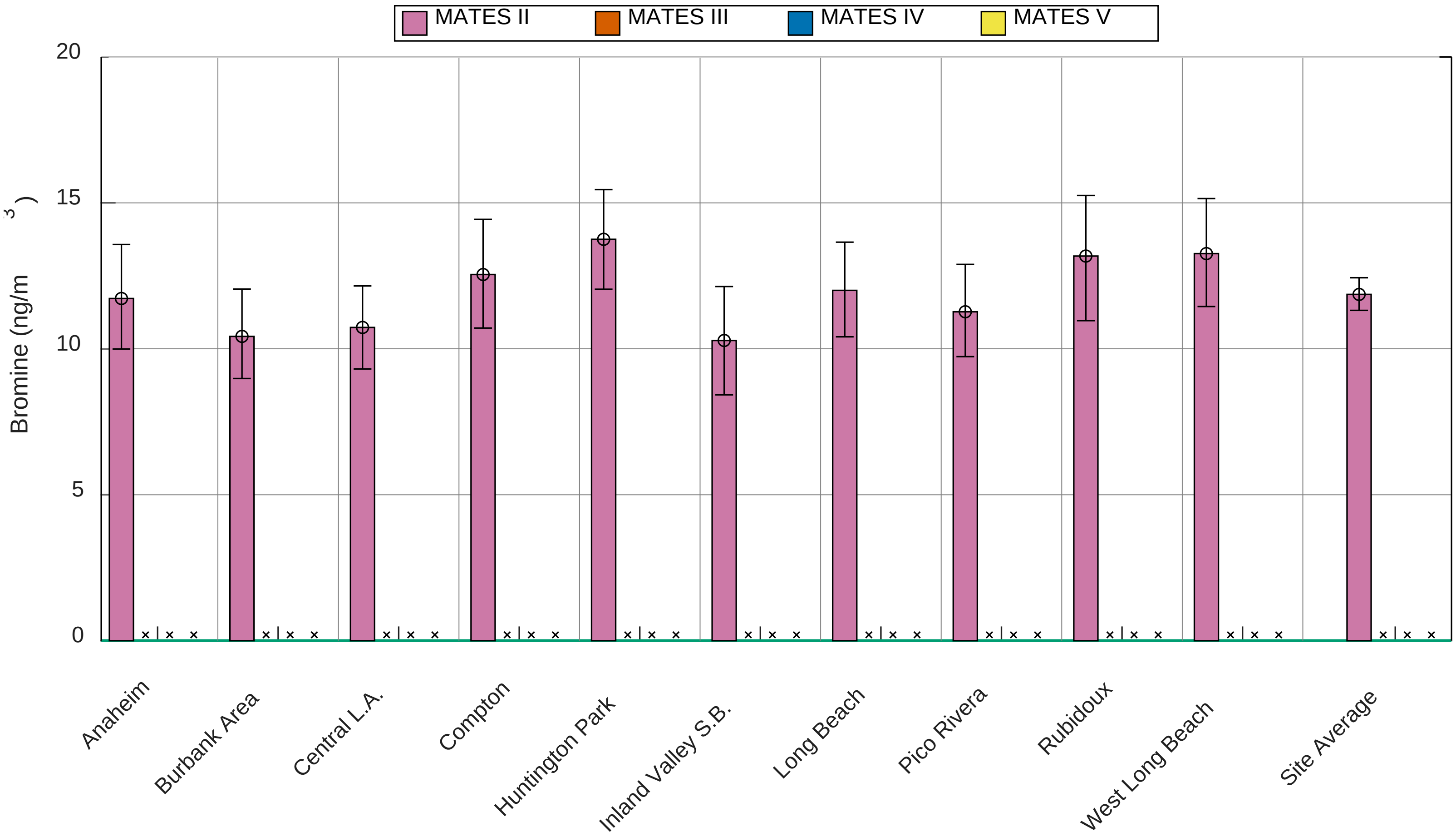


Figure IV-76. Annual Average Concentrations of Bromine in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

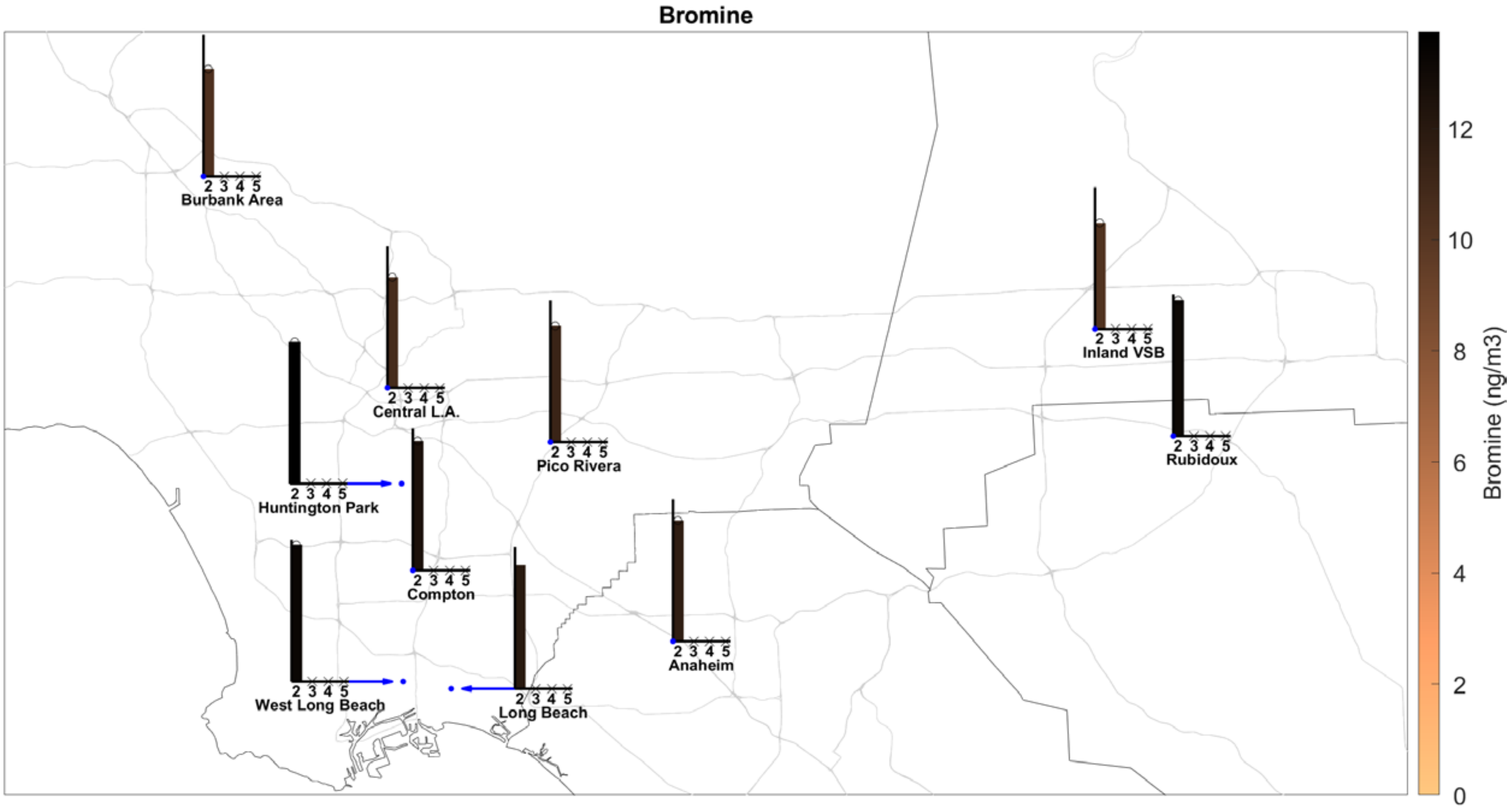


Figure IV-77. Geographic distribution of Bromine from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Cadmium

Table IV-41. Ambient Concentrations (ng/m^3) of Cadmium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 10[a]	9.64, 19.1[a]	0, 10[a]	0, 10[a]	0, 10[a]	0, 10[a]	0, 10[a]	2.01, 11.2[a]	0, 10[a]	0, 10[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	10[a]	37.4[a]	10[a]	10[a]	10[a]	10[a]	10[a]	13.3[a]	10[a]	10[a]
N	25[a]	20[a]	18[a]	21[a]	22[a]	26[a]	23[a]	26[a]	21[a]	19[a]
% < MDL	100[a]	95[a]	100[a]	100[a]	100[a]	100[a]	100[a]	92.3[a]	100[a]	100[a]
Max	< MDL[a]	193[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	31.7[a]	< MDL[a]	< MDL[a]
MATES III										
Average	0.595, 2.21[a]	0.821, 2.46[a]	0.555, 2.16[a]	2.27	2.24	0.531, 2.18[a]	0.542, 2.18[a]	0.614, 2.22[a]	2.11	2.22
95% CI LB	0.437[a]	0.49[a]	0.409[a]	2.15	2.15	0.384[a]	0.391[a]	0.387[a]	2.08	2.15
95% CI UB	2.28[a]	2.84[a]	2.22[a]	2.47	2.36	2.25[a]	2.25[a]	2.34[a]	2.15	2.3
N	232[a]	218[a]	228[a]	224	116	230[a]	229[a]	118[a]	237	227
% < MDL	80.6[a]	82.1[a]	80.3[a]	76.8	74.1	82.6[a]	82.1[a]	80.5[a]	78.9	77.5
Max	6.58[a]	28.1[a]	4.6[a]	17.5	5.71	5.45[a]	5.34[a]	6.53[a]	3.83	6.94
MATES IV										
Average	0.0876	0.134	0.168	0.283	0.181	0.227	0.26	0.124	0.131	0.127
95% CI LB	0.0817	0.109	0.13	0.232	0.144	0.14	0.134	0.106	0.108	0.107
95% CI UB	0.0947	0.164	0.211	0.346	0.222	0.36	0.491	0.148	0.164	0.152
N	60	58	59	56	55	59	59	60	58	58
% < MDL	80	41.4	40.7	7.1	27.3	35.6	30.5	35	39.7	44.8
Max	0.2	0.65	0.7	1.45	0.76	3.19	6.5	0.59	0.84	0.42
MATES V										
Average	0.244	0.69	0.249	0.311	0.449	0.088	0.15	0.144	0.588	0.771
95% CI LB	0.193	0.136	0.166	0.239	0.234	0.0646	0.107	0.1	0.251	0.531
95% CI UB	0.306	1.76	0.359	0.394	0.751	0.129	0.219	0.214	1.04	1.05
N	61	58	61	59	61	60	60	60	60	59
% < MDL	0	0	0	0	3.3	0	1.7	0	0	0
Max	1.42	30	2.62	1.72	7.13	1.01	1.85	1.77	9.18	4.43

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

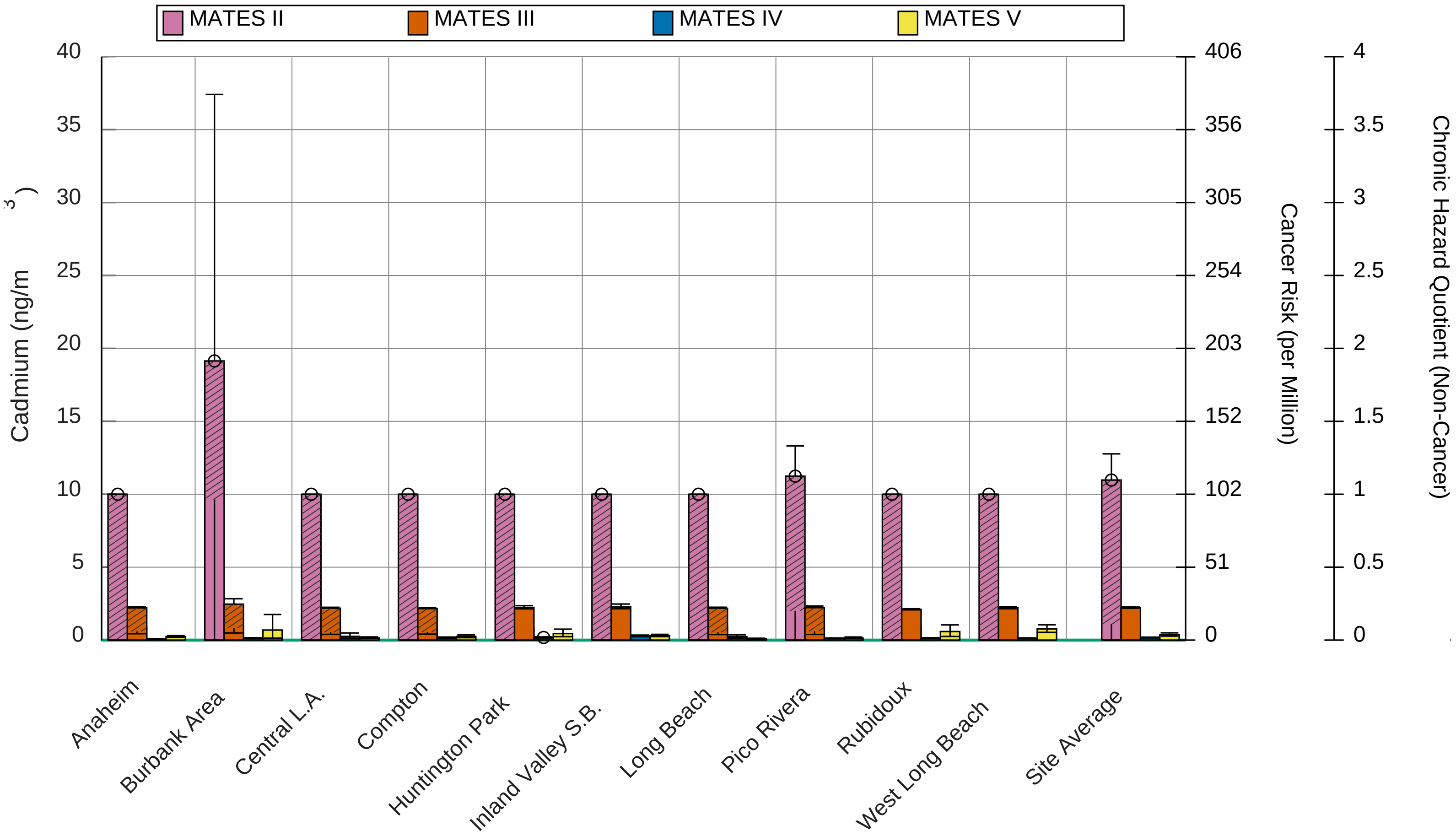


Figure IV-78. Annual Average Concentrations of Cadmium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

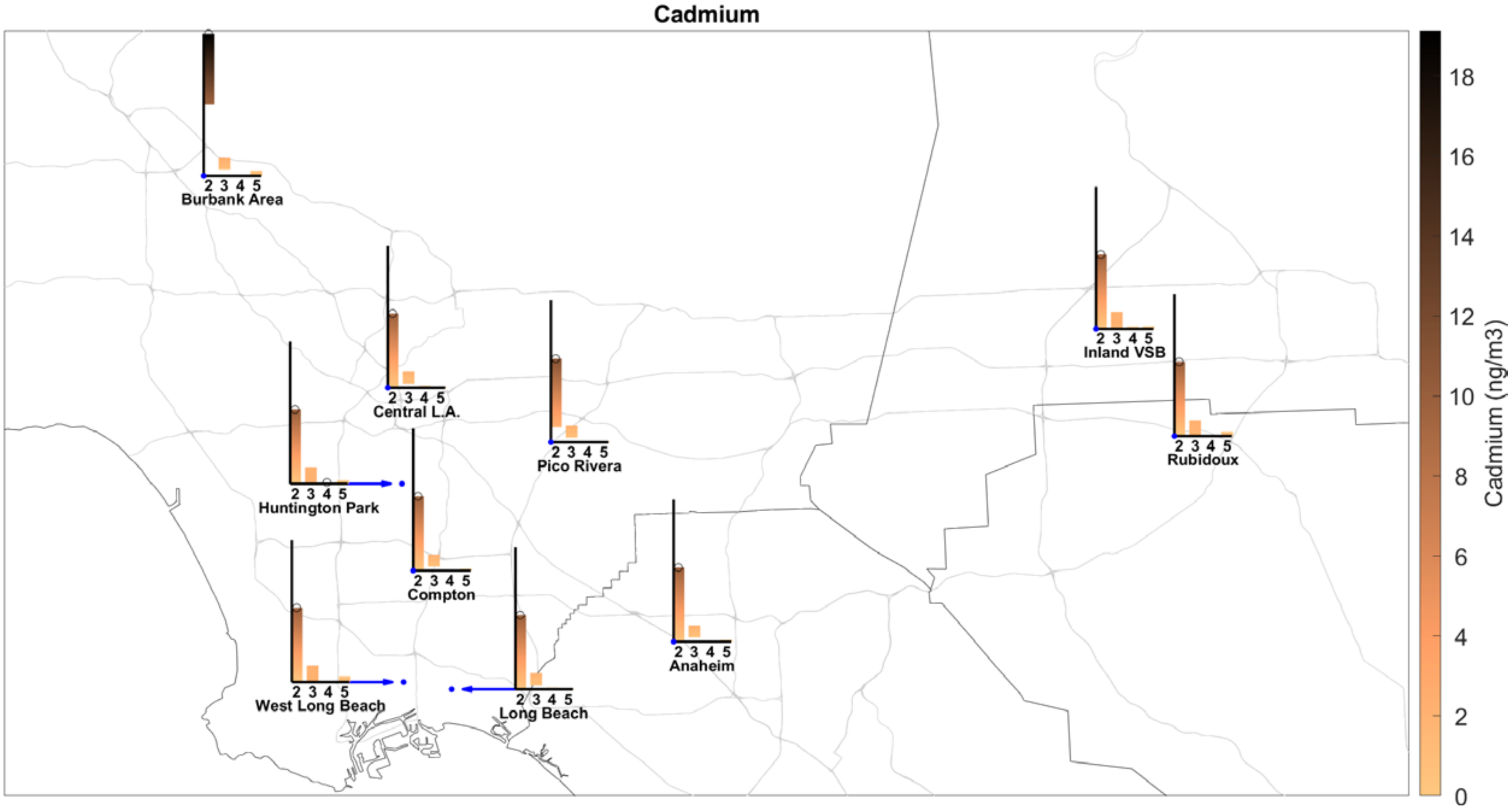


Figure IV-79. Geographic distribution of Cadmium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Calcium

Table IV-42. Ambient Concentrations (ng/m^3) of Calcium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1670	1530	1670	3330	1780	1160	1400	1640	5130	1570
95% CI LB	1390	1250	1250	2550	1470	937	1190	1340	3870	1300
95% CI UB	1960	1840	2170	4230	2110	1430	1640	1970	6480	1840
N	45	47	39	41	42	56	51	41	41	39
% < MDL	0	2.1	0	0	0	0	0	2.4	4.9	0
Max	3840	5920	9710	14600	4750	6070	4320	4930	16100	3810
MATES III										
Average	1200	1360	1280	2710	1690	1170	1460	1440	5360	1800
95% CI LB	1100	1260	1190	2500	1490	1080	1380	1310	4900	1660
95% CI UB	1320	1470	1370	2920	1910	1250	1550	1560	5840	1950
N	232	218	228	224	116	230	229	118	237	227
% < MDL	0	0	0	0.4	0	0	0	0	0	0
Max	5750	5920	3720	9080	10300	4630	3330	3660	20600	7020
MATES IV										
Average	640	903	987	2330	1020	879	1130	1150	2320	1300
95% CI LB	507	767	840	1810	869	725	935	974	1850	1070
95% CI UB	799	1050	1150	2950	1190	1050	1360	1350	2890	1570
N	60	58	59	56	55	59	59	60	58	58
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	3540	2880	3090	11200	3420	3340	4610	3800	9220	4640
MATES V										
Average	962	1160	1010	2300	1020	795	1210	1680	1960	1110
95% CI LB	821	974	851	1890	861	669	1020	1400	1630	925
95% CI UB	1110	1350	1160	2780	1200	930	1430	1980	2290	1300
N	41	39	40	42	41	38	37	39	39	38
% < MDL	7.3	5.1	7.5	4.8	14.6	7.9	5.4	5.1	7.7	5.3
Max	2430	2530	2500	7320	2490	1860	3540	4280	4320	2660

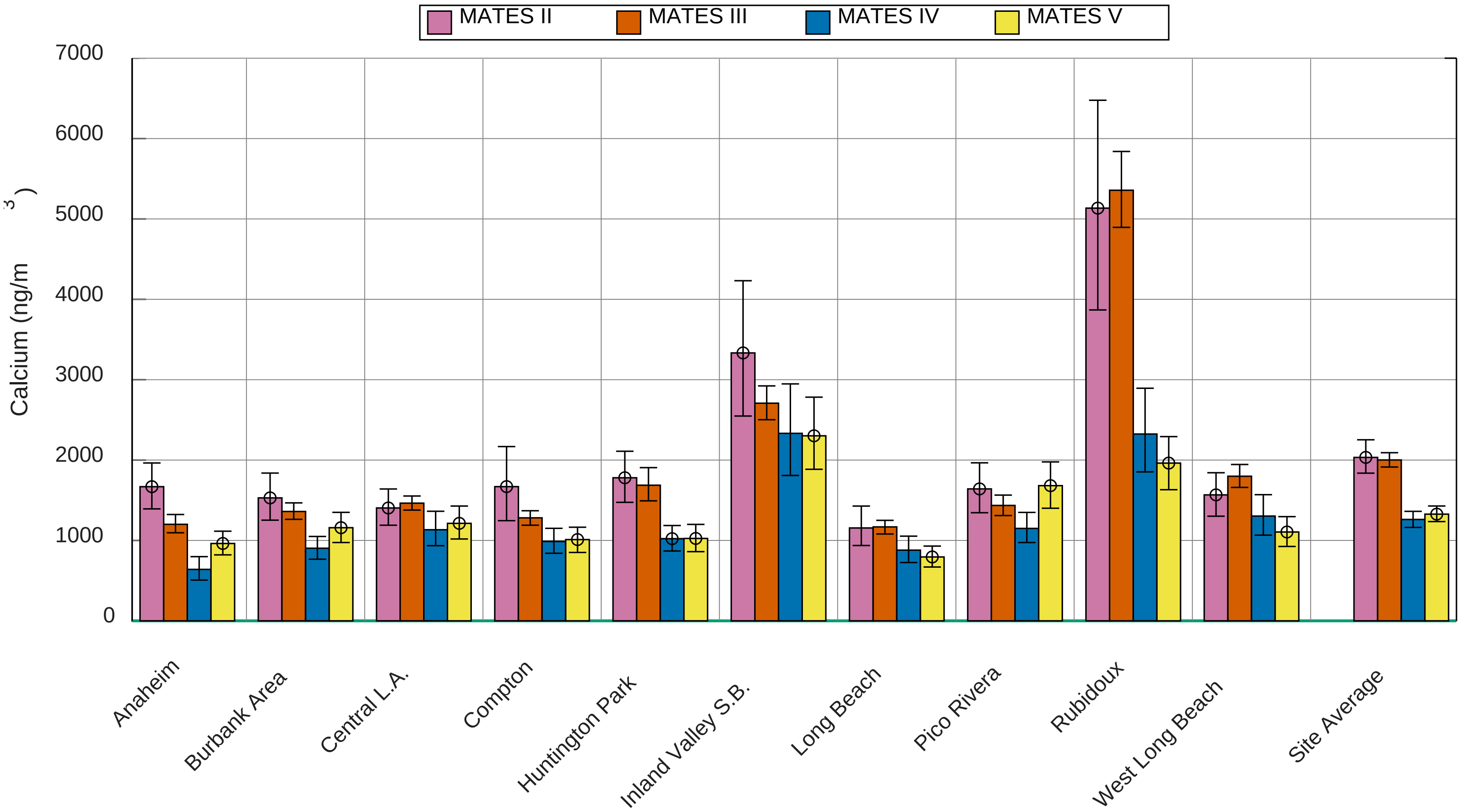


Figure IV-80. Annual Average Concentrations of Calcium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

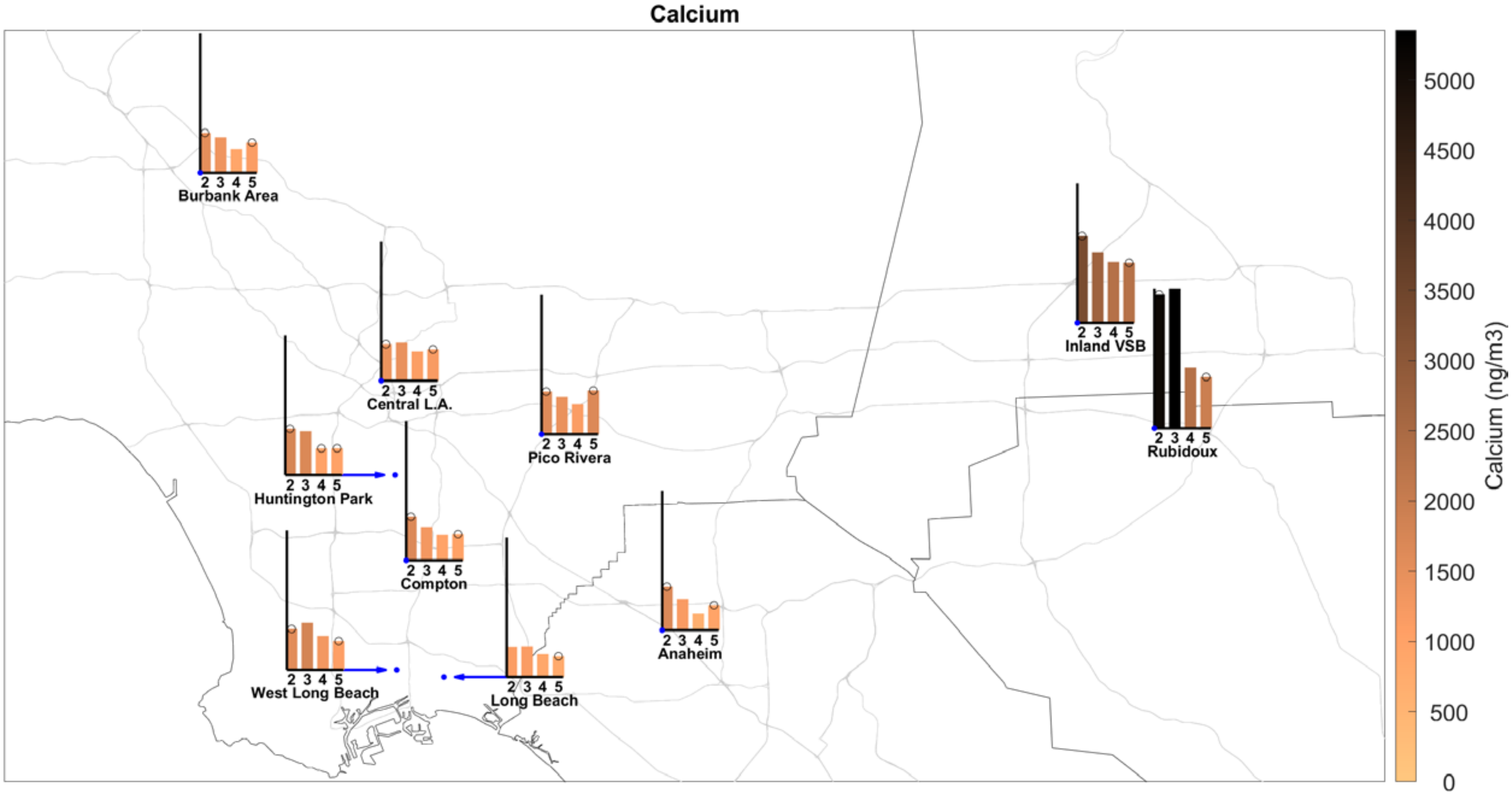


Figure IV-81. Geographic distribution of Calcium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Cesium

Table IV-43. Ambient Concentrations (ng/m^3) of Cesium from the TSP Metals analysis at the Fixed Sites.

Statistic	AN	BU	CP	SB	HP	LB	LA	PR	RU	WLB
	Measurement Site									
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	0, 0.291[a]	0, 0.291[a]	0, 0.291[a]	0.0328, 0.301[a]	0, 0.291[a]	0, 0.291[a]	0, 0.291[a]	0, 0.291[a]	0.0259, 0.302[a]	0, 0.291[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	0.291[a]	0.291[a]	0.291[a]	0.319[a]	0.291[a]	0.291[a]	0.291[a]	0.291[a]	0.321[a]	0.291[a]
N	41[a]	39[a]	40[a]	39[a]	40[a]	41[a]	40[a]	42[a]	39[a]	41[a]
% < MDL	100[a]	100[a]	100[a]	92.3[a]	100[a]	100[a]	100[a]	100[a]	94.9[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	0.63[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	0.67[a]	< MDL[a]
MATES V										
Average	0.0757	0.0773	0.0644	0.148	0.0551	0.0581	0.0604	0.109	0.162	0.0746
95% CI LB	0.0624	0.0648	0.0522	0.122	0.0439	0.0467	0.0522	0.0919	0.139	0.0582
95% CI UB	0.0907	0.0905	0.0788	0.179	0.0671	0.0742	0.0699	0.126	0.188	0.0954
N	58	55	59	56	59	58	56	58	56	57
% < MDL	1.7	3.6	3.4	3.6	20.3	5.2	5.4	5.2	0	3.5
Max	0.28	0.27	0.3	0.6	0.2	0.38	0.19	0.33	0.53	0.5

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

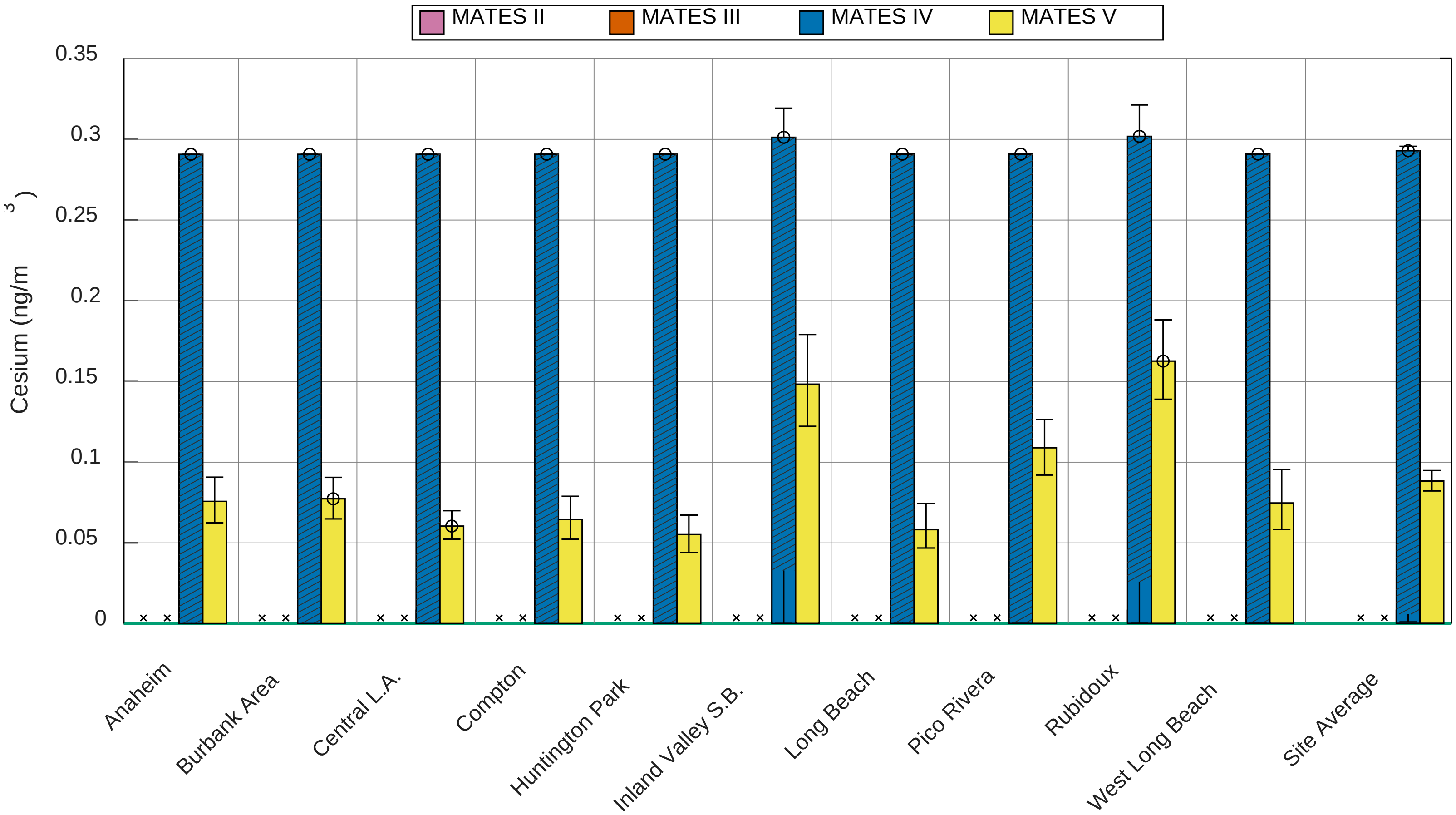


Figure IV-82. Annual Average Concentrations of Cesium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

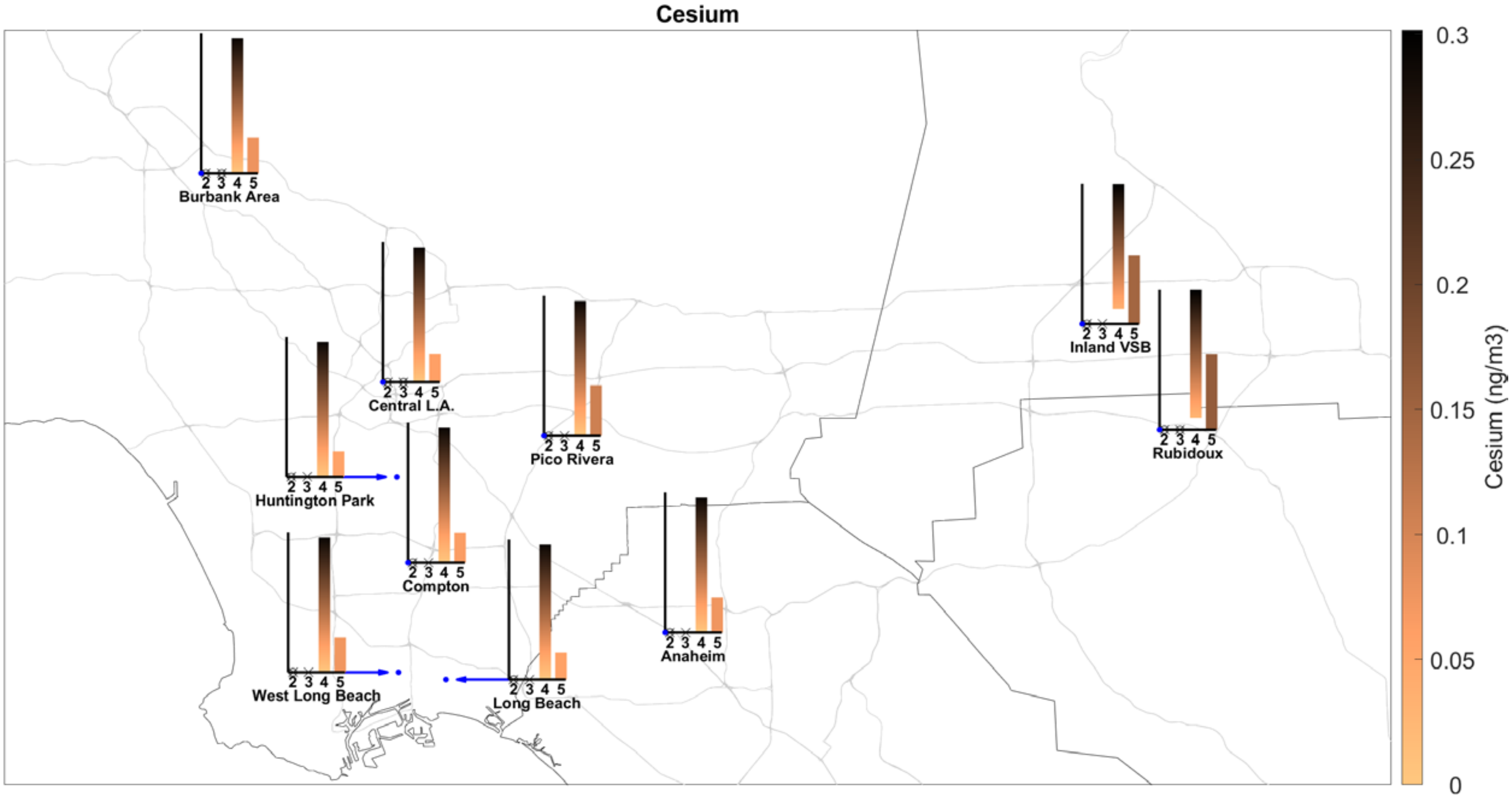


Figure IV-83. Geographic distribution of Cesium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Chlorine

Table IV-44. Ambient Concentrations (ng/m^3) of Chlorine from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1340	1160	1810	1260	1910	1920	1350	1320	1200	1980
95% CI LB	962	883	1420	873	1500	1550	1010	923	813	1600
95% CI UB	1840	1460	2240	1730	2390	2340	1790	1810	1680	2360
N	45	47	39	41	42	56	51	41	41	39
% < MDL	0	0	0	0	0	0	2	2.4	2.4	0
Max	9700	5180	7040	7950	7730	8320	7920	8760	7890	5140
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

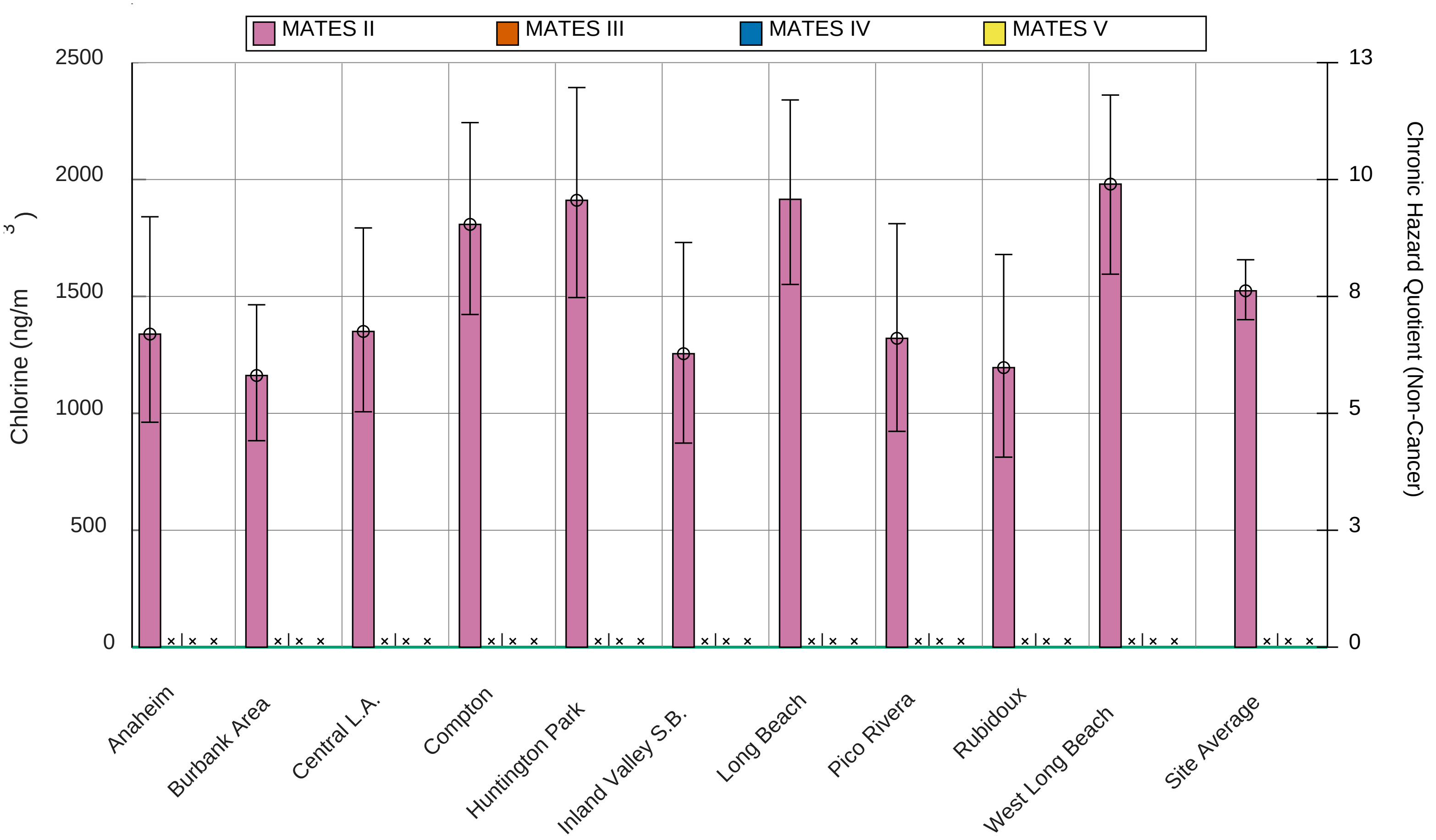


Figure IV-84. Annual Average Concentrations of Chlorine in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

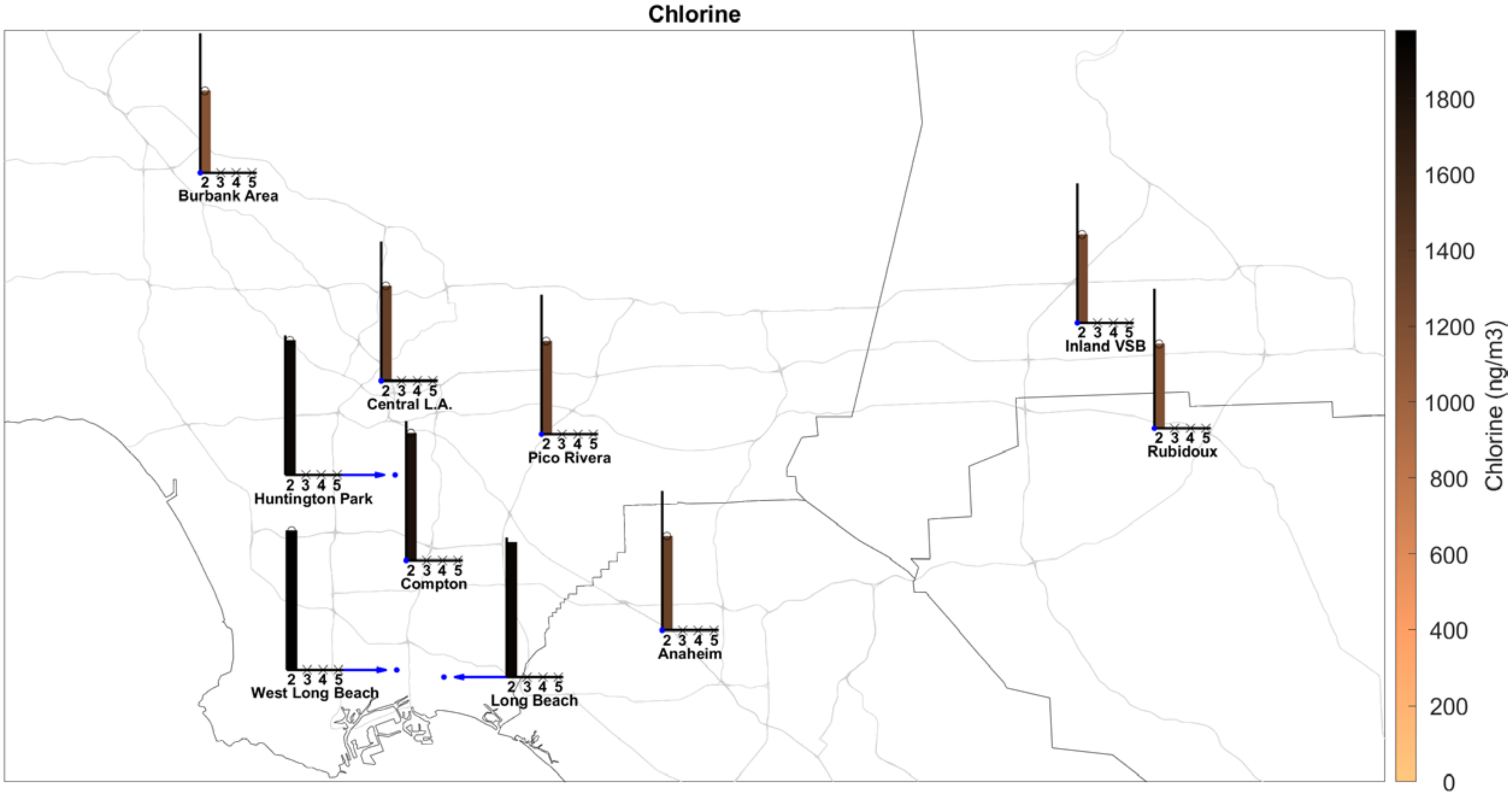


Figure IV-85. Geographic distribution of Chlorine from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Chromium

Table IV-45. Ambient Concentrations (ng/m^3) of Chromium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	3.62	4.64	6.07	7.38	9.17	3.54	4.35	6.05	4.67	4.63
95% CI LB	2.87	3.8	4.37	5.76	6.56	2.88	3.47	4.66	3.69	3.46
95% CI UB	4.47	5.57	8.03	9.1	12.2	4.31	5.35	7.56	5.71	6.03
N	45	47	39	41	42	56	51	41	41	39
% < MDL	57.8	38.3	43.6	36.6	38.1	51.8	49	41.5	46.3	46.2
Max	14	14	27	20	38	15	20	19	13	20
MATES III										
Average	2.8	3.98	4.62	7	9.45	4.28	4.51	4.61	4.74	4.33
95% CI LB	2.57	3.64	4.14	6.36	6.98	3.77	4.2	4.07	4.42	3.83
95% CI UB	3.06	4.31	5.13	7.65	12.3	4.88	4.83	5.21	5.07	4.88
N	232	218	228	224	116	230	229	118	237	227
% < MDL	68.1	36.7	36.8	21	19	51.3	23.6	27.1	22.8	48
Max	15	20.3	22.5	21.9	83.3	34.1	18	20.1	15	24.5
MATES IV										
Average	1.97	3.15	3.66	5.54	5.28	3.74	3.76	3.53	4.21	3.37
95% CI LB	1.77	2.75	3.04	4.71	3.64	2.68	3.37	3.16	3.36	2.94
95% CI UB	2.21	3.56	4.29	6.46	7.49	5.48	4.14	3.93	5.4	3.84
N	60	58	59	56	55	59	59	60	58	58
% < MDL	20	3.4	0	1.8	0	6.8	5.1	0	5.2	3.4
Max	4.6	7.94	13.1	19.9	49.5	47.7	6.92	8.17	31.5	8.83
MATES V										
Average	2.31	2.69	3.32	5.83	3.14	2.95	3.03	4.19	3.6	3.63
95% CI LB	1.99	2.36	2.72	4.93	2.49	2.34	2.68	3.66	3.12	2.97
95% CI UB	2.66	3.03	4.01	6.83	3.92	3.66	3.41	4.71	4.12	4.38
N	61	58	61	59	61	60	60	60	60	59
% < MDL	1.6	5.2	0	1.7	9.8	8.3	3.3	3.3	0	3.4
Max	8.49	5.66	13.7	17.3	17.5	12.9	7.6	9.66	8.61	14.5

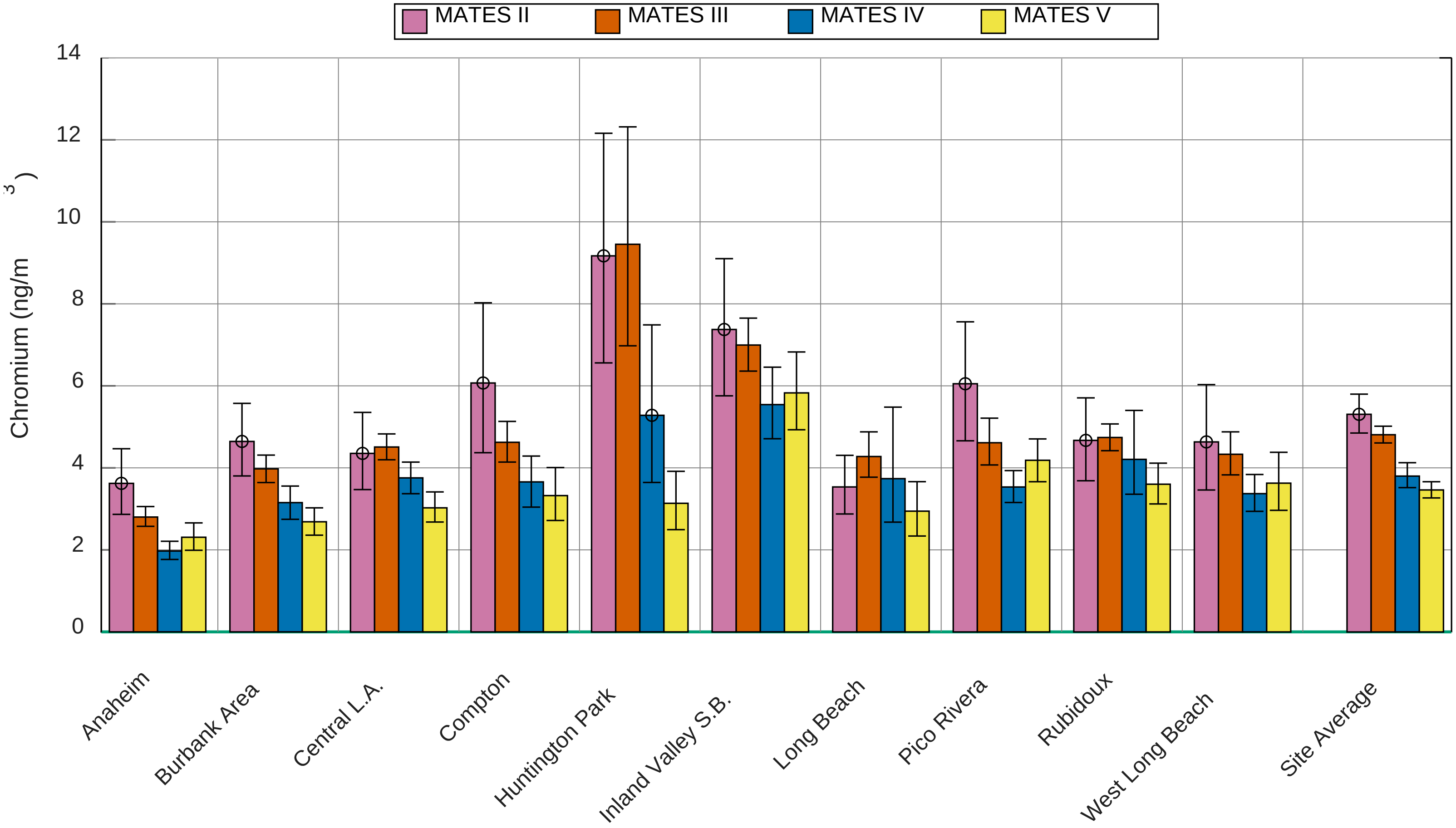


Figure IV-86. Annual Average Concentrations of Chromium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

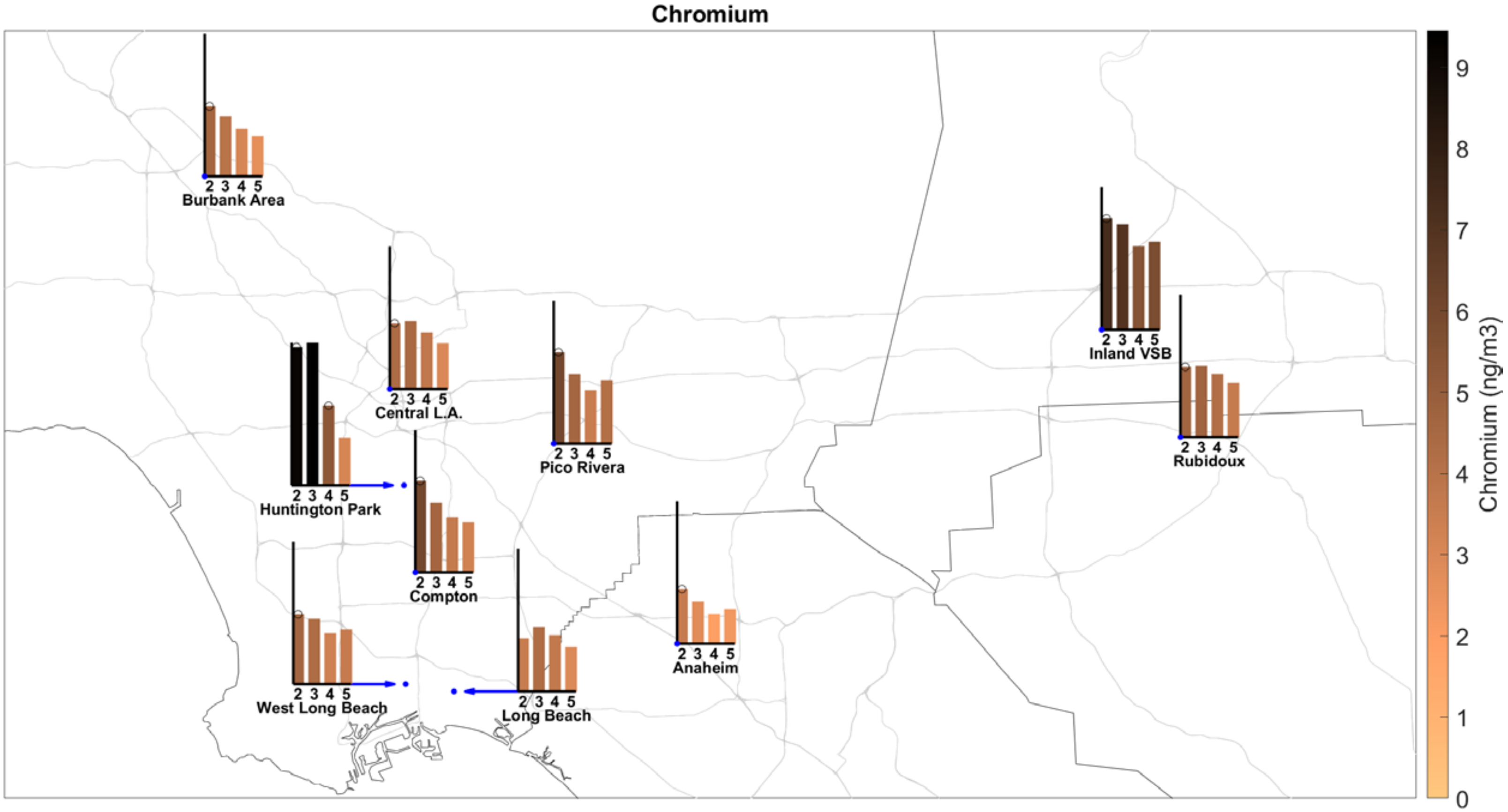


Figure IV-87. Geographic distribution of Chromium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Cobalt

Table IV-46. Ambient Concentrations (ng/m^3) of Cobalt from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 26.6[a]	0, 24.1[a]	0, 24.8[a]	0, 25.7[a]	0, 26[a]	0, 24.8[a]	0, 24.6[a]	0, 28[a]	0, 25.7[a]	0, 25.3[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	29.1[a]	26.9[a]	27.7[a]	28.5[a]	28.7[a]	27.2[a]	27.2[a]	30.8[a]	28.5[a]	28.2[a]
N	45[a]	47[a]	39[a]	41[a]	42[a]	56[a]	51[a]	41[a]	41[a]	39[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES III										
Average	2.71	3.63	3.38	6.06	4.81	2.85	3.98	4.13	5.78	3.64
95% CI LB	2.46	3.35	3.11	5.55	4.32	2.62	3.72	3.7	5.38	3.27
95% CI UB	2.97	3.92	3.67	6.58	5.32	3.11	4.25	4.6	6.18	4.04
N	232	218	228	224	116	230	229	118	237	227
% < MDL	26.7	8.7	14.9	8.5	4.3	21.3	8.3	5.9	7.2	15
Max	10.7	11	12.7	18.5	14.5	9.6	11.4	17	15.4	16.7
MATES IV										
Average	0.217	0.482	0.414	0.792	0.458	0.367	0.426	0.461	0.646	0.562
95% CI LB	0.187	0.401	0.356	0.682	0.382	0.312	0.375	0.403	0.526	0.442
95% CI UB	0.252	0.572	0.477	0.904	0.543	0.425	0.478	0.522	0.791	0.716
N	60	58	59	56	55	59	59	60	58	58
% < MDL	35	10.3	8.5	0	0	10.2	8.5	8.3	5.2	8.6
Max	0.66	1.92	1.04	1.96	1.74	0.98	1	1.26	3.57	3.7
MATES V										
Average	0.329	0.454	0.452	0.804	0.366	0.751	0.4	0.674	0.594	0.636
95% CI LB	0.284	0.388	0.383	0.666	0.304	0.523	0.349	0.576	0.514	0.504
95% CI UB	0.38	0.519	0.527	0.96	0.431	1.01	0.455	0.784	0.675	0.79
N	60	58	60	58	60	59	59	59	60	58
% < MDL	1.7	1.7	1.7	1.7	10	1.7	3.4	1.7	1.7	0
Max	1.04	1.01	1.52	3.47	1.02	4.48	1.27	2.54	1.54	2.73

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

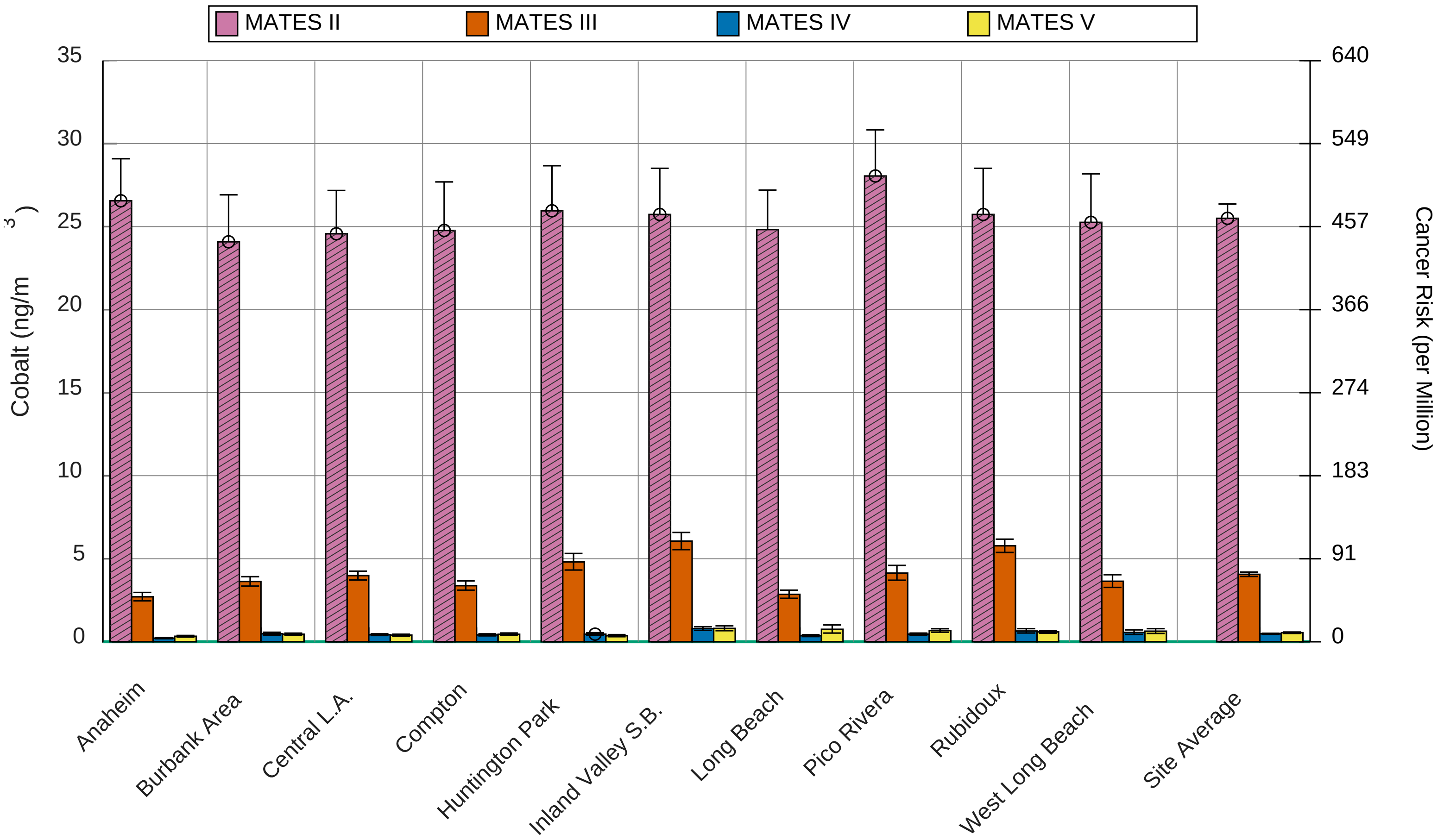


Figure IV-88. Annual Average Concentrations of Cobalt in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

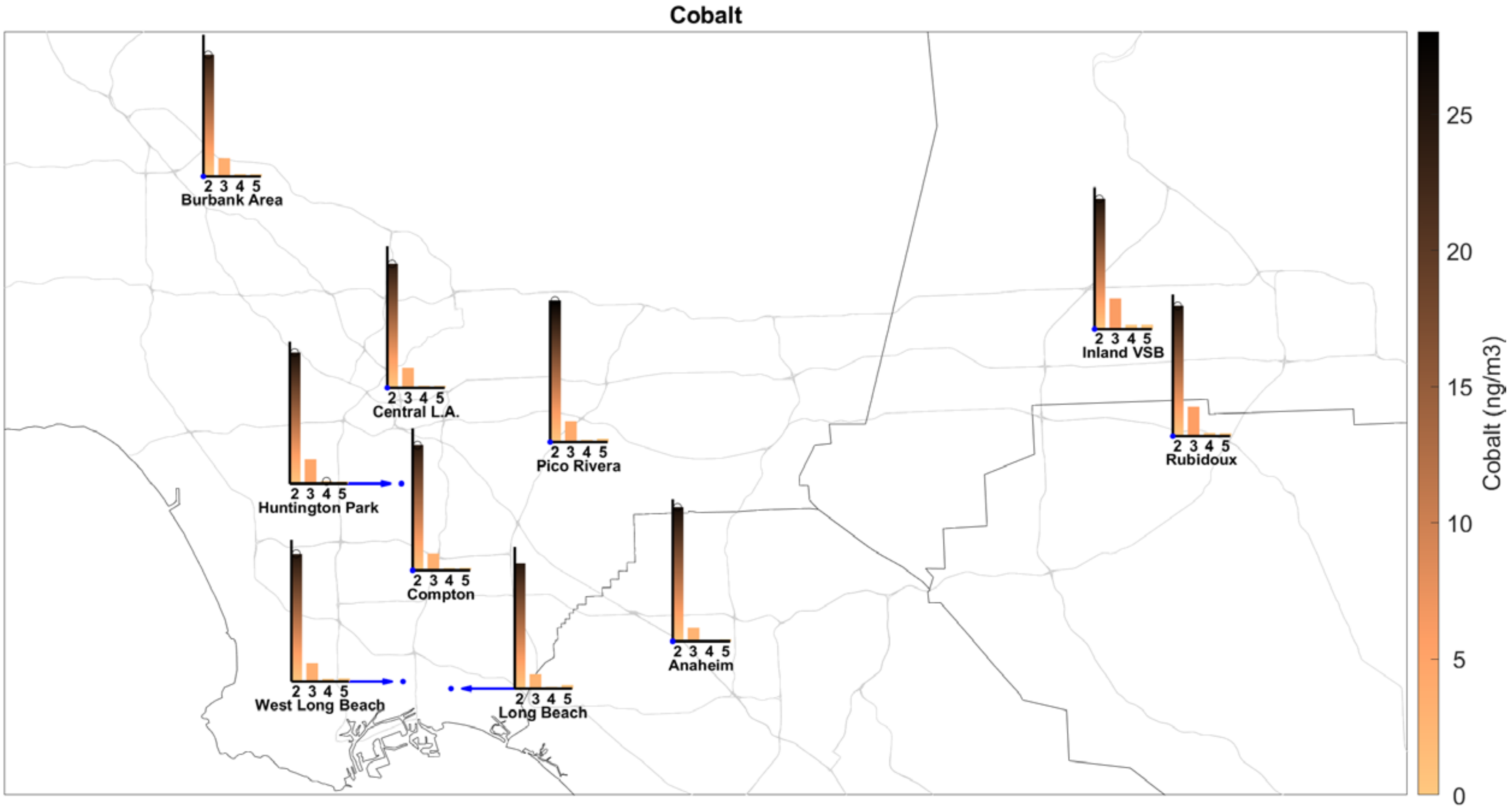


Figure IV-89. Geographic distribution of Cobalt from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Copper

Table IV-47. Ambient Concentrations (ng/m^3) of Copper from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	25.4	52.3	18.9	77.3	72.2	25.4	38.7	36.6	25.8	17.4
95% CI LB	20.8	42.6	15.1	67.6	60.7	22.3	33.9	30.5	21.3	13.7
95% CI UB	30.6	62.9	22.9	87.3	84.2	28.9	43.8	43.2	30.4	21.1
N	45	47	39	41	42	56	51	41	41	39
% < MDL	2.2	0	2.6	0	0	0	3.9	0	2.4	7.7
Max	72	173	72	171	162	77	89	114	71	53
MATES III										
Average	33.1	45.8	37.3	56.6	167	23.8	57.5	34.8	37.8	35.3
95% CI LB	30.2	42.4	33.6	50.1	150	21.7	53.3	31.4	33.3	32.6
95% CI UB	36.4	49.3	42	66.6	185	25.9	61.6	38.3	44.8	38.1
N	232	218	228	224	116	230	229	118	237	227
% < MDL	0	0	0.4	0.4	0	0	0	0	0	0
Max	265	199	417	959	496	79.9	198	101	697	110
MATES IV										
Average	17.3	38	29.6	42.5	49.7	32	42.2	46.9	33.4	31.6
95% CI LB	13.6	31.7	24.7	35.5	40.1	21.4	34.1	38.6	27.1	24
95% CI UB	21.5	45.1	34.8	50.3	60.8	49	50.9	55.6	40.8	42
N	60	58	59	56	55	59	59	60	58	58
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	74.1	127	87.4	147	261	459	160	140	162	251
MATES V										
Average	21.9	22.7	24.9	27.7	24.3	17.9	32.5	28.3	21.8	19.6
95% CI LB	17.6	19.6	19.9	24.1	18.9	14.2	27.6	24.2	18.8	15.6
95% CI UB	26.9	25.9	30.3	31.5	29.5	22.1	37.5	32.7	25	24.3
N	61	58	61	59	61	60	60	60	60	59
% < MDL	0	0	0	0	4.9	0	1.7	0	0	0
Max	111	52.4	94	73.3	79.1	72.4	91.1	78.4	60.2	84.1

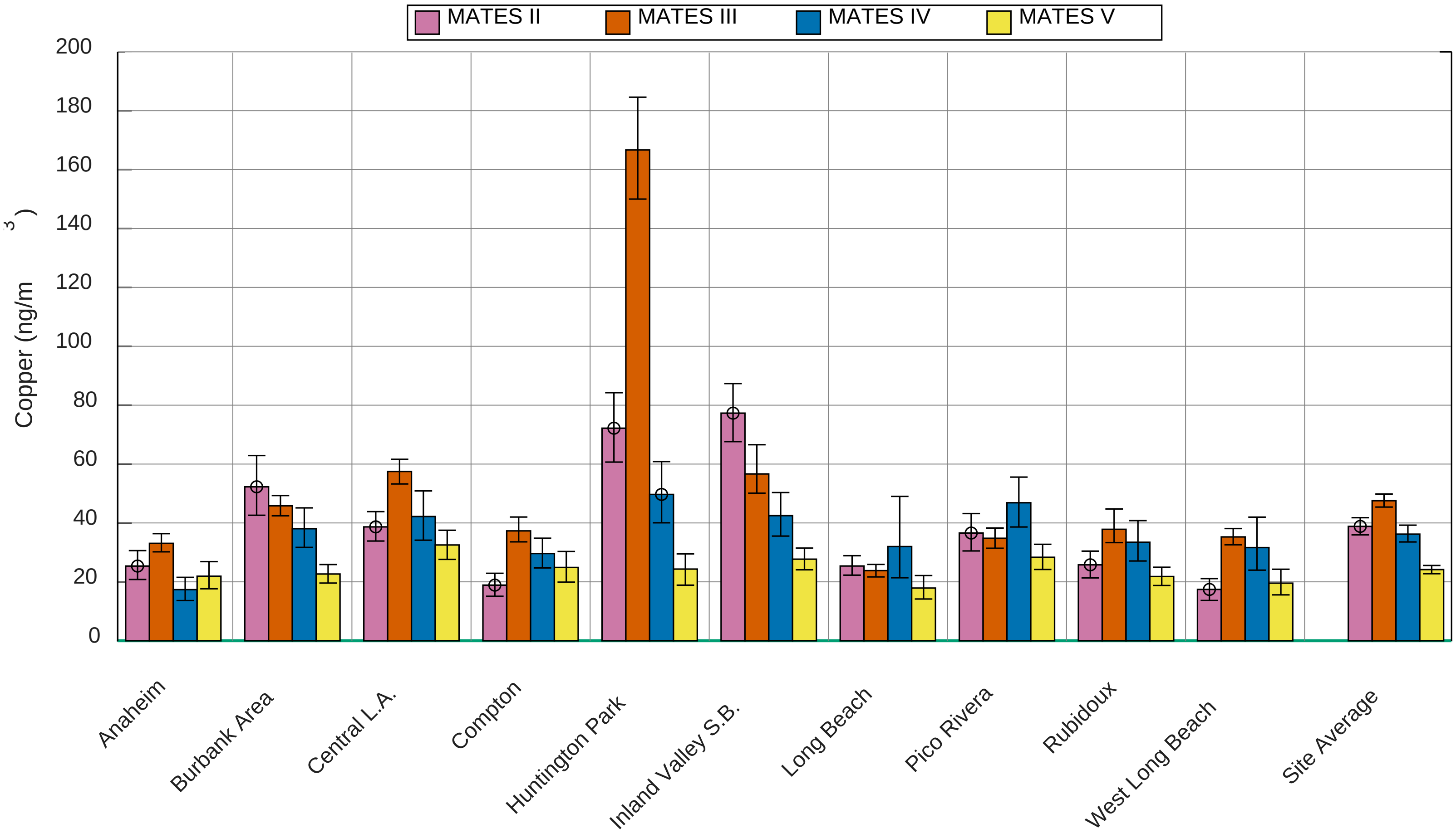


Figure IV-90. Annual Average Concentrations of Copper in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

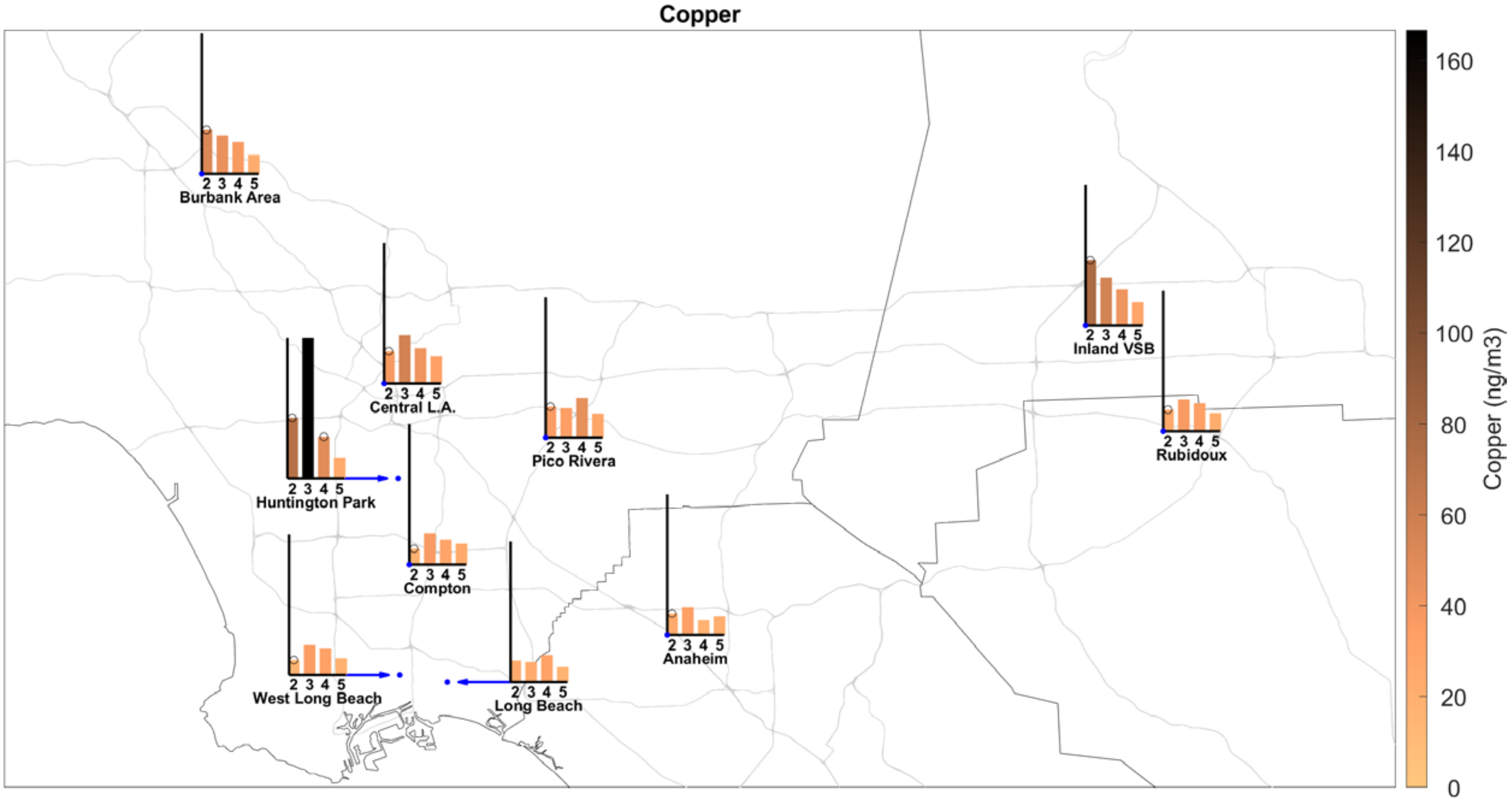


Figure IV-91. Geographic distribution of Copper from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Gallium

Table IV-48. Ambient Concentrations (ng/m^3) of Gallium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	4.6	4.4	0.408, 3.24[a]	2.22, 4.65[a]	4.28	5.26	4.32	4.67	0.763, 3.48[a]	0.859, 3.54[a]
95% CI LB	3.59	3.33	0[a]	0.326[a]	3.45	4.14	3.47	3.54	0[a]	0[a]
95% CI UB	5.81	5.81	3.72[a]	6.76[a]	5.43	6.41	5.32	6.02	4.26[a]	4.45[a]
N	25	20	18[a]	21[a]	22	26	23	26	21[a]	19[a]
% < MDL	72	80	94.4[a]	81[a]	77.3	61.5	73.9	73.1	90.5[a]	89.5[a]
Max	11.6	13.1	7.34[a]	20.3[a]	10	11.6	10.6	14.1	9.33[a]	9.83[a]
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

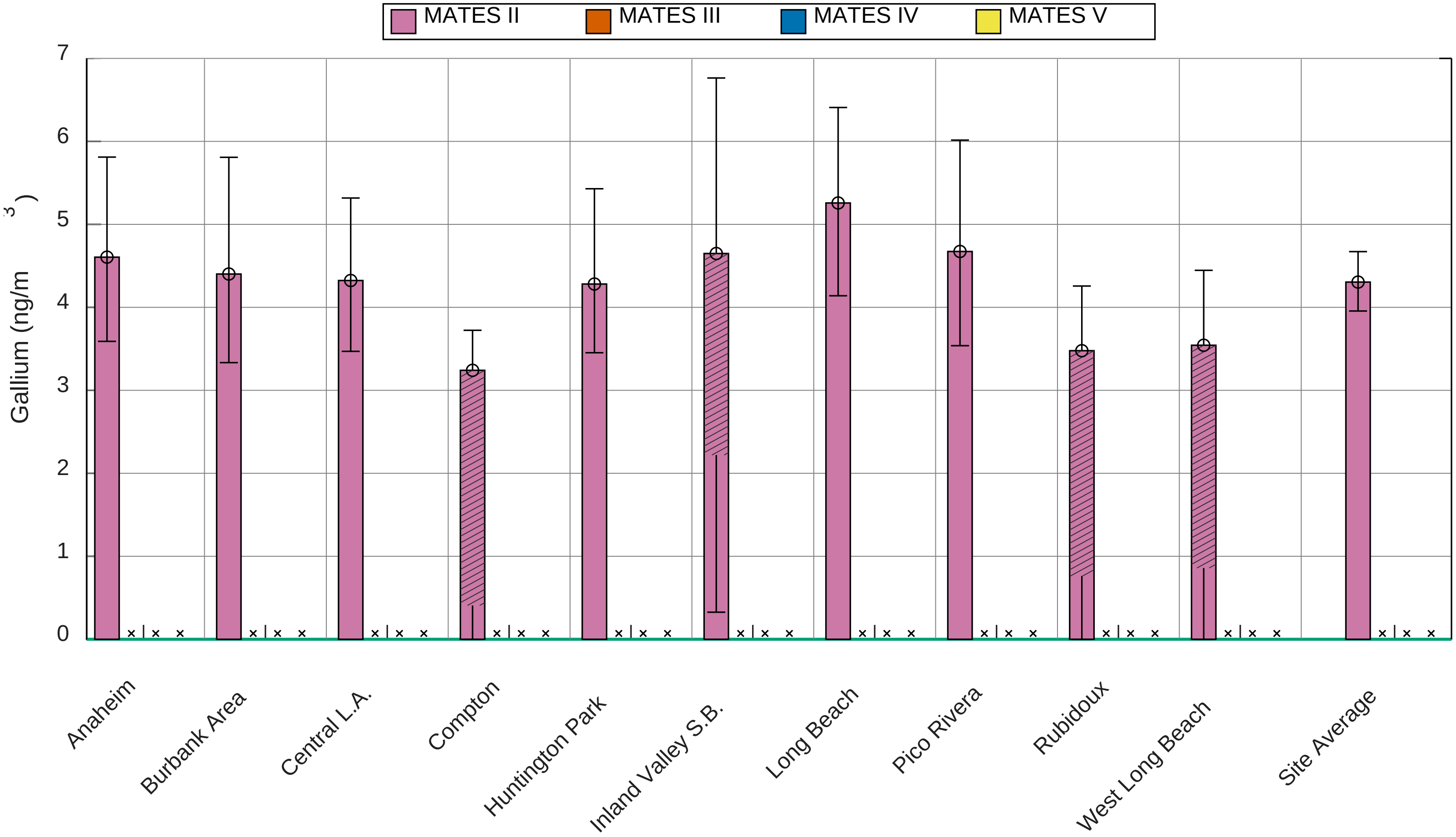


Figure IV-92. Annual Average Concentrations of Gallium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

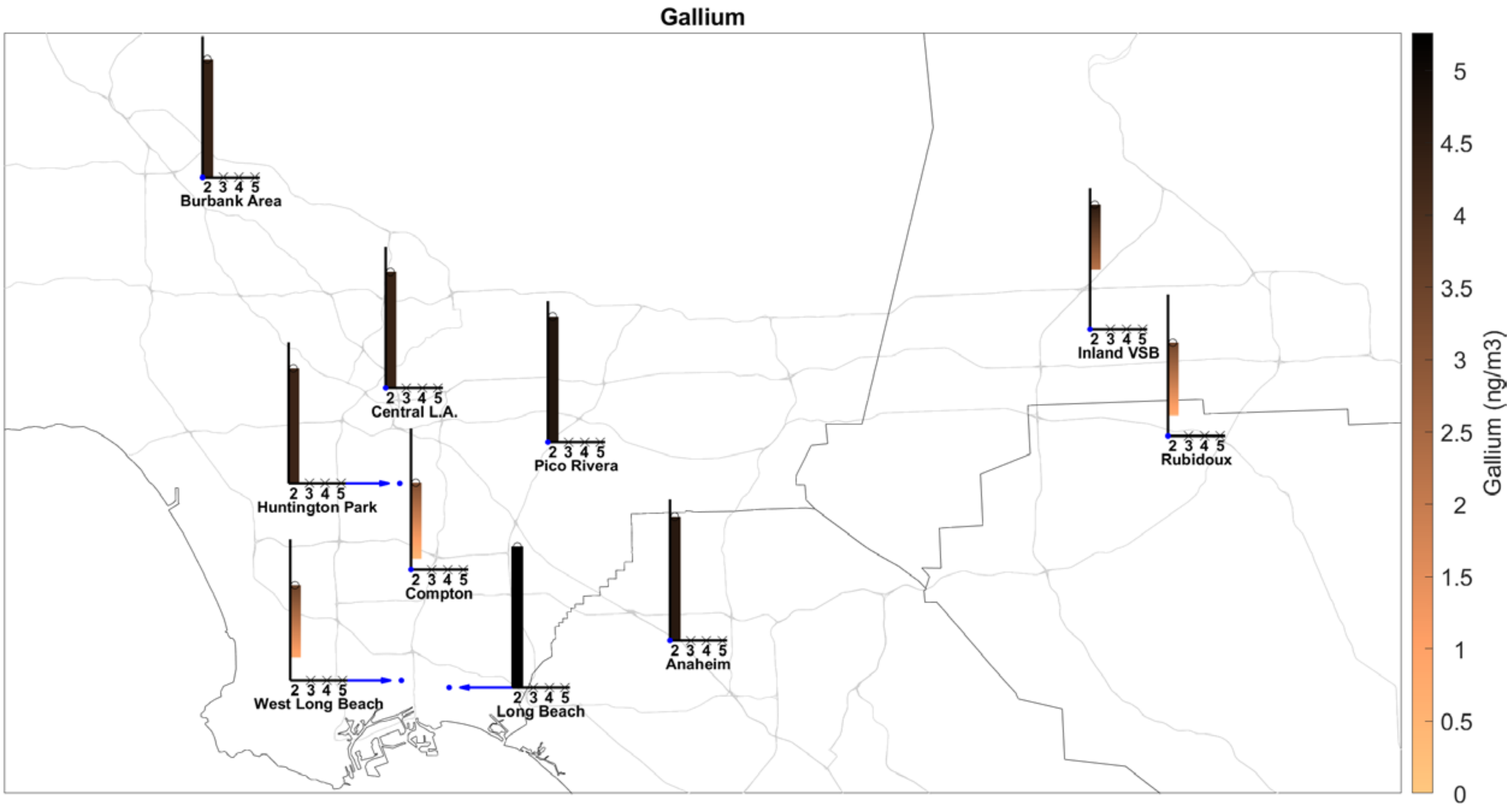


Figure IV-93. Geographic distribution of Gallium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Indium

Table IV-49. Ambient Concentrations (ng/m^3) of Indium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 11[a]	0, 11[a]	0, 11[a]	0, 11[a]	0, 11[a]	0, 11[a]	0, 11[a]	2.91, 13.1[a]	0, 11[a]	0, 11[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	11[a]	11[a]	11[a]	11[a]	11[a]	11[a]	11[a]	16.3[a]	11[a]	11[a]
N	25[a]	20[a]	18[a]	21[a]	22[a]	26[a]	23[a]	26[a]	21[a]	19[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	92.3[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	41[a]	< MDL[a]	< MDL[a]
MATES III										
Average	2.43	2.4	2.45	2.42	2.38	2.34	2.35	2.44	2.28	2.4
95% CI LB	2.34	2.3	2.34	2.32	2.24	2.26	2.28	2.3	2.21	2.29
95% CI UB	2.53	2.5	2.58	2.54	2.55	2.44	2.44	2.59	2.35	2.53
N	232	218	228	224	116	230	229	118	237	227
% < MDL	64.2	70.2	68.4	64.7	74.1	68.7	68.6	63.6	67.9	66.5
Max	7.32	6.15	7.28	6.83	6.47	7.18	5	6.15	4.91	9.96
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

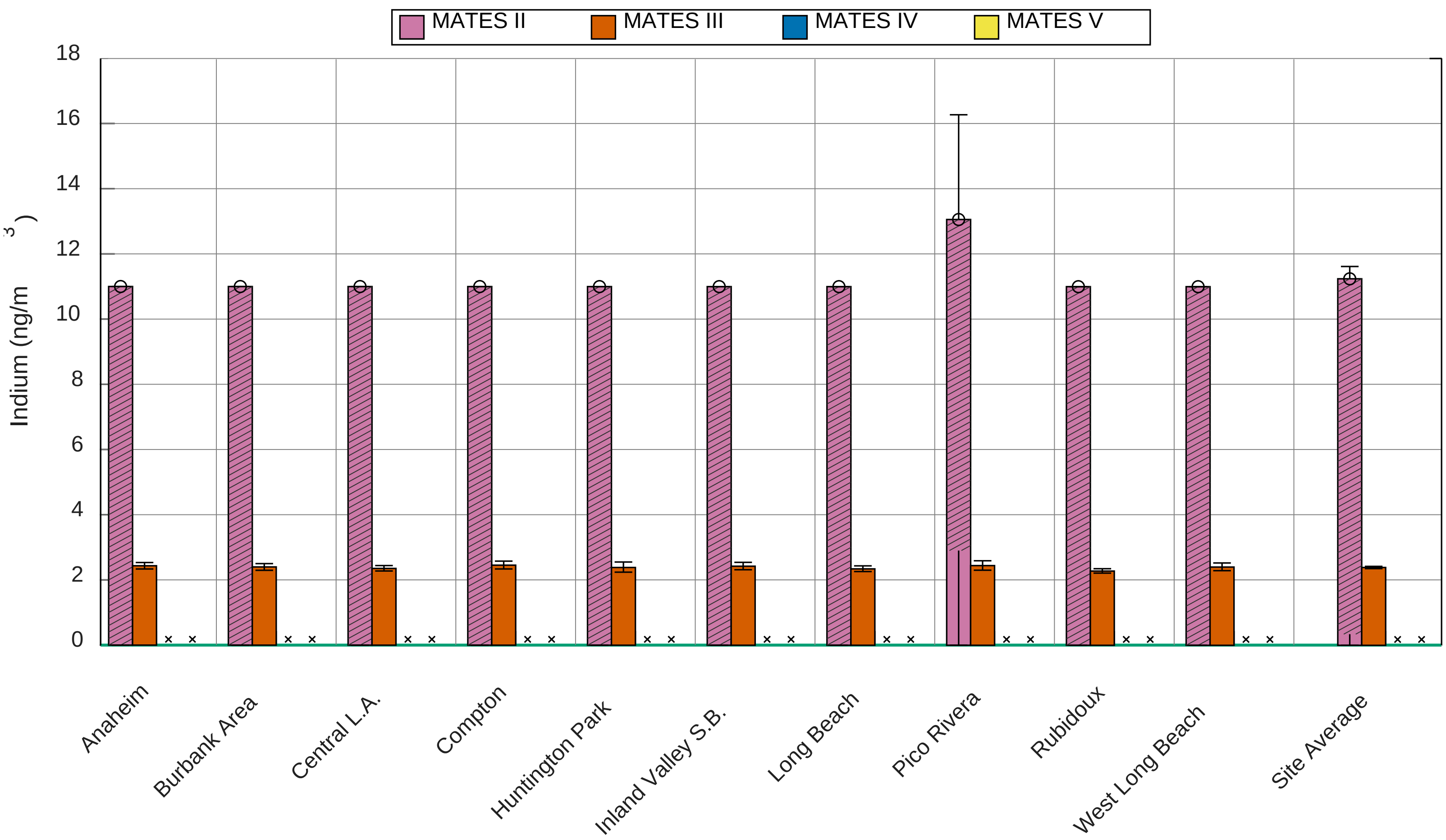


Figure IV-94. Annual Average Concentrations of Indium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

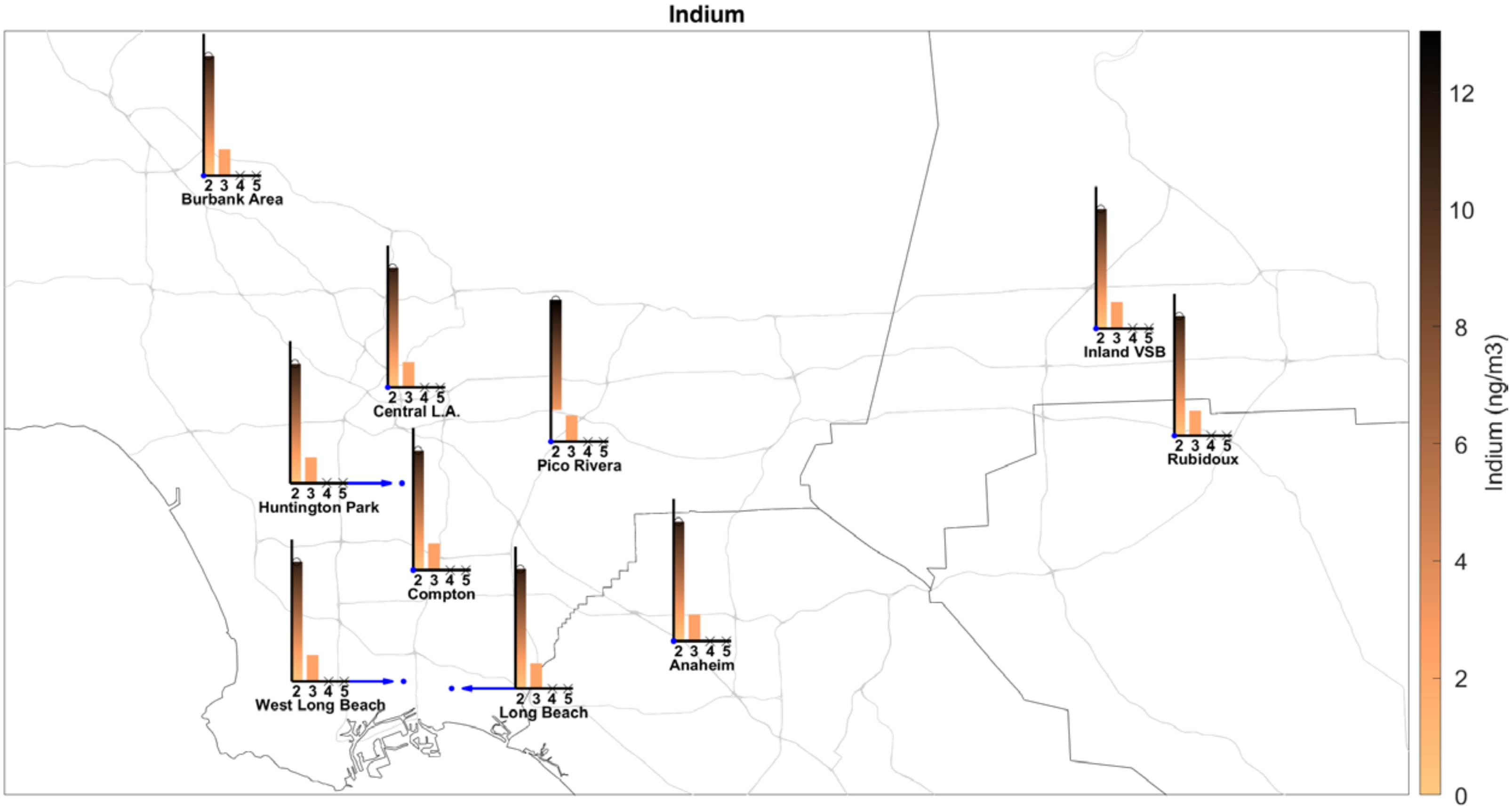


Figure IV-95. Geographic distribution of Indium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Iron

Table IV-50. Ambient Concentrations (ng/m^3) of Iron from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1470	1470	1660	2590	1640	1100	1350	2220	2680	1520
95% CI LB	1210	1250	1350	2140	1420	930	1160	1800	2240	1270
95% CI UB	1760	1700	1980	3050	1870	1270	1540	2700	3130	1760
N	45	47	39	41	42	56	51	41	41	39
% < MDL	0	0	0	0	0	0	2	2.4	2.4	0
Max	3870	3910	4380	5630	3890	3630	3680	8550	5870	3710
MATES III										
Average	1540	1910	1750	3170	2220	1580	2100	2140	3140	2050
95% CI LB	1410	1790	1630	2950	2030	1470	1980	1950	2960	1880
95% CI UB	1670	2040	1880	3420	2430	1690	2230	2340	3330	2230
N	232	218	228	224	116	230	229	118	237	227
% < MDL	0	0	0	0.4	0	0	0	0	0	0
Max	5800	7570	5260	8470	5700	4950	5330	6240	7180	9820
MATES IV										
Average	613	1160	1150	2730	1240	1040	1420	1470	2150	1490
95% CI LB	477	988	981	2140	1050	848	1180	1240	1710	1220
95% CI UB	786	1350	1330	3410	1460	1250	1700	1720	2650	1800
N	60	58	59	56	55	59	59	60	58	58
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	4050	3310	3000	11600	3660	3920	5560	4470	9440	5730
MATES V										
Average	843	981	926	1500	890	749	1030	1370	1410	1120
95% CI LB	692	798	776	1200	722	605	885	1130	1120	932
95% CI UB	1010	1170	1090	1830	1060	912	1180	1630	1690	1320
N	44	37	42	31	46	43	43	33	35	41
% < MDL	0	0	0	0	0	0	2.3	0	0	0
Max	2520	2230	2020	3380	2580	2300	2650	3240	3260	2570

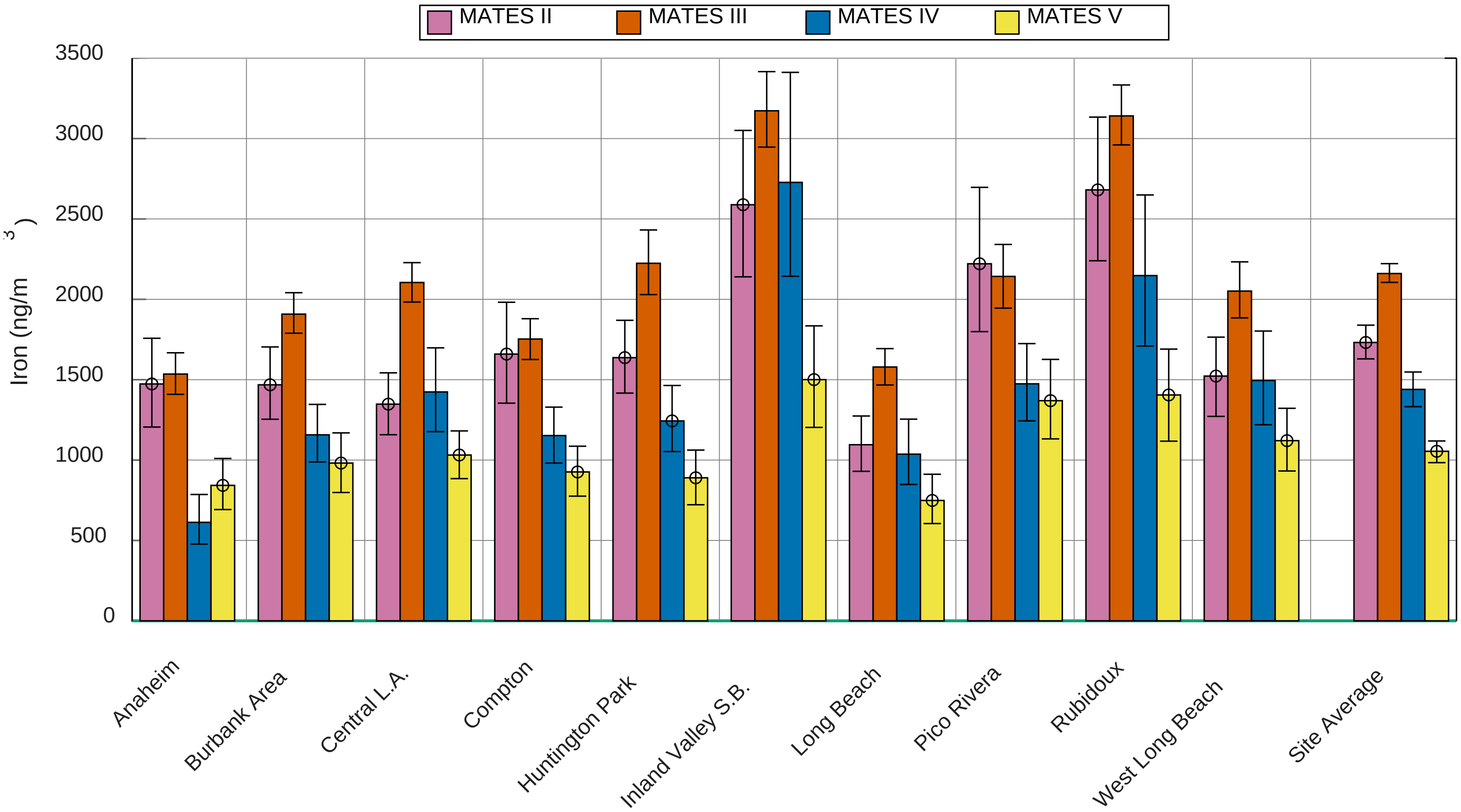


Figure IV-96. Annual Average Concentrations of Iron in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

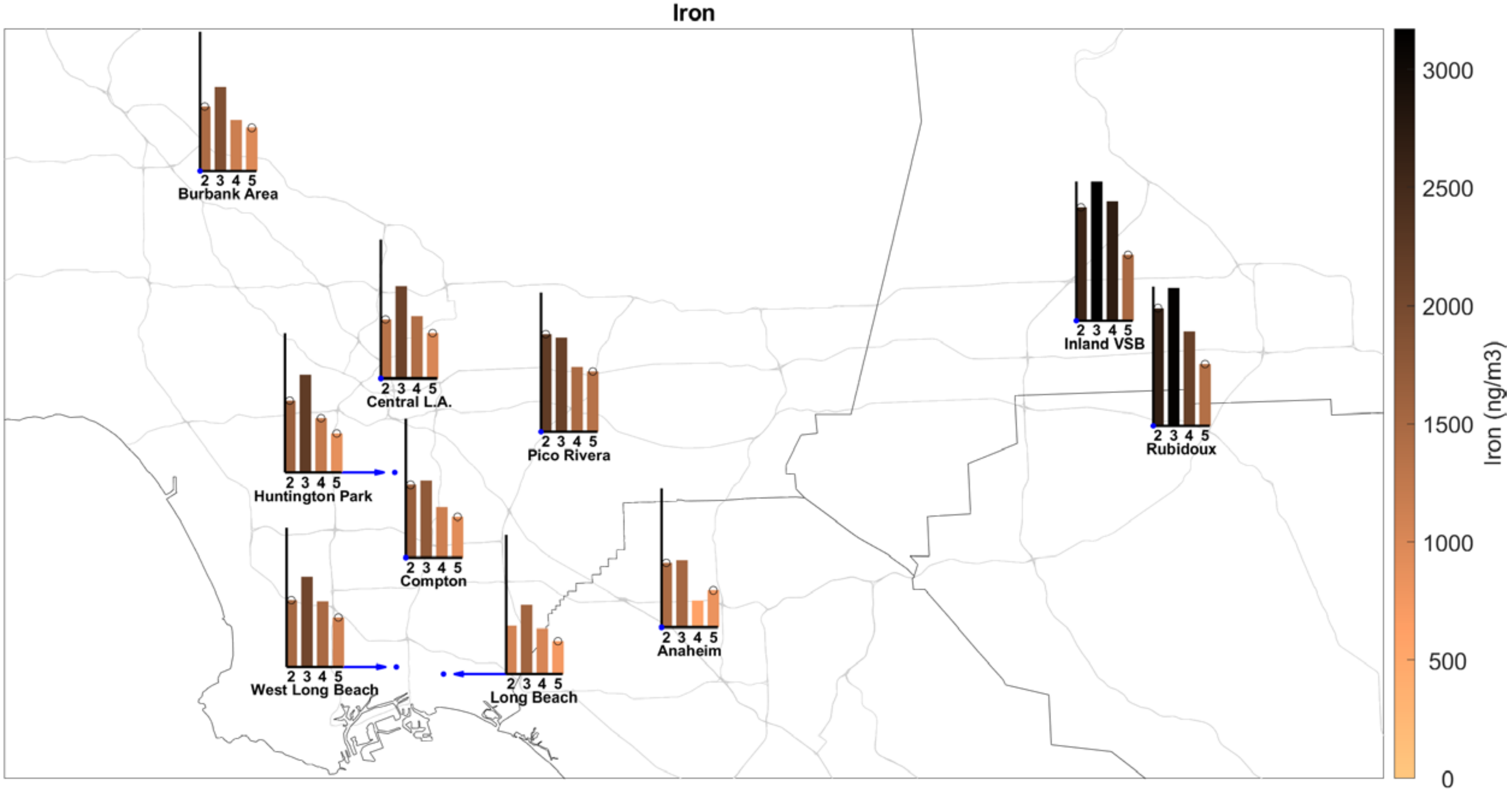


Figure IV-97. Geographic distribution of Iron from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Lanthanum

Table IV-51. Ambient Concentrations (ng/m^3) of Lanthanum from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 67[a]	0, 67[a]	0, 67[a]	0, 67[a]	0, 67[a]	6.91, 71.3[a]	0, 67[a]	0, 67[a]	0, 67[a]	0, 67[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	67[a]	67[a]	67[a]	67[a]	67[a]	80[a]	67[a]	67[a]	67[a]	67[a]
N	25[a]	20[a]	18[a]	21[a]	22[a]	26[a]	23[a]	26[a]	21[a]	19[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	96.2[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	180[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

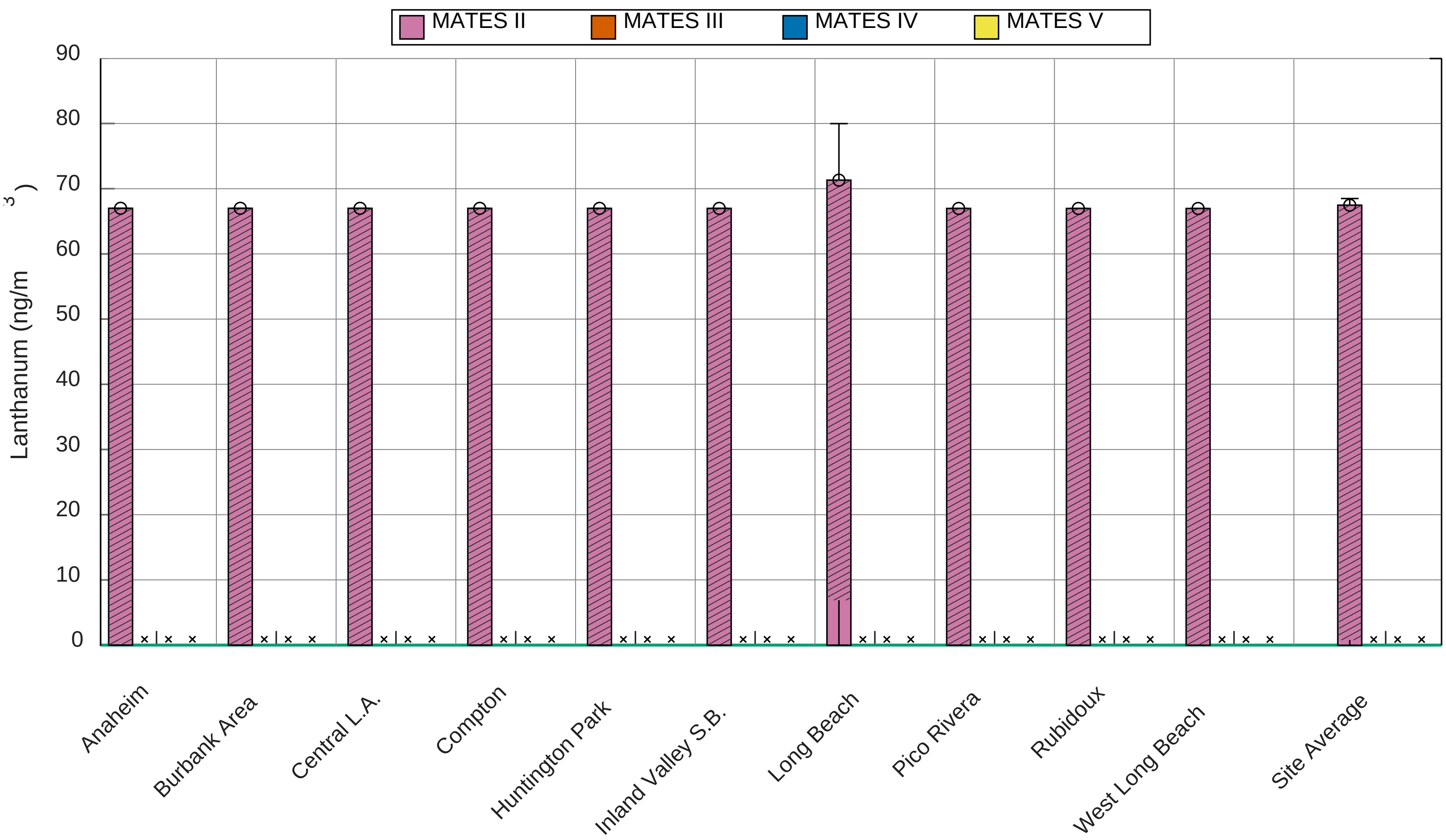


Figure IV-98. Annual Average Concentrations of Lanthanum in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

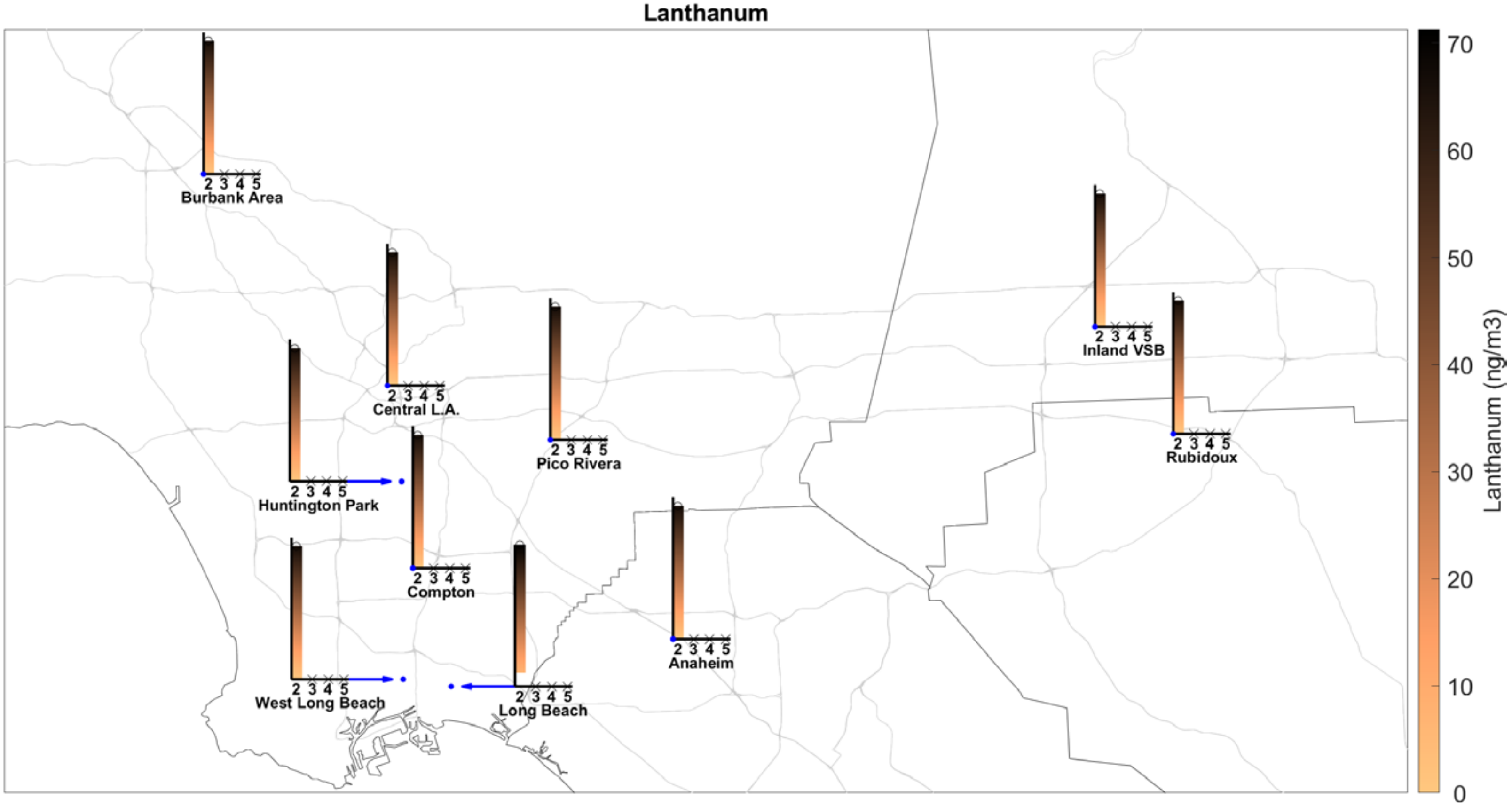


Figure IV-99. Geographic distribution of Lanthanum from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Lead

Table IV-52. Ambient Concentrations (ng/m^3) of Lead from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	21.5	23	21.5	27.7	49.7	16.4	22.9	31.3	24.7	17
95% CI LB	12.2	18.7	17.1	22.3	30.3	13.7	19.4	23.1	19.2	13.9
95% CI UB	33.6	27.7	26.3	34.4	76.3	19.4	26.7	42.3	30.7	20
N	45	47	39	41	42	56	51	41	41	39
% < MDL	11.1	0	2.6	0	0	3.6	3.9	4.9	7.3	5.1
Max	181	93.2	62	124	391	57.1	60.2	189	96.5	41.6
MATES III										
Average	7.32	10.5	12	15.8	22.8	9.66	15.3	14.8	12.4	11.4
95% CI LB	6.7	9.88	10.7	14.2	18.8	8.86	14.3	13.2	11.3	10.2
95% CI UB	8.05	11.3	13.3	17.6	27.3	10.6	16.3	16.5	13.7	12.9
N	232	218	228	224	116	230	229	118	237	227
% < MDL	51.7	17.4	27.2	15.2	5.2	30	11.4	5.9	15.6	26
Max	51.4	37.8	75.9	146	156	37.6	54.9	48.4	93.3	111
MATES IV										
Average	2.12	5.27	6.24	9.8	9.46	4.4	7.34	5.89	6.21	5.83
95% CI LB	1.82	4.59	5.25	8.52	7.29	3.8	6.5	5.28	5.19	4.58
95% CI UB	2.44	6.02	7.42	11	12.8	5.02	8.19	6.51	7.46	7.57
N	60	58	59	56	55	59	59	60	58	58
% < MDL	5	0	0	0	0	1.7	0	0	0	0
Max	6.84	16.8	20.1	19.3	81.7	13	15.6	12.6	32.3	43.3
MATES V										
Average	2.72	6.87	4.81	7.66	5.75	3.19	4.97	4.73	4.46	4.02
95% CI LB	2.28	5.97	3.94	6.51	3.46	2.54	4.21	4.06	3.8	3.05
95% CI UB	3.19	7.75	5.83	8.89	9.35	3.96	5.83	5.46	5.17	5.17
N	61	58	61	59	61	60	60	60	60	59
% < MDL	0	0	0	0	3.3	0	1.7	0	0	0
Max	9.53	19.7	16.9	24	106	15.2	20	18.2	11.3	20.4

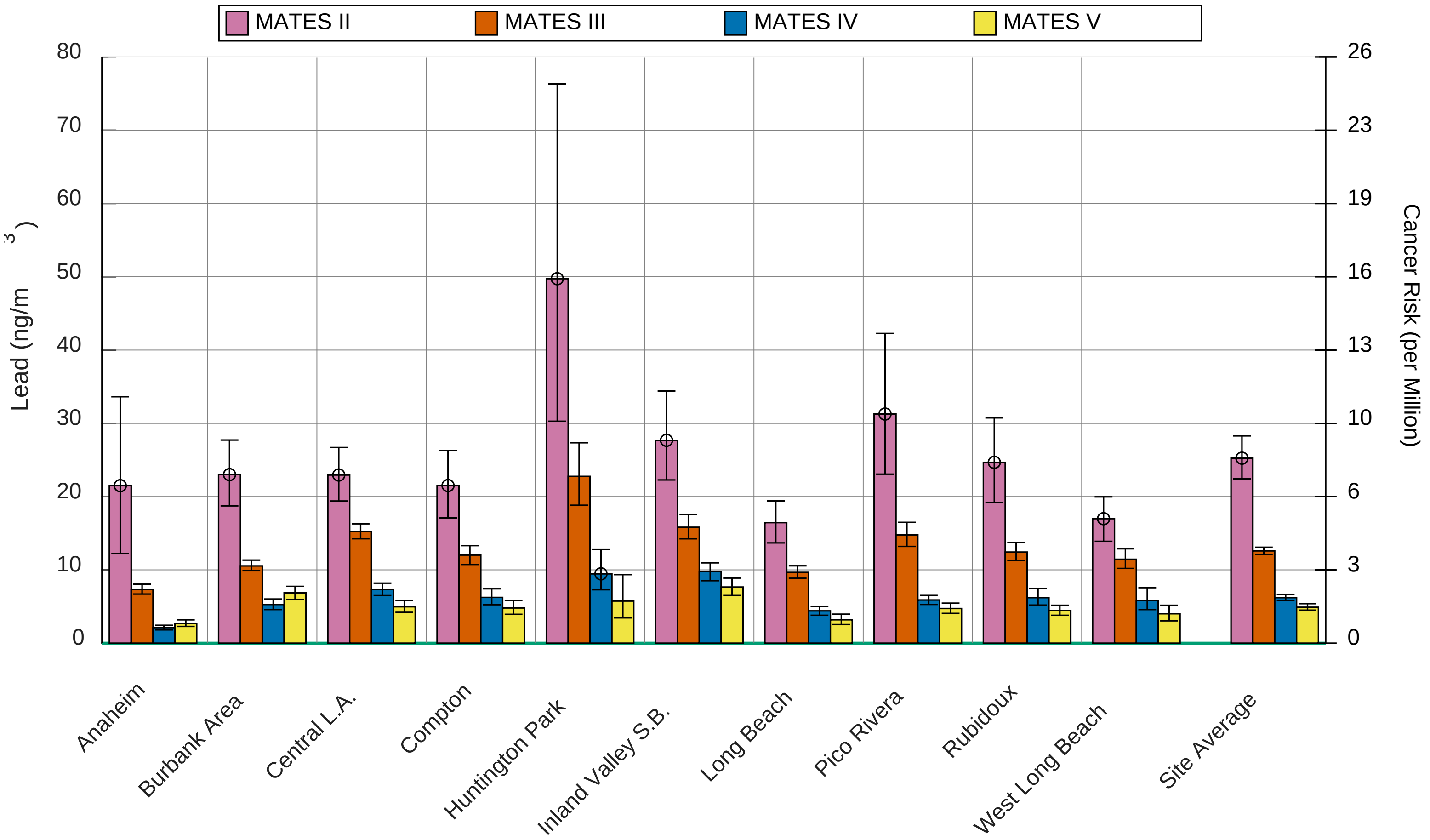


Figure IV-100. Annual Average Concentrations of Lead in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

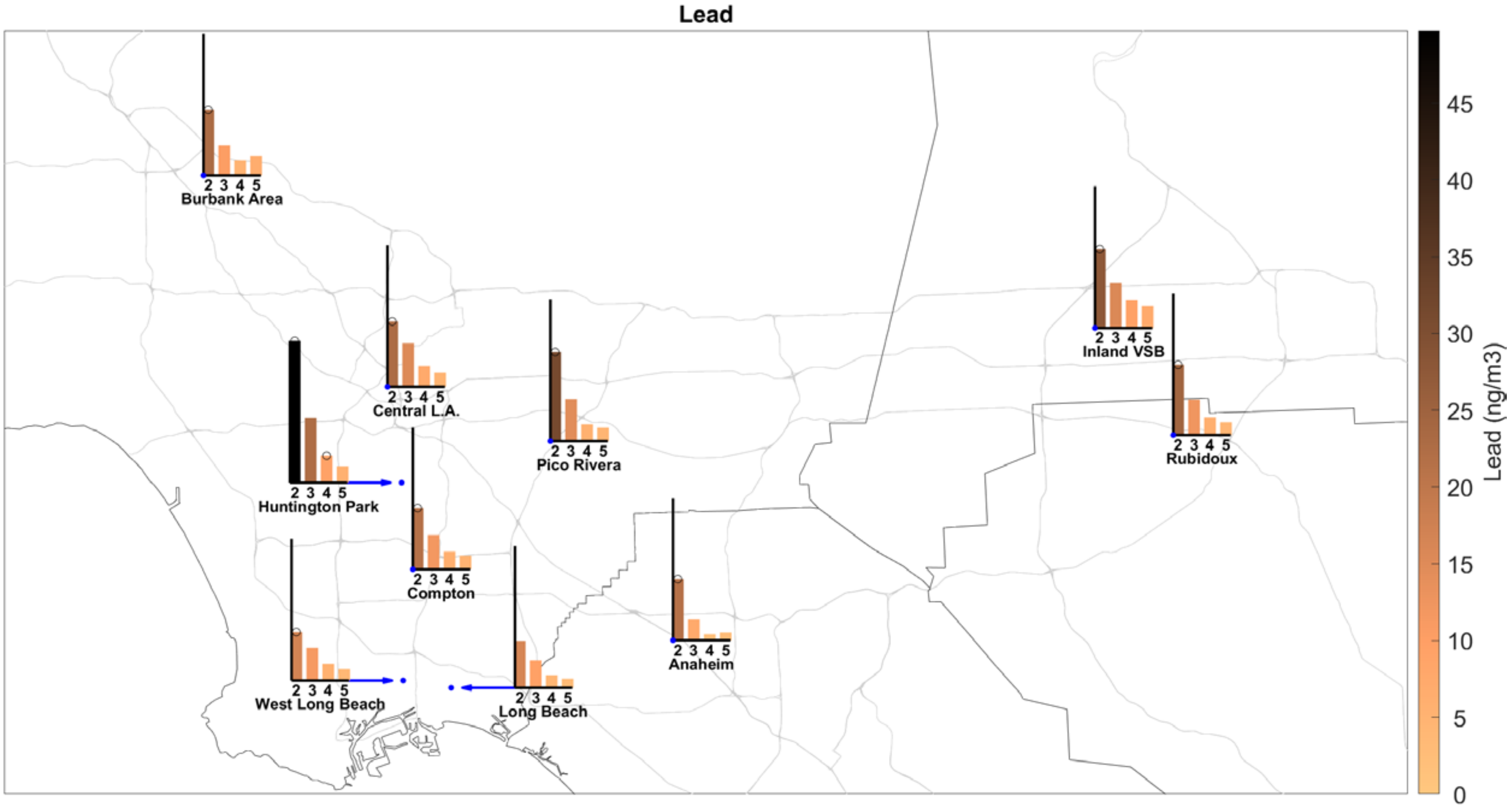


Figure IV-101. Geographic distribution of Lead from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Magnesium

Table IV-53. Ambient Concentrations (ng/m^3) of Magnesium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	175	149	195	204	190	173	123	143	280	231
95% CI LB	112	117	130	161	122	112	90.8	105	231	140
95% CI UB	268	184	281	246	282	264	163	186	330	360
N	25	20	18	21	22	26	23	26	21	19
% < MDL	48	35	33.3	23.8	40.9	46.2	65.2	53.8	9.5	26.3
Max	1170	331	762	357	999	1130	422	498	543	1160
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

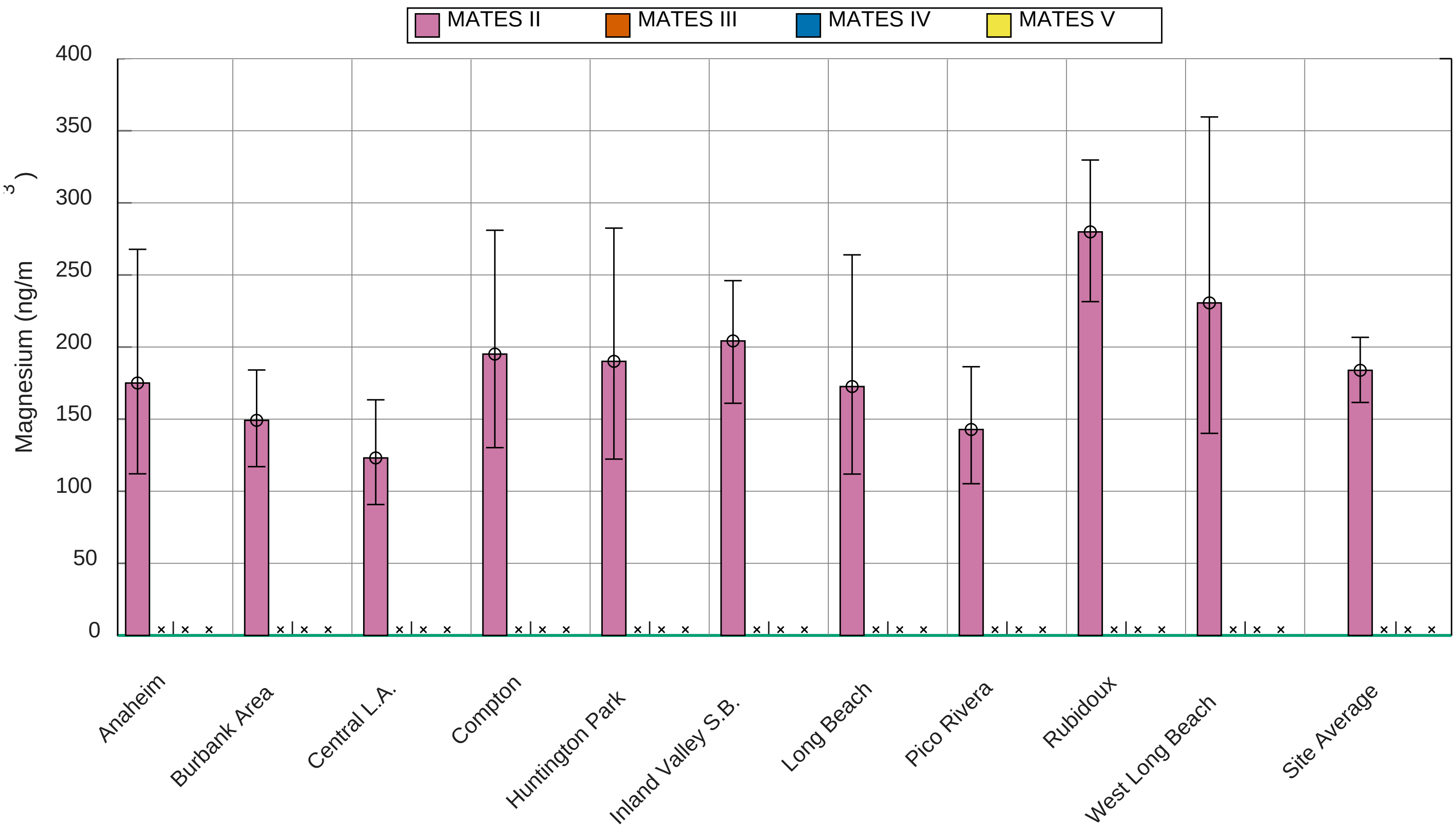


Figure IV-102. Annual Average Concentrations of Magnesium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

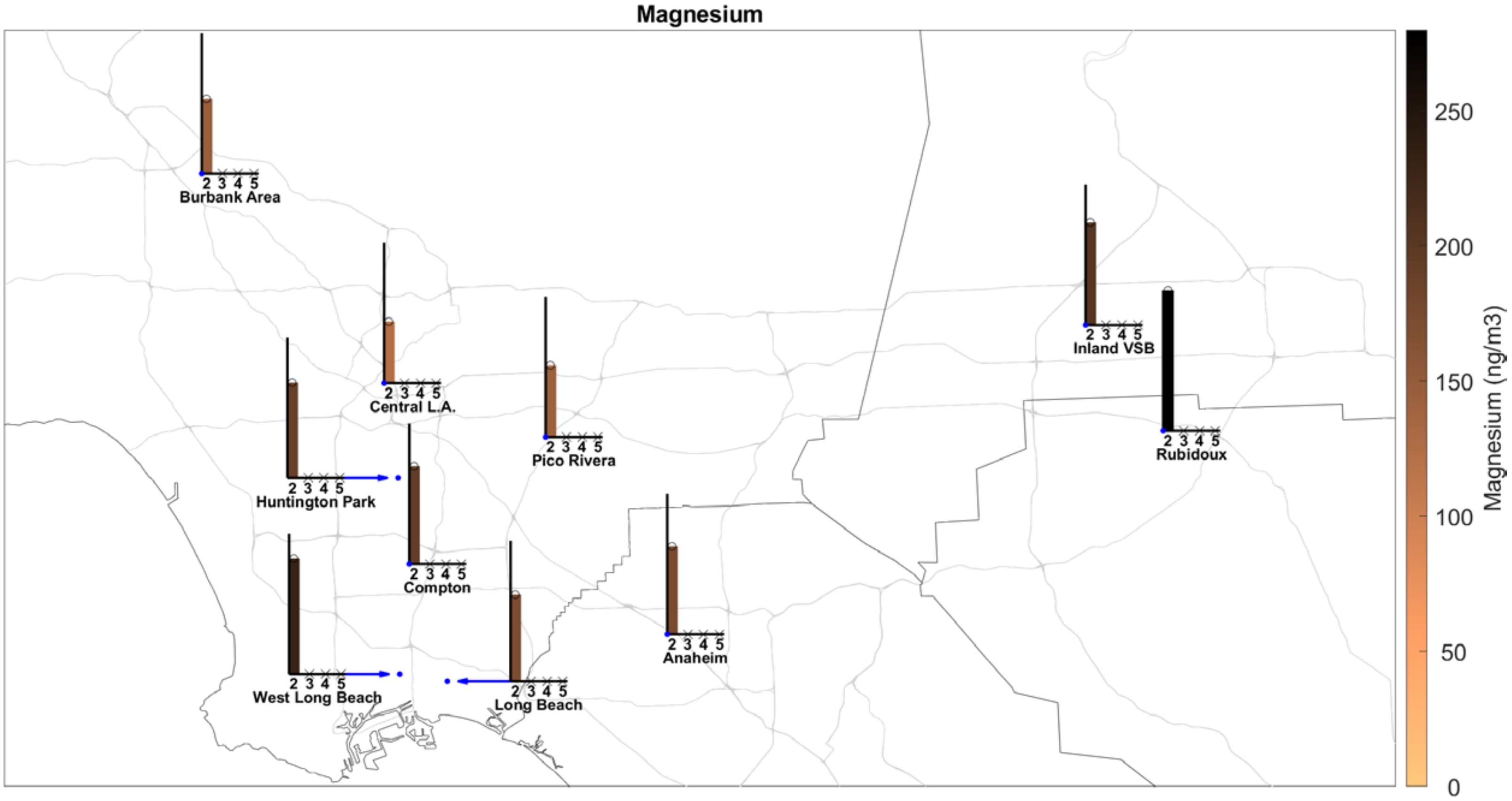


Figure IV-103. Geographic distribution of Magnesium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Manganese

Table IV-54. Ambient Concentrations (ng/m^3) of Manganese from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	21.4	19.7	27	70	26.1	18.6	19.1	29.8	51.5	24.5
95% CI LB	17	16.5	21.4	57.1	21.6	15.1	15.7	24.5	42.7	19
95% CI UB	26.1	22.9	33	83.3	30.5	22.4	22.4	35.3	60.4	30.1
N	45	47	39	41	42	56	51	41	41	39
% < MDL	17.8	8.5	10.3	2.4	7.1	12.5	11.8	4.9	2.4	10.3
Max	66	55.3	76	158	71	72.7	55	68	110	85.1
MATES III										
Average	18.6	21.6	25.1	60.2	32	19.7	25.6	27.3	51.5	29.3
95% CI LB	16.7	20	23.1	55.4	28.4	18	24.1	24.6	48.2	25.7
95% CI UB	20.5	23.3	27.1	65.2	35.9	21.3	27.2	30	55	33.7
N	232	218	228	224	116	230	229	118	237	227
% < MDL	0.4	0.5	0	0.4	0	0.4	0	0	0	0.4
Max	110	128	102	192	99.6	72.5	56.5	86.7	158	357
MATES IV										
Average	8.32	15.2	18.6	52	22.7	14.4	19.2	21.2	33	21.3
95% CI LB	7.01	13	15.5	44.4	17.8	12.3	17	18.7	27.3	18.1
95% CI UB	9.73	17.3	22	60.1	28.6	16.5	21.5	23.8	40.1	24.9
N	60	58	59	56	55	59	59	60	58	58
% < MDL	0	0	0	0	0	1.7	0	0	0	0
Max	28.3	40.2	77.5	120	103	42.6	38.8	40.3	178	61.7
MATES V										
Average	14.3	19.3	17.8	54.1	14.7	13.8	16.7	29.4	31.7	20.2
95% CI LB	12.2	16.5	14.9	44.9	12.1	11.1	14.6	25.4	27.1	16.4
95% CI UB	16.9	22.3	21.3	64.4	17.3	17.4	19	33.5	36.5	25.1
N	61	58	61	59	61	60	60	60	60	59
% < MDL	0	0	0	0	0	0	1.7	0	0	0
Max	43.6	51.2	68.7	194	43.1	86.8	40.6	75.5	99	122

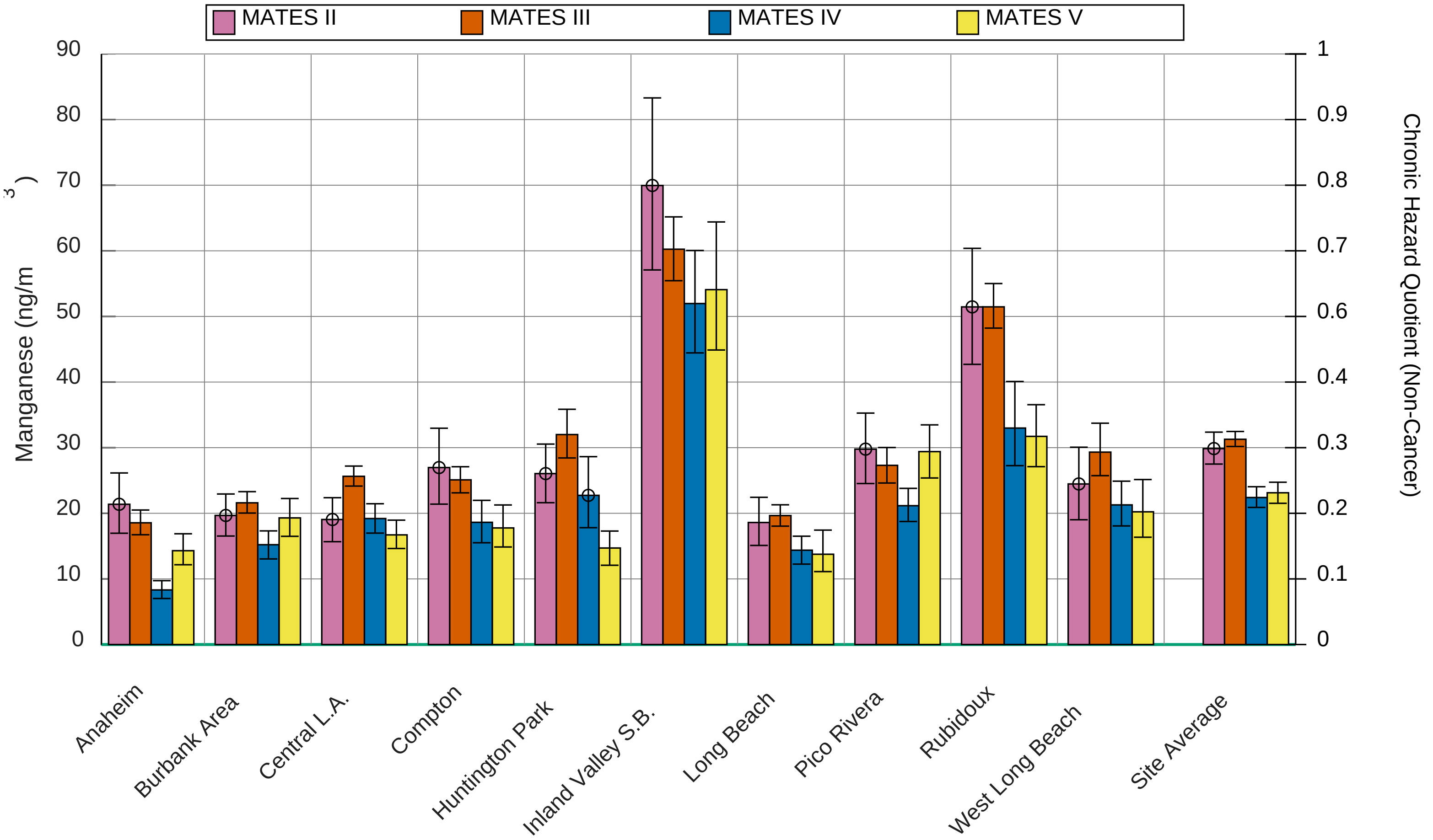


Figure IV-104. Annual Average Concentrations of Manganese in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

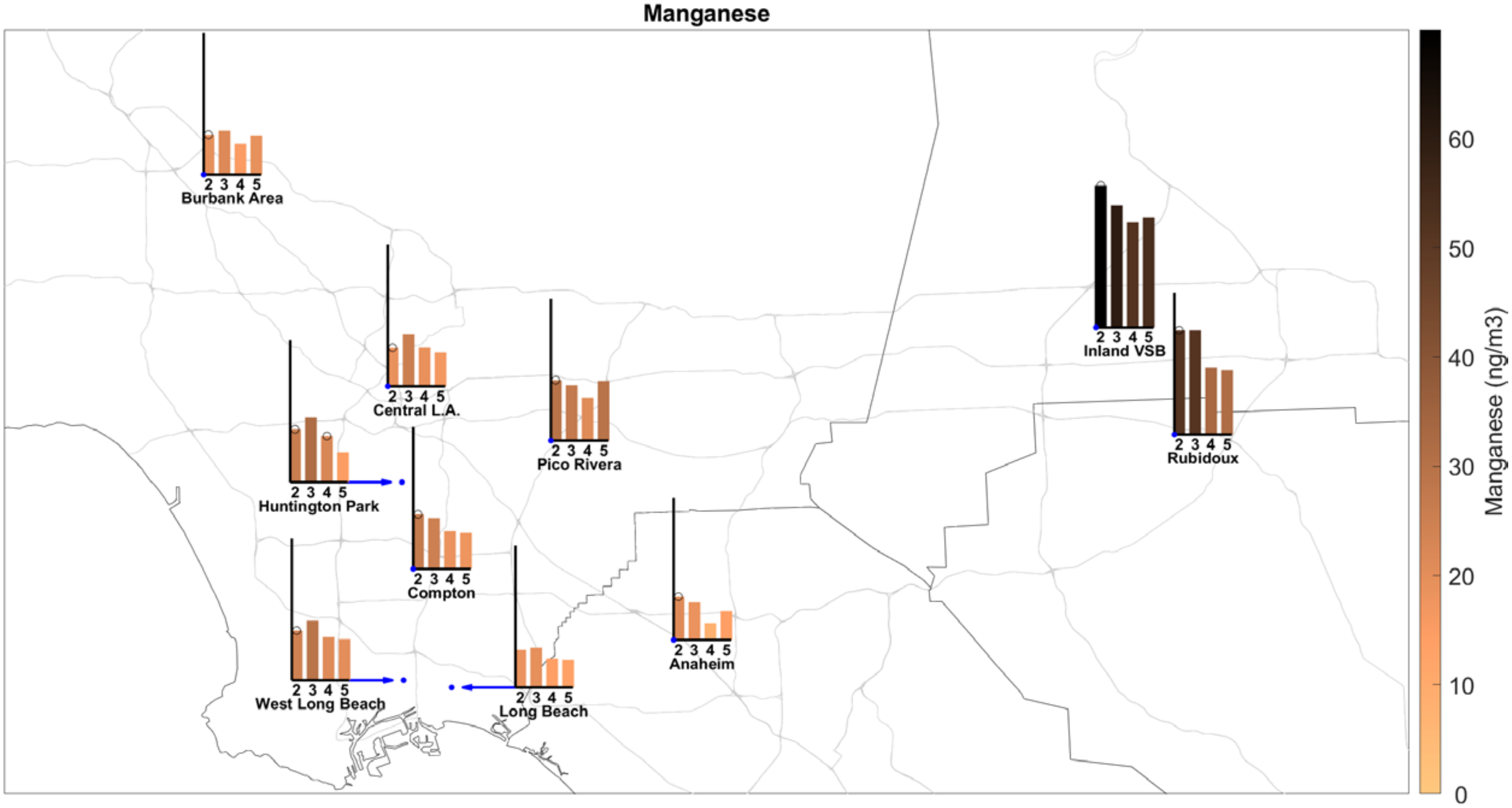


Figure IV-105. Geographic distribution of Manganese from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Mercury

Table IV-55. Ambient Concentrations (ng/m^3) of Mercury from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.2, 3.05[a]	0.111, 3[a]	0.143, 3[a]	0.25, 3.1[a]	3.65	0, 3[a]	0, 3[a]	0.2, 3[a]	0.55, 3.1[a]	0.2, 3.05[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	3	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	3.15[a]	3[a]	3[a]	3.3[a]	4.7	3[a]	3[a]	3[a]	3.25[a]	3.15[a]
N	20[a]	27[a]	21[a]	20[a]	20	30[a]	28[a]	15[a]	20[a]	20[a]
% < MDL	95[a]	96.3[a]	95.2[a]	95[a]	80	100[a]	100[a]	93.3[a]	85[a]	95[a]
Max	4[a]	3[a]	3[a]	5[a]	12	< MDL[a]	< MDL[a]	3[a]	4[a]	4[a]
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

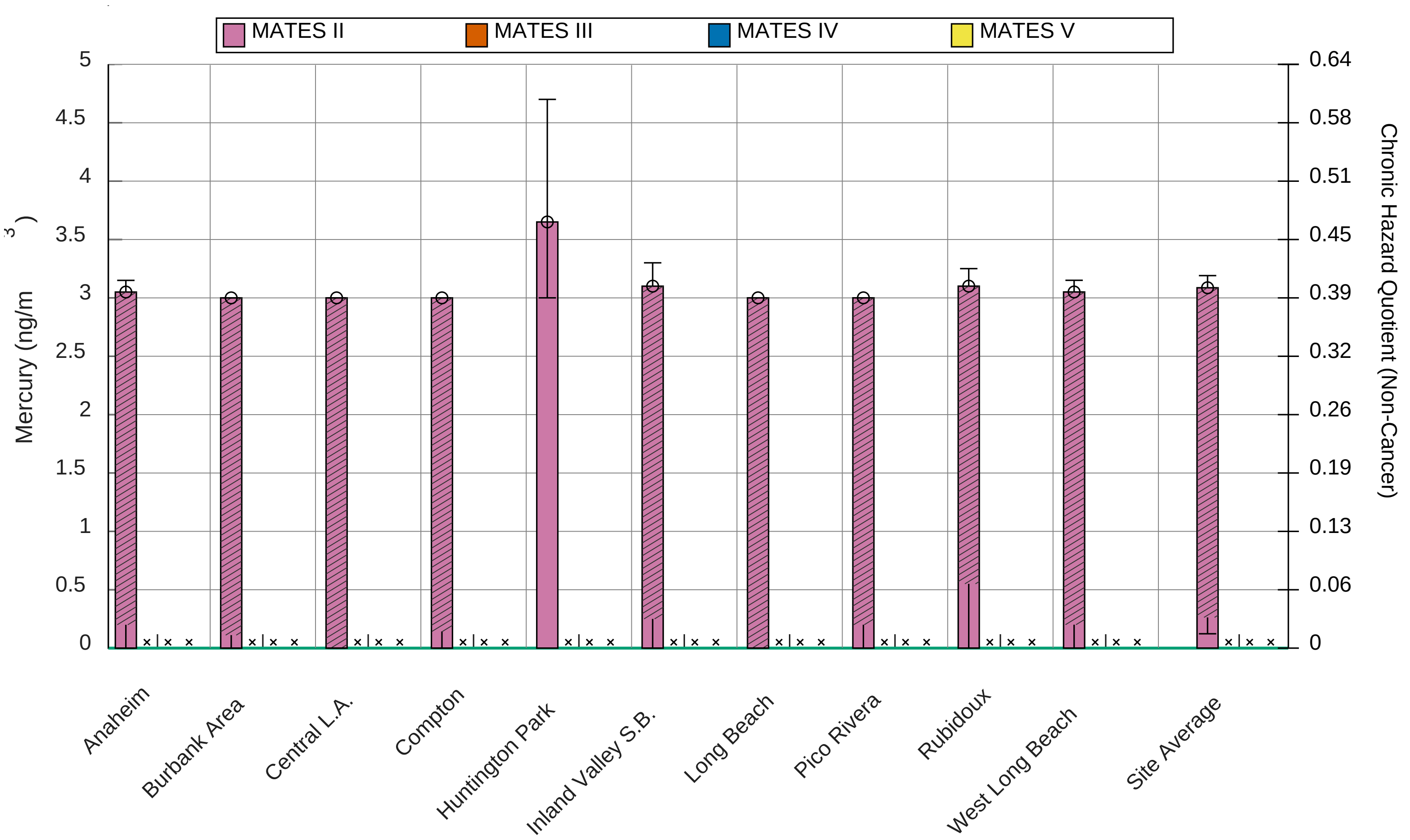


Figure IV-106. Annual Average Concentrations of Mercury in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

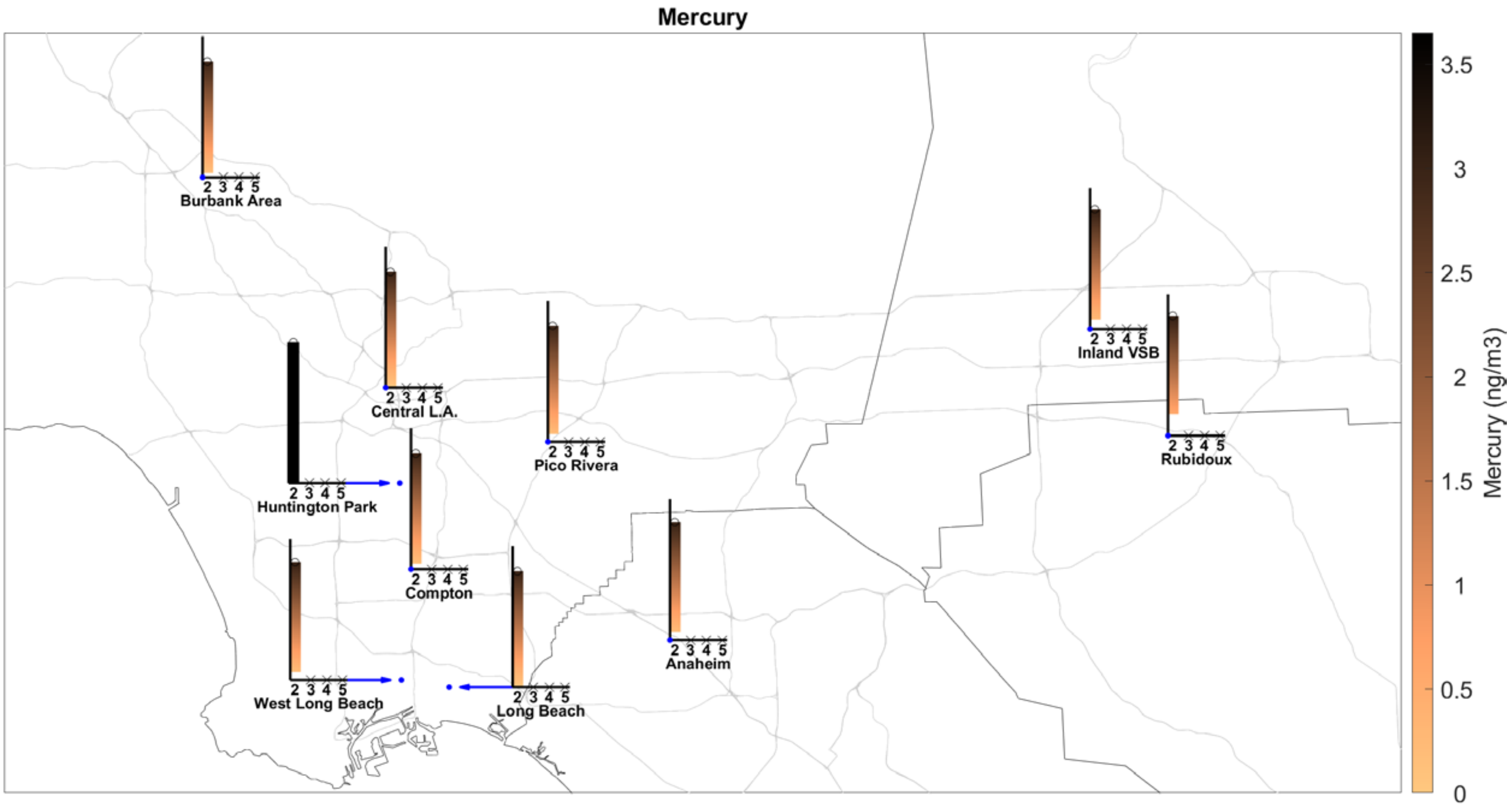


Figure IV-107. Geographic distribution of Mercury from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Molybdenum

Table IV-56. Ambient Concentrations (ng/m^3) of Molybdenum from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	7.73	6.91	3.5	8.33	9.99	7.96	5.05	9.22	5.46	4.17
95% CI LB	4.63	4.65	2.27	4.69	6.47	4.89	3.52	5.74	2.98	2.62
95% CI UB	11.1	10.9	5.32	12.7	13.8	11.8	7.66	13.1	8.96	6.93
N	45	47	39	41	42	56	51	41	41	39
% < MDL	60	74.5	71.8	56.1	45.2	67.9	74.5	48.8	70.7	76.9
Max	32.7	63.6	27.7	57.7	38.4	59.8	35	44.2	39.5	36.7
MATES III										
Average	3.95	4.13	3.99	3.73	4.14	3.93	4.74	4.55	3.68	4.32
95% CI LB	3.48	3.67	3.57	3.33	3.35	3.53	4.21	3.87	3.36	3.77
95% CI UB	4.44	4.65	4.5	4.21	5.05	4.37	5.32	5.33	4.06	4.93
N	232	218	228	224	116	230	229	118	237	227
% < MDL	34.1	26.1	31.6	29.5	33.6	27	21	20.3	23.2	32.2
Max	26.3	24.7	29.6	23.6	28.1	23.4	25.3	22.3	22.6	28.2
MATES IV										
Average	0.826	1.81	1.9	2.13	2.39	1.74	3.36	1.66	1.39	1.58
95% CI LB	0.678	1.53	1.56	1.72	1.81	1.34	2.72	1.4	1.12	1.28
95% CI UB	0.991	2.12	2.29	2.64	3.15	2.18	4.03	1.96	1.72	1.96
N	60	58	59	56	55	59	59	60	58	58
% < MDL	0	0	0	0	0	1.7	0	0	0	0
Max	2.84	5.27	6.62	9.78	17	7.25	12.6	5.88	8.48	7.35
MATES V										
Average	0.793	0.852	1.31	1.52	1.25	1	2.45	1.07	0.766	1.17
95% CI LB	0.647	0.729	1.06	1.16	0.931	0.737	2.1	0.922	0.664	0.915
95% CI UB	0.97	0.981	1.61	2.08	1.64	1.35	2.82	1.23	0.873	1.46
N	60	57	60	59	59	59	60	60	60	58
% < MDL	0	0	0	0	3.4	0	0	0	0	0
Max	4.16	2.09	5.01	14.7	9.48	8	6.52	2.84	1.87	5.56

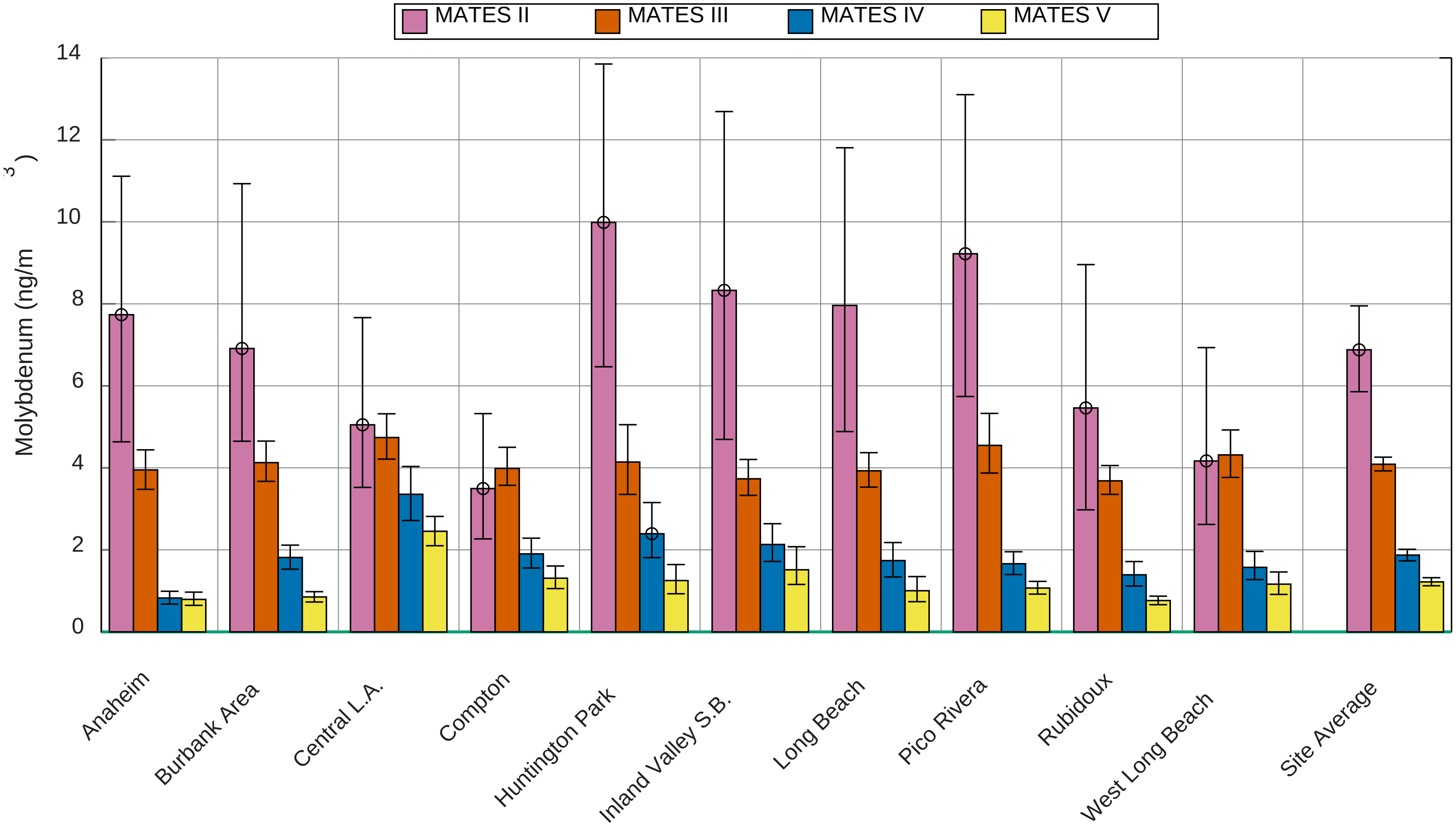


Figure IV-108. Annual Average Concentrations of Molybdenum in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

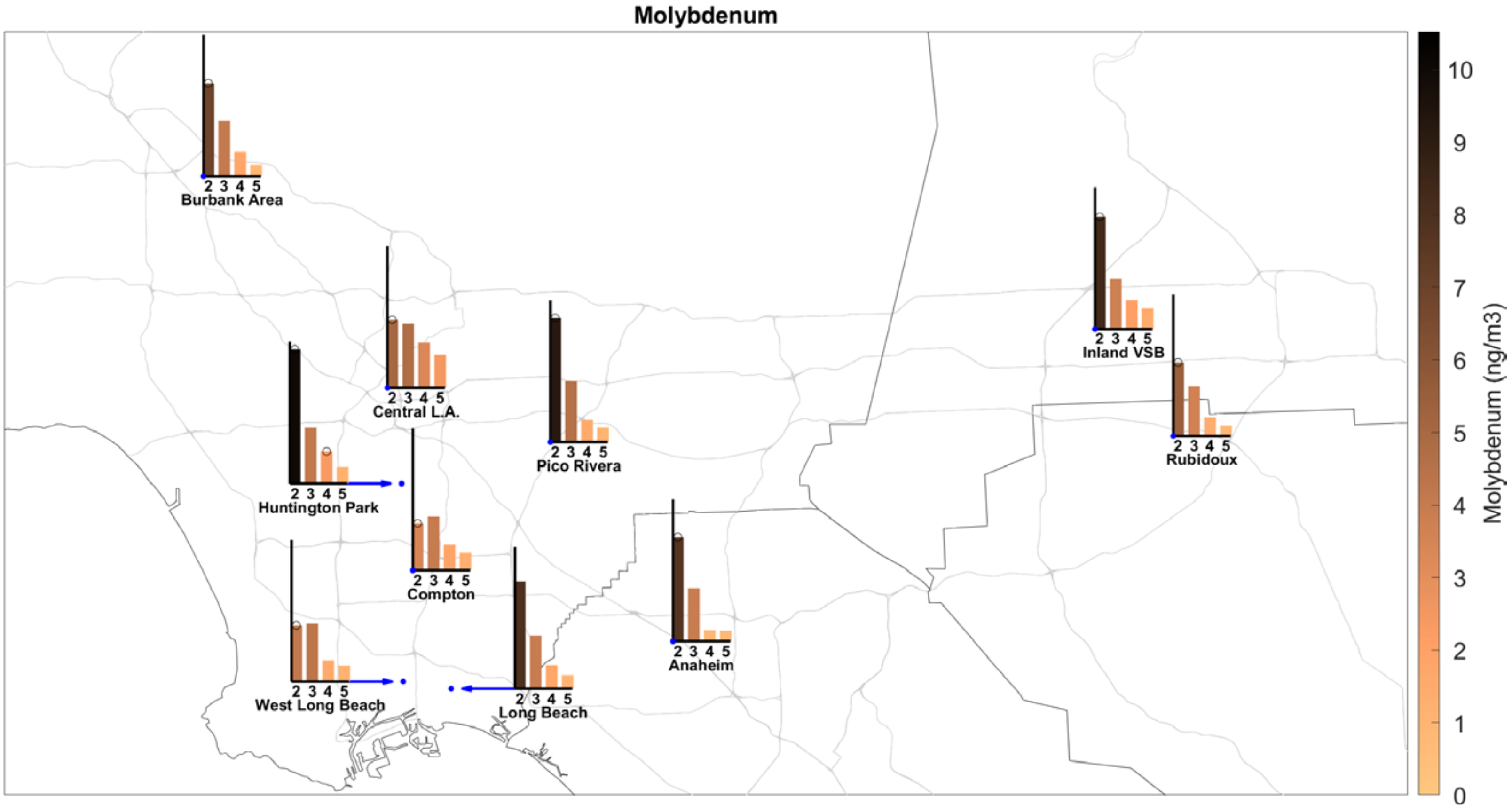


Figure IV-109. Geographic distribution of Molybdenum from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Nickel

Table IV-57. Ambient Concentrations (ng/m^3) of Nickel from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	7.29	6.41	8.65	8.65	11.8	7.89	7.36	12.5	7.65	10.2
95% CI LB	6.03	5.26	6.96	7.01	9.61	6.61	5.76	7.78	6.02	8.25
95% CI UB	8.64	7.79	10.4	10.4	14.2	9.28	9.31	20.4	9.42	12.2
N	45	47	39	41	42	56	51	41	41	39
% < MDL	6.7	8.5	0	4.9	2.4	5.4	9.8	4.9	9.8	2.6
Max	18.7	24.9	30.2	21.4	38.8	21.8	38	153	21.6	25.7
MATES III										
Average	4.3	3.97	6.24	4.04	7.79	7.12	5.49	5.2	3.91	11.2
95% CI LB	3.97	3.69	5.76	3.71	6.8	6.64	4.89	4.71	3.62	10.4
95% CI UB	4.64	4.27	6.71	4.38	8.86	7.62	6.23	5.71	4.2	12.1
N	232	218	228	224	116	230	229	118	237	227
% < MDL	4.3	5	3.1	11.2	1.7	2.6	3.5	0.8	11	1.8
Max	15	17.1	21.4	13.2	29.7	19.2	69.8	17.4	15	34.5
MATES IV										
Average	1.78	3.9	4.06	4.06	5.4	3.6	3.37	4.47	3.36	3.73
95% CI LB	1.55	2.3	3.44	3.51	3.95	2.98	2.69	3.87	2.79	3.23
95% CI UB	2.03	6.2	4.75	4.68	7.5	4.34	4.44	5.19	4.02	4.3
N	60	58	59	56	55	59	59	60	58	58
% < MDL	15	5.2	0	1.8	0	5.1	0	0	6.9	1.7
Max	5.8	44.5	13.7	13.4	50	14.8	29.4	17.5	14.6	13
MATES V										
Average	2.17	2.01	2.93	6.31	2.64	3.64	2	3	2.41	3.74
95% CI LB	1.82	1.75	2.38	4.04	2	2.8	1.77	2.67	2.08	3.07
95% CI UB	2.58	2.28	3.49	9.66	3.53	4.6	2.26	3.33	2.79	4.48
N	61	58	61	59	61	60	60	60	60	59
% < MDL	0	0	0	0	3.3	0	1.7	0	0	0
Max	8.32	4.24	8.85	83.5	23.2	18.3	5.24	7.55	9.23	12.2

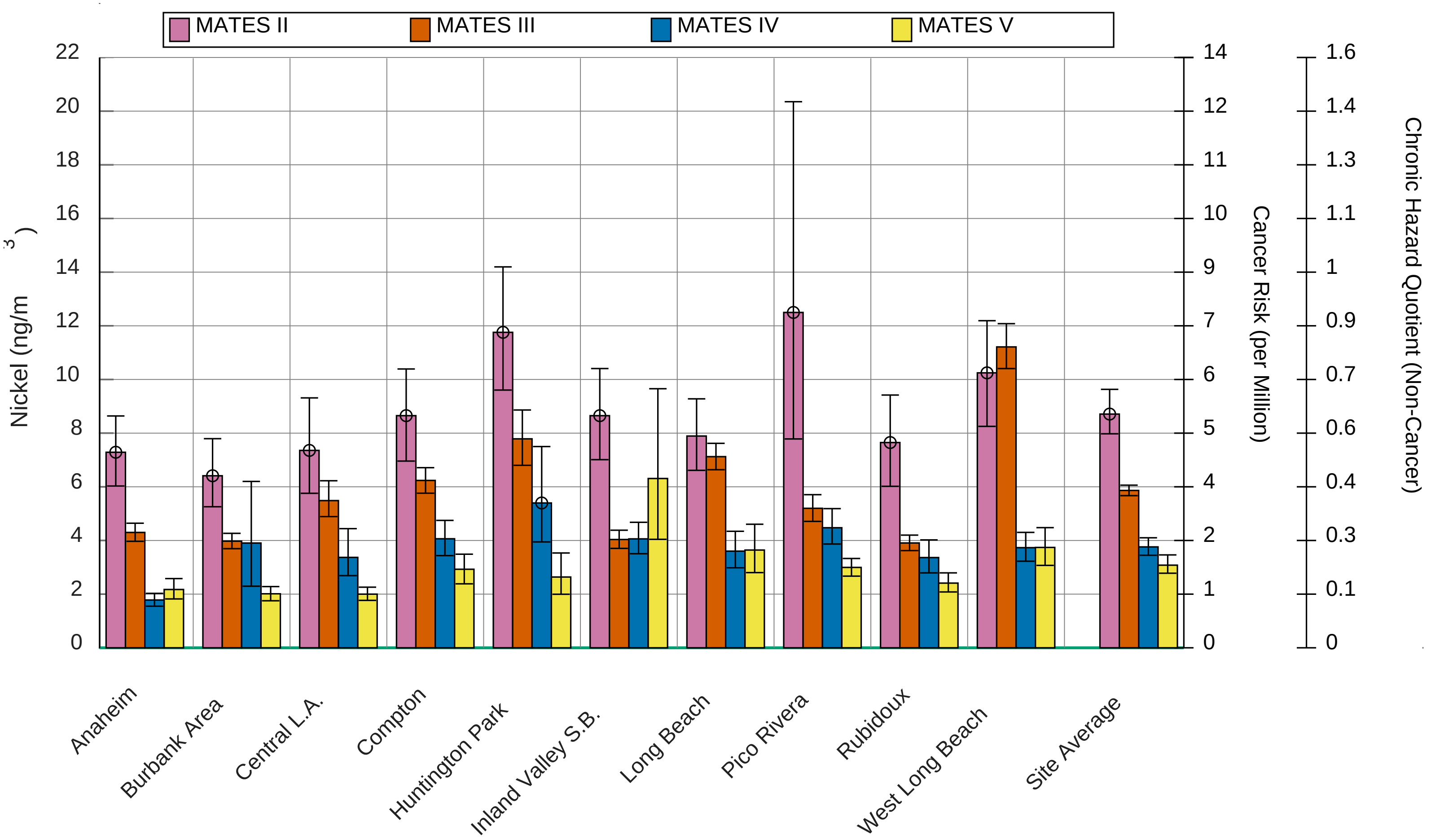


Figure IV-110. Annual Average Concentrations of Nickel in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

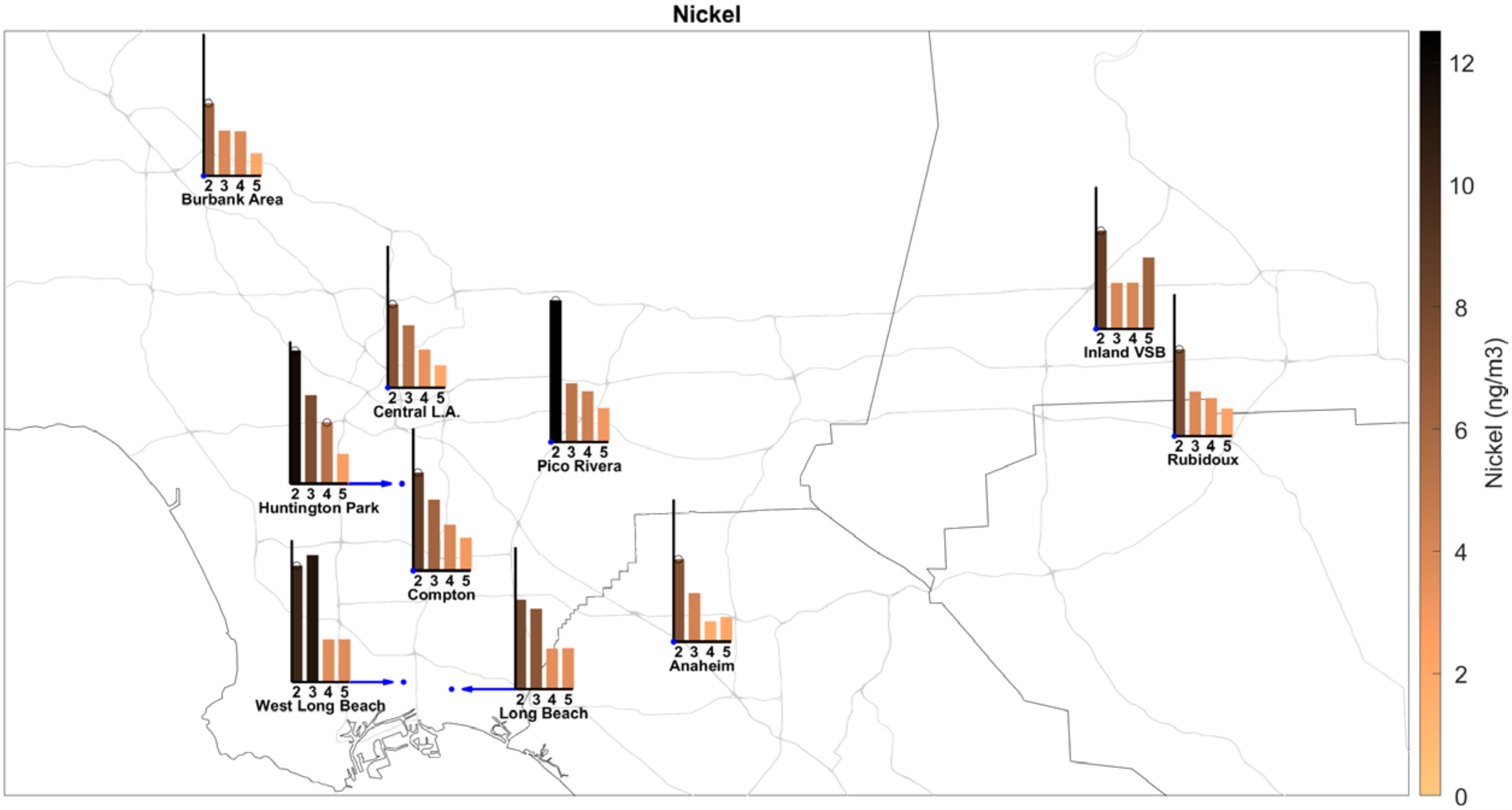


Figure IV-111. Geographic distribution of Nickel from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Palladium

Table IV-58. Ambient Concentrations (ng/m^3) of Palladium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 11[a]	1.29, 11.7[a]	0, 11[a]	1.1, 11.6[a]	0, 11[a]	0, 11[a]	1.37, 11.9[a]	1.24, 11.8[a]	1.19, 11.7[a]	0, 11[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	11[a]	13.2[a]	11[a]	12.7[a]	11[a]	11[a]	13.7[a]	13.5[a]	13[a]	11[a]
N	25[a]	20[a]	18[a]	21[a]	22[a]	26[a]	23[a]	26[a]	21[a]	19[a]
% < MDL	100[a]	95[a]	100[a]	95.2[a]	100[a]	100[a]	95.7[a]	96.2[a]	95.2[a]	100[a]
Max	< MDL[a]	25.7[a]	< MDL[a]	23.1[a]	< MDL[a]	< MDL[a]	31.4[a]	32.3[a]	24.9[a]	< MDL[a]
MATES III										
Average	0.142, 3.03[a]	0.145, 3.02[a]	0.0487, 3.01[a]	0.0997, 3.01[a]	0.0852, 3.01[a]	0.0621, 3.01[a]	0.101, 3.01[a]	0.256, 3.05[a]	0.0267, 3[a]	0.093, 3.01[a]
95% CI LB	0.0583[a]	0.0613[a]	0[a]	0.0297[a]	0[a]	0.0136[a]	0.0304[a]	0.0939[a]	0[a]	0.027[a]
95% CI UB	3.05[a]	3.04[a]	3.03[a]	3.01[a]	3.02[a]	3.02[a]	3.02[a]	3.11[a]	3[a]	3.04[a]
N	232[a]	218[a]	228[a]	224[a]	116[a]	230[a]	229[a]	118[a]	237[a]	227[a]
% < MDL	96.1[a]	95.9[a]	98.7[a]	96.9[a]	97.4[a]	98.3[a]	96.9[a]	93.2[a]	99.2[a]	97.4[a]
Max	4.64[a]	4.55[a]	4.61[a]	3.52[a]	3.8[a]	4.28[a]	3.8[a]	5.63[a]	3.26[a]	5.4[a]
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

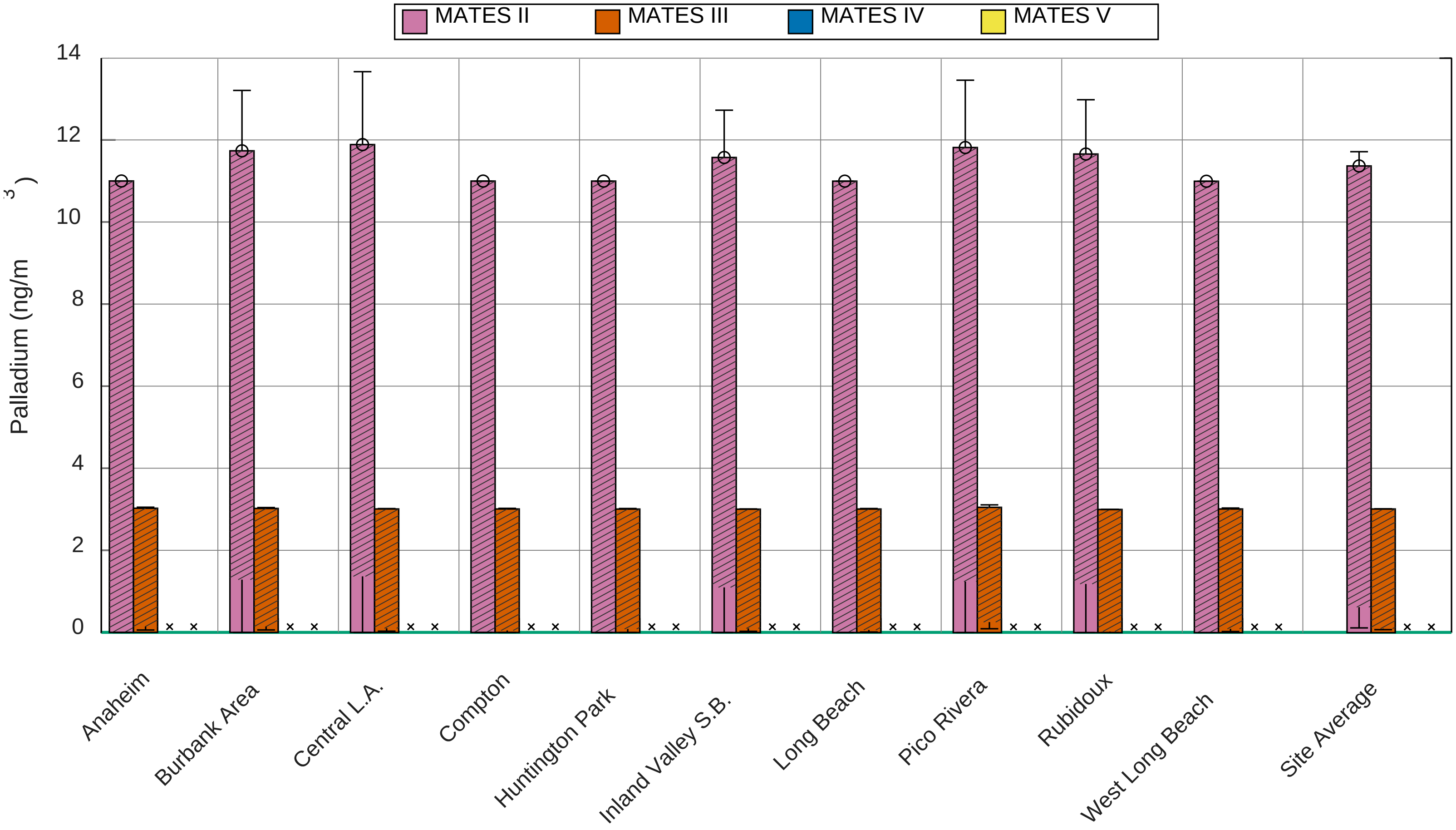


Figure IV-112. Annual Average Concentrations of Palladium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

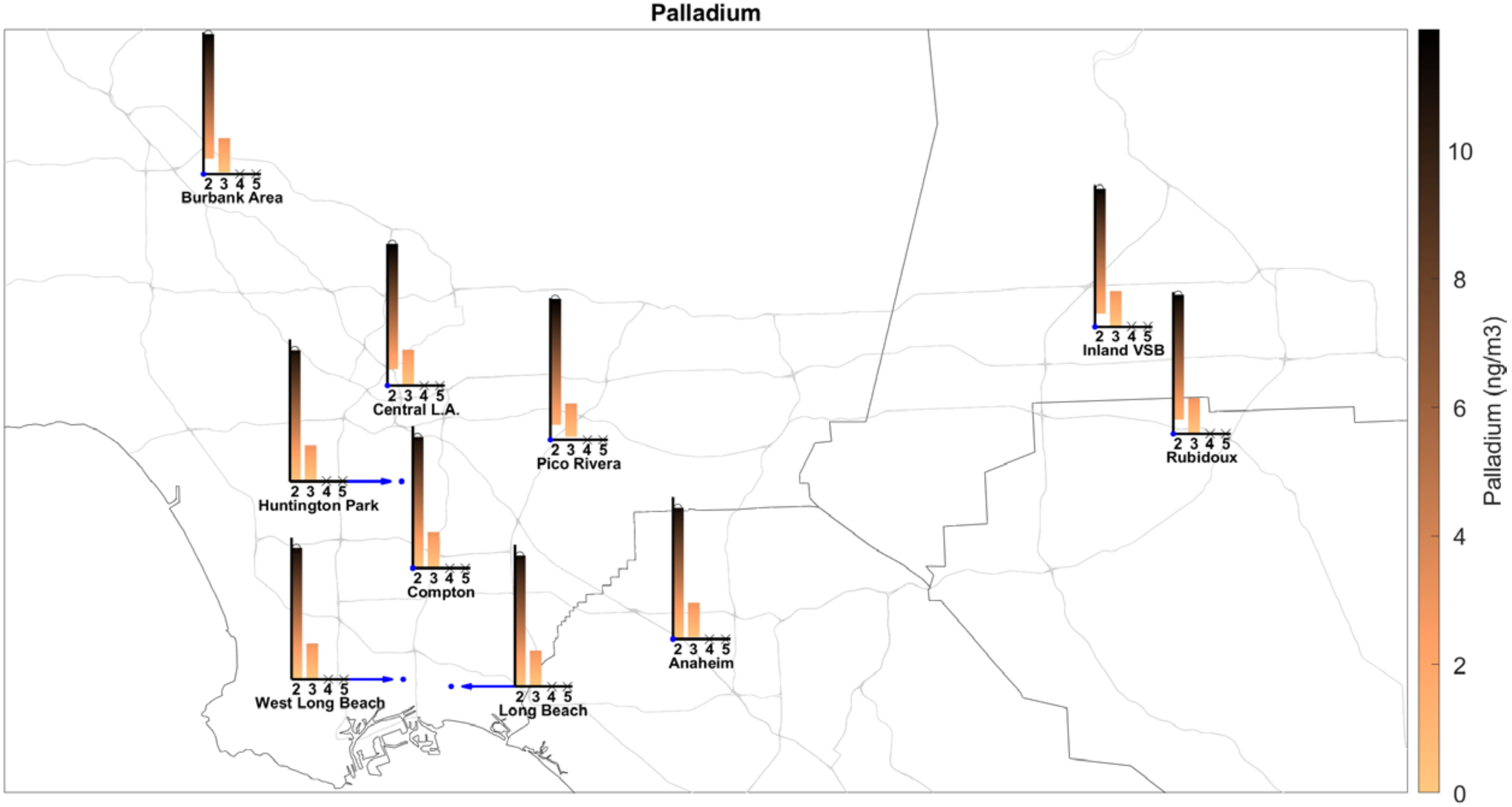


Figure IV-113. Geographic distribution of Palladium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Phosphorus

Table IV-59. Ambient Concentrations (ng/m^3) of Phosphorus from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	35.6	42.1	53.3	80.6	47.6	33	40	35.2	196	39.2
95% CI LB	26.9	34	39.6	58.1	35.6	26.7	31.9	26.5	152	29.9
95% CI UB	45.3	50.1	68.5	106	60.5	39.4	48.2	44.4	243	49.5
N	45	47	39	41	42	56	51	41	41	39
% < MDL	55.6	42.6	41	36.6	50	48.2	45.1	63.4	17.1	48.7
Max	151	101	187	372	186	121	140	109	471	143
MATES III										
Average	48.2	45.5	57.7	42.8	63.6	54.8	47.5	44.9	91.2	55.4
95% CI LB	44.5	42.3	53.4	39.4	57.7	50.2	43.4	40.2	82.1	50.7
95% CI UB	52.2	48.7	62.2	46.8	69.8	59.7	51.5	49.7	101	60.1
N	232	218	228	224	116	230	229	118	237	227
% < MDL	25	23.9	10.1	37.9	6	18.7	31	23.7	24.5	18.1
Max	152	126	160	147	159	200	182	143	264	197
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

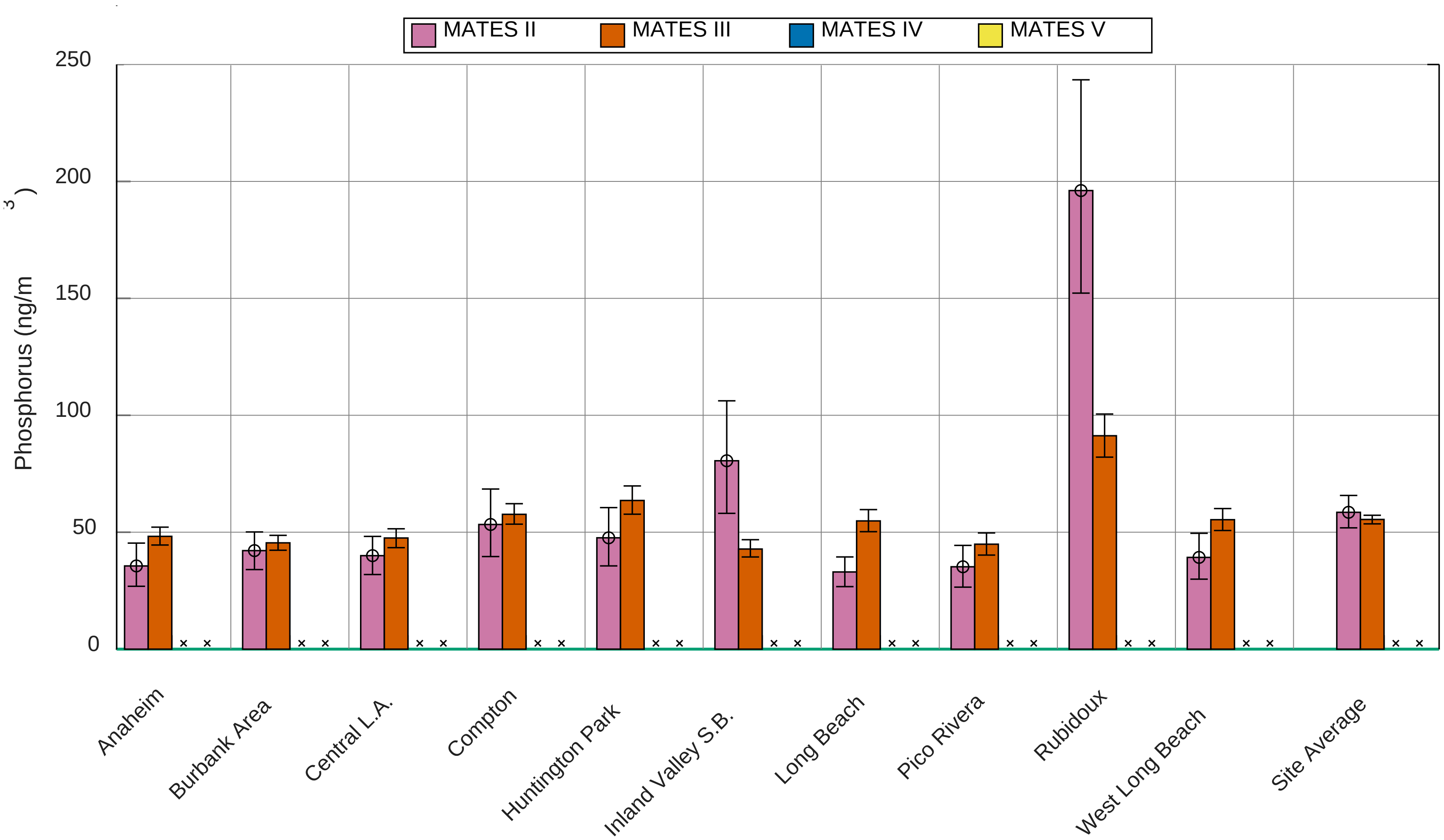


Figure IV-114. Annual Average Concentrations of Phosphorus in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

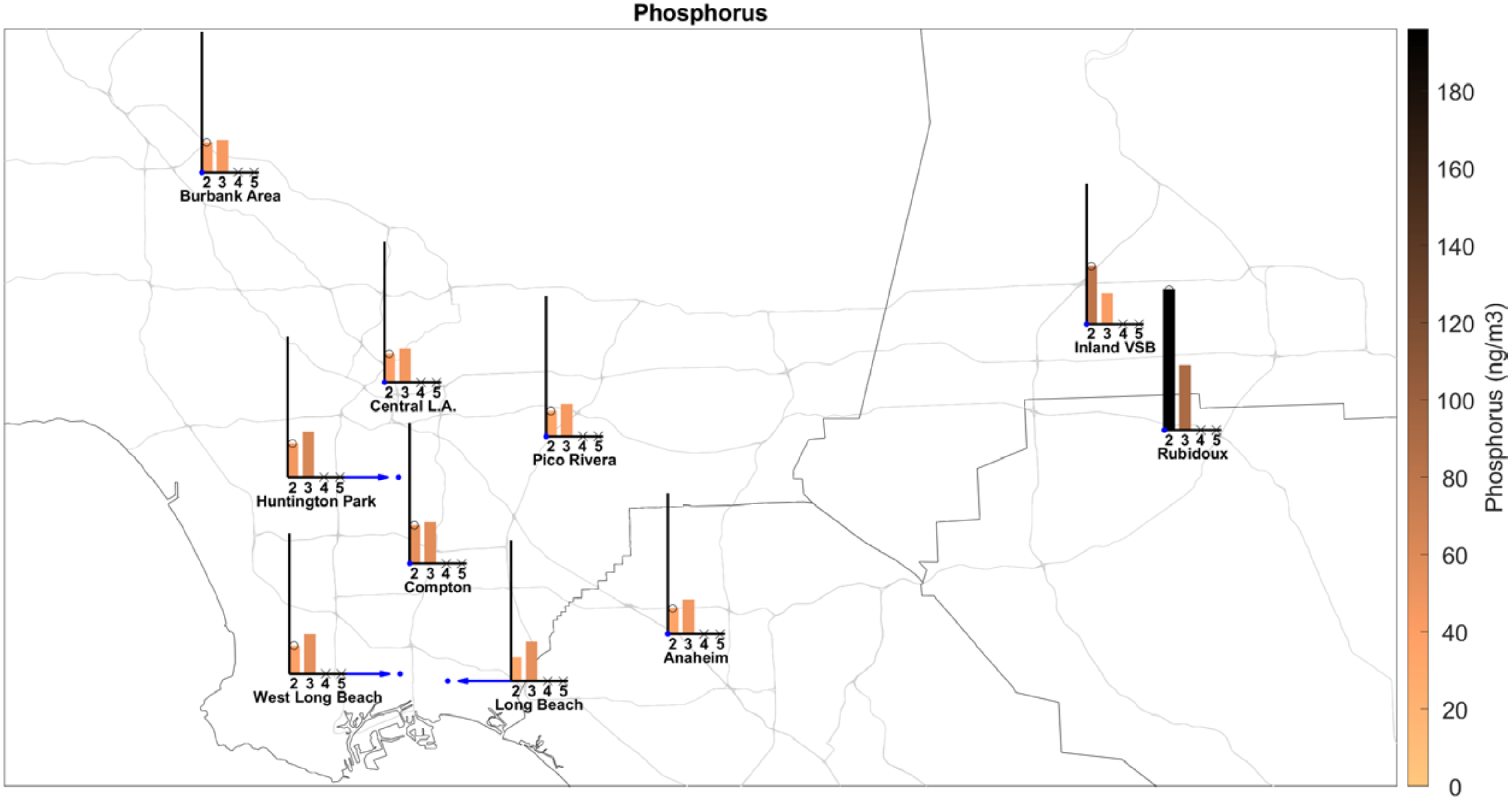


Figure IV-115. Geographic distribution of Phosphorus from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Potassium

Table IV-60. Ambient Concentrations (ng/m^3) of Potassium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	913	655	777	1120	1040	588	568	910	1690	725
95% CI LB	694	575	650	891	653	510	489	695	1380	618
95% CI UB	1190	743	913	1370	1580	673	653	1180	2010	830
N	45	47	39	41	42	56	51	41	41	39
% < MDL	0	0	0	0	0	0	2	2.4	2.4	0
Max	4380	1760	1810	3390	7950	1740	1640	4550	4100	1760
MATES III										
Average	447	460	483	762	582	429	457	531	1130	524
95% CI LB	404	422	449	649	521	401	422	488	1020	485
95% CI UB	505	511	524	940	660	458	501	578	1270	567
N	232	218	228	224	116	230	229	118	237	227
% < MDL	0	0	0	0.4	0	0	0	0	0	0
Max	5650	4540	3040	17500	3720	1740	4190	1910	13100	2380
MATES IV										
Average	250	320	398	812	371	357	382	454	985	475
95% CI LB	199	271	342	616	316	293	315	380	751	390
95% CI UB	308	372	463	1040	433	431	458	537	1250	572
N	60	58	59	56	55	59	59	60	58	58
% < MDL	0	0	0	0	0	1.7	0	0	0	0
Max	1150	998	1240	4420	1350	1350	1490	1470	4170	1920
MATES V										
Average	350	372	431	641	323	352	336	634	791	415
95% CI LB	297	313	357	526	270	275	291	504	660	349
95% CI UB	410	439	521	765	382	462	387	783	932	488
N	46	44	47	45	47	45	45	44	44	44
% < MDL	0	2.3	0	0	12.8	0	4.4	2.3	0	0
Max	1260	950	1760	1880	911	2290	850	2390	1710	1190

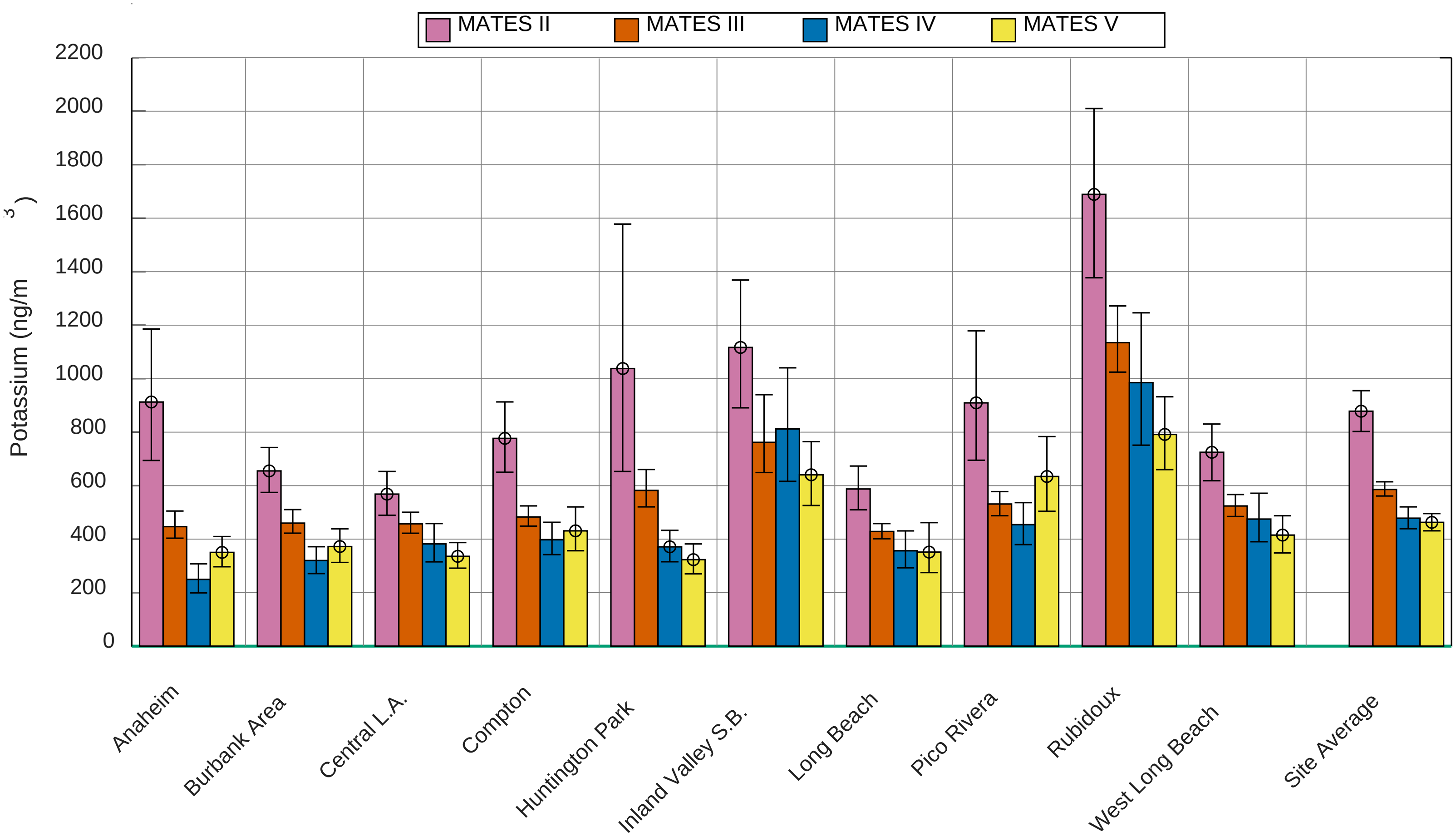


Figure IV-116. Annual Average Concentrations of Potassium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

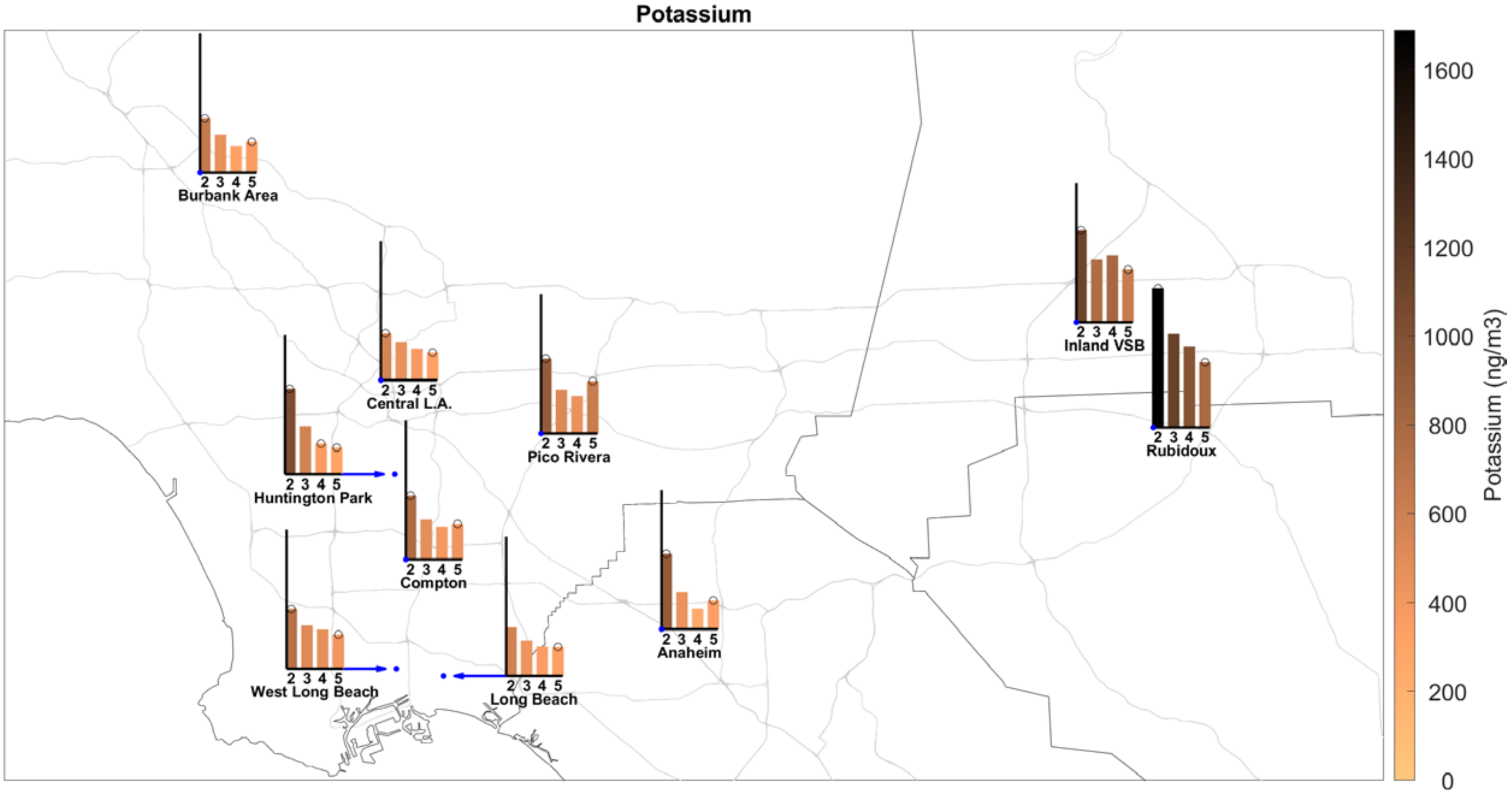


Figure IV-117. Geographic distribution of Potassium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Rubidium

Table IV-61. Ambient Concentrations (ng/m^3) of Rubidium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	3.89	3	3.44	5.22	3.2	2.71	2.71	3.18	7.19	3.17
95% CI LB	3.28	2.57	2.84	4.23	2.74	2.4	2.42	2.68	5.8	2.64
95% CI UB	4.56	3.48	4.1	6.33	3.73	3.08	3.05	3.73	8.64	3.76
N	45	47	39	41	42	56	51	41	41	39
% < MDL	35.6	48.9	43.6	24.4	42.9	62.5	58.8	48.8	19.5	51.3
Max	10	8.81	9.94	16.6	8.29	8.84	6.55	7.87	18.1	9.01
MATES III										
Average	1.41	1.25	1.29	2.64	1.52	1.29	1.3	1.69	4.22	1.67
95% CI LB	1.31	1.19	1.23	2.41	1.34	1.22	1.23	1.5	3.91	1.51
95% CI UB	1.54	1.32	1.38	2.9	1.73	1.36	1.36	1.9	4.53	1.86
N	232	218	228	224	116	230	229	118	237	227
% < MDL	62.9	64.2	61.4	30.8	50.9	64.8	58.1	44.9	16.5	53.7
Max	6.9	4.57	5.36	12	9.13	5.29	3.51	8.13	11.6	13.6
MATES IV										
Average	0.643	1.14	1.17	2.24	1.14	0.948	1.12	1.25	2.18	1.45
95% CI LB	0.539	0.924	0.966	1.78	0.938	0.783	0.926	1.02	1.73	1.17
95% CI UB	0.758	1.36	1.39	2.68	1.36	1.12	1.31	1.46	2.61	1.78
N	41	39	40	39	40	41	40	42	39	41
% < MDL	19.5	7.7	7.5	0	5	7.3	12.5	7.1	5.1	7.3
Max	1.63	3.24	2.77	5.77	3.39	2.07	3.41	3.18	5.57	4.48
MATES V										
Average	1.33	1.53	1.38	3.01	1.1	1.18	1.18	2.38	3.16	1.58
95% CI LB	1.11	1.29	1.13	2.43	0.905	0.937	1.01	2.03	2.7	1.25
95% CI UB	1.57	1.78	1.68	3.67	1.3	1.53	1.36	2.75	3.63	2.03
N	61	58	61	59	61	60	60	60	60	59
% < MDL	0	0	0	0	0	0	1.7	0	0	0
Max	5.17	4.41	6.85	14.7	3.68	8.84	3.54	7.26	9.39	11.3

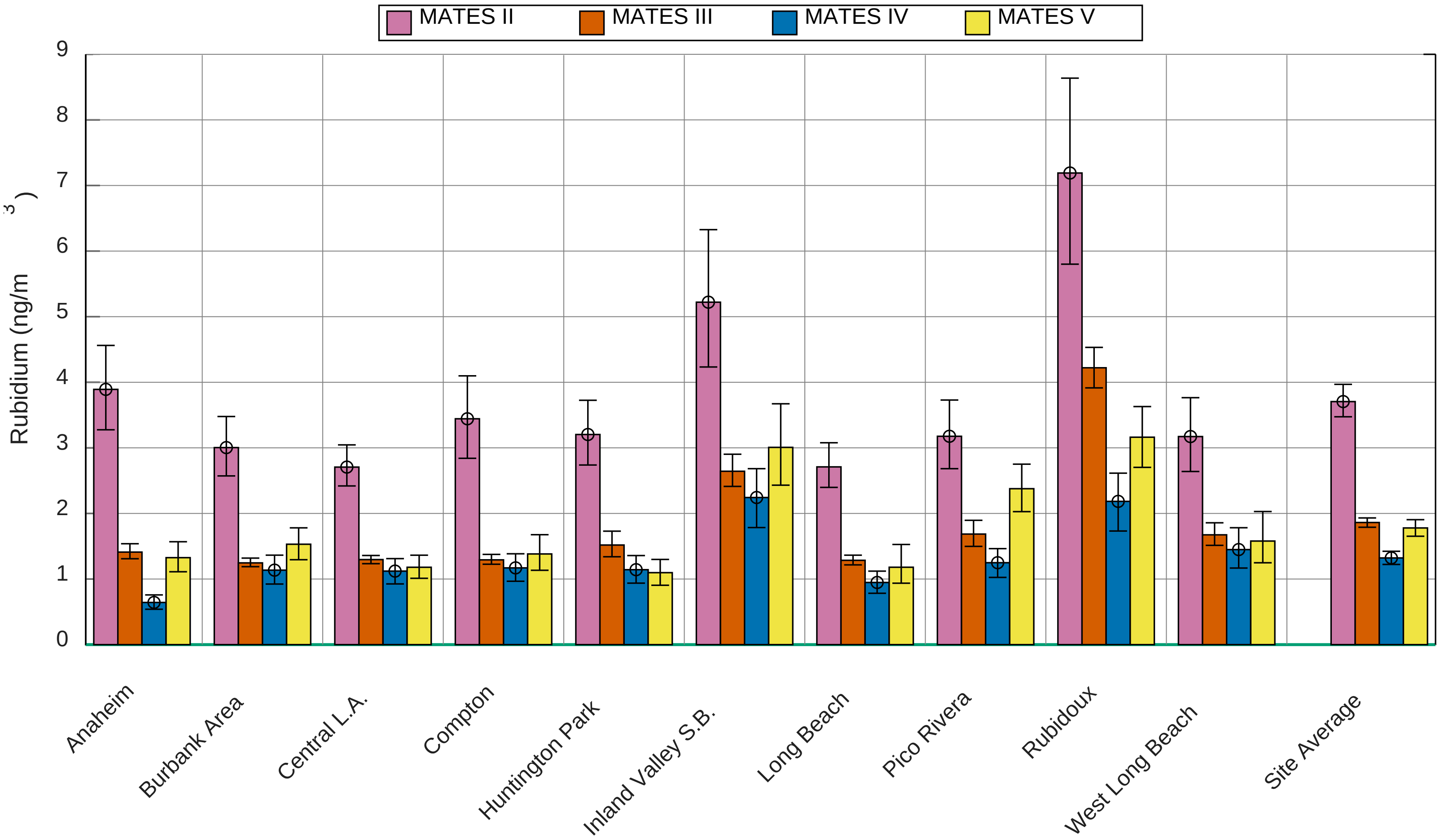


Figure IV-118. Annual Average Concentrations of Rubidium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

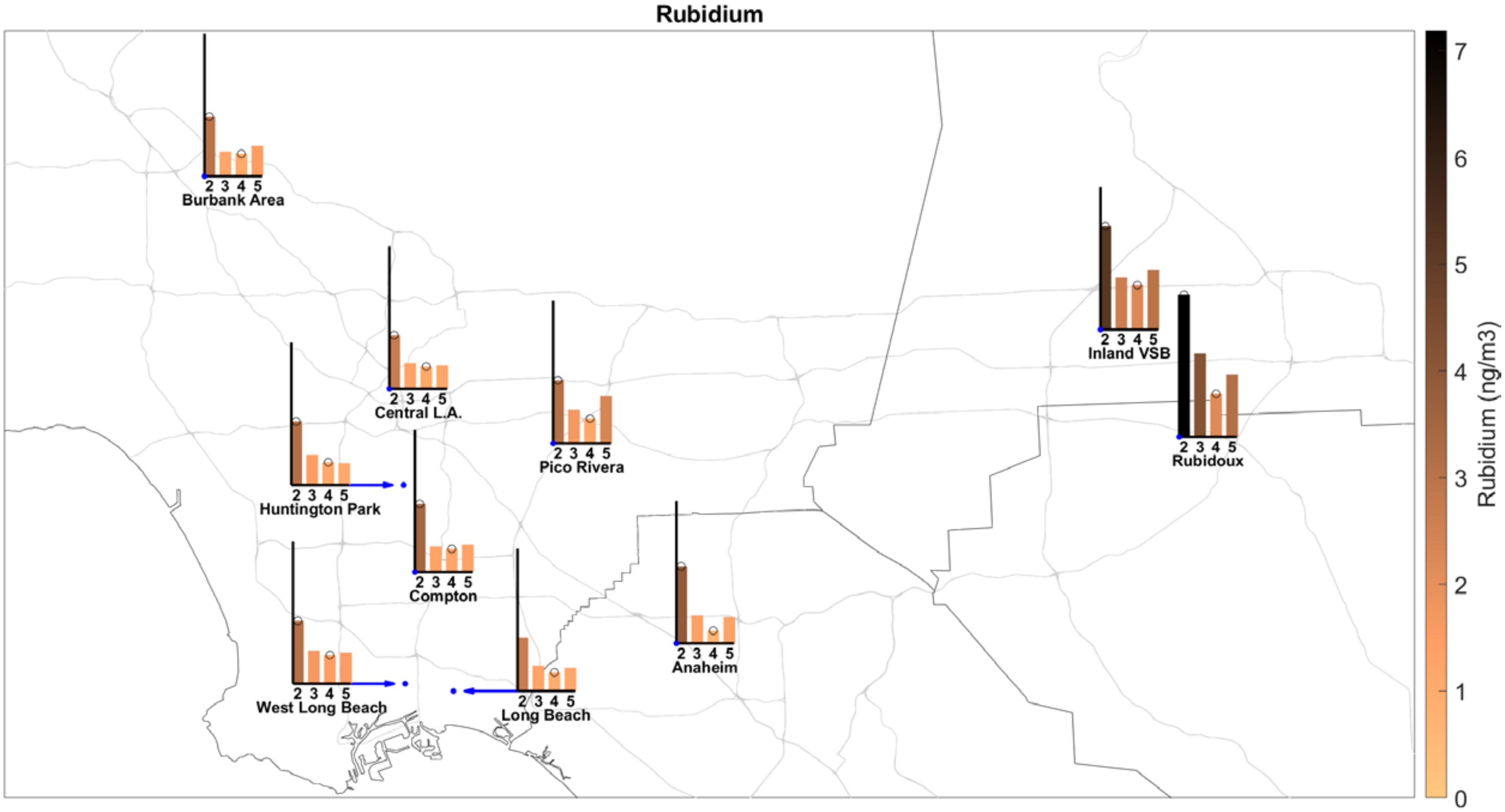


Figure IV-119. Geographic distribution of Rubidium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Selenium

Table IV-62. Ambient Concentrations (ng/m^3) of Selenium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1.41	1.71	2.07	1.72	3.76	1.75	2.15	3.16	0.556, 1.87[a]	1.85
95% CI LB	1.27	1.44	1.55	1.47	2.44	1.44	1.7	2.41	0.202[a]	1.56
95% CI UB	1.71	2.17	2.78	2.15	5.33	2.12	2.69	4.01	2.13[a]	2.69
N	45	47	39	41	42	56	51	41	41[a]	39
% < MDL	68.9	70.2	69.2	70.7	50	66.1	58.8	39	82.9[a]	79.5
Max	2.96	7	11.2	5.41	20.7	7.17	11.4	12.1	4.29[a]	13
MATES III										
Average	0, 2[a]	0, 2[a]	0, 2[a]	0, 2[a]	0, 2[a]	0, 2[a]	0, 2[a]	0, 2[a]	0, 2[a]	0, 2[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	2[a]	2[a]	2[a]	2[a]	2[a]	2[a]	2[a]	2[a]	2[a]	2[a]
N	232[a]	218[a]	228[a]	224[a]	116[a]	230[a]	229[a]	118[a]	237[a]	227[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES IV										
Average	0.0942, 0.889[a]	0.207, 0.925[a]	1.04	1	1.79	1.08	1.17	1.17	1.02	0.182, 0.975[a]
95% CI LB	0.0207[a]	0.0947[a]	0.929	0.933	1.35	0.895	1.07	1.04	0.908	0.0283[a]
95% CI UB	0.917[a]	0.972[a]	1.24	1.07	2.33	1.4	1.3	1.3	1.17	1.14[a]
N	60[a]	58[a]	59	56	55	59	59	60	58	58[a]
% < MDL	91.7[a]	82.8[a]	72.9	62.5	36.4	78	50.8	65	75.9	91.4[a]
Max	1.46[a]	1.73[a]	5.21	2.14	12.6	9.26	2.52	3.32	4.06	5.19[a]
MATES V										
Average	0.117, 0.601[a]	0.135, 0.615[a]	0.614	0.681	0.697	0.0785, 0.591[a]	0.637	0.691	0.0842, 0.597[a]	0.591
95% CI LB	0.0543[a]	0.0624[a]	0.595	0.642	0.622	0.0305[a]	0.608	0.631	0.0299[a]	0.585
95% CI UB	0.619[a]	0.642[a]	0.638	0.723	0.817	0.601[a]	0.681	0.771	0.613[a]	0.608
N	61[a]	58[a]	61	59	61	60[a]	60	60	60[a]	59
% < MDL	83.6[a]	82.8[a]	75.4	61	73.8	88.3[a]	71.7	63.3	88.3[a]	78
Max	0.89[a]	0.99[a]	0.96	1.12	3.68	0.79[a]	1.23	2.37	0.88[a]	0.82

---

[a]More than 80% of data are < MDL. Values based on zero and MDL substitutions.

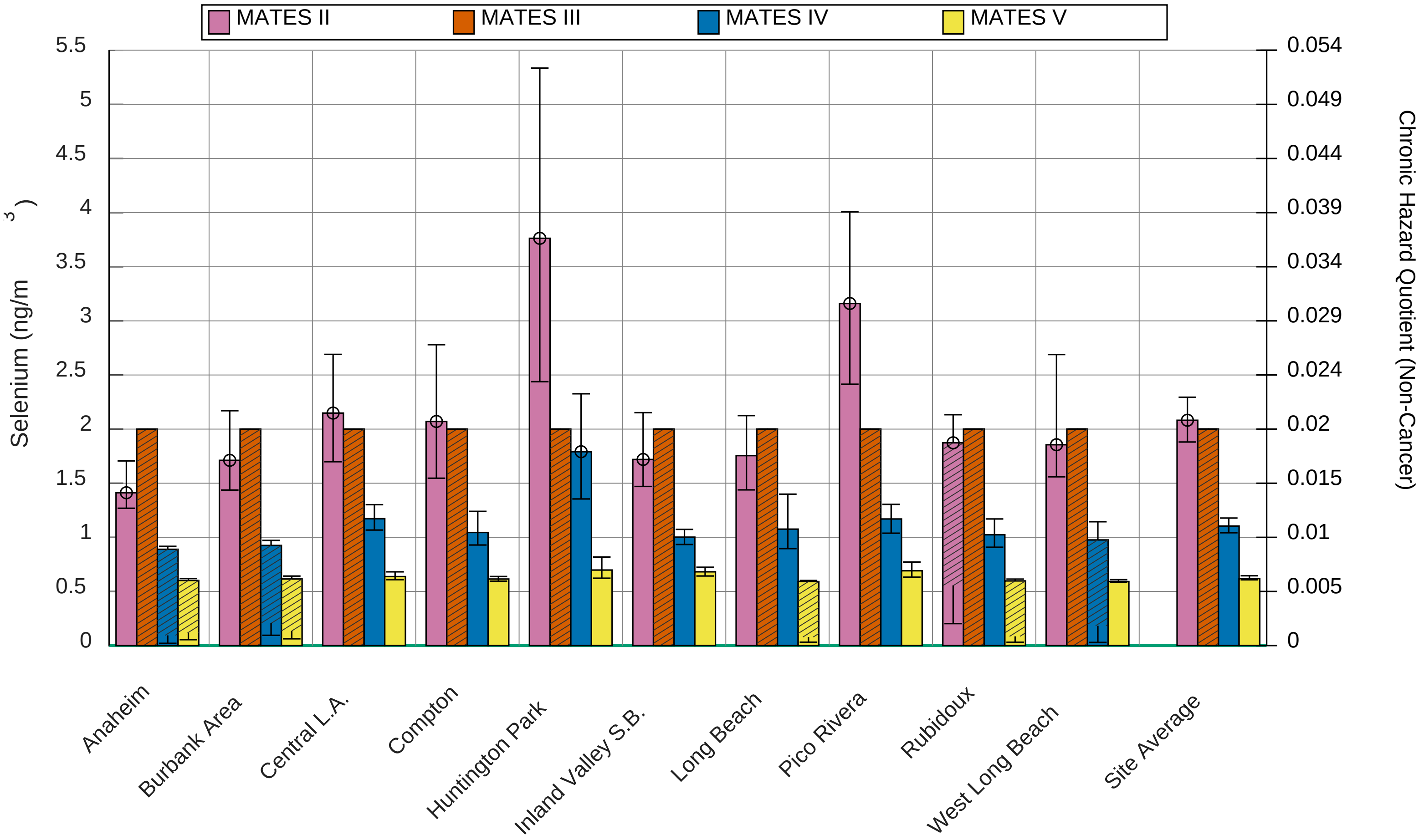


Figure IV-120. Annual Average Concentrations of Selenium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

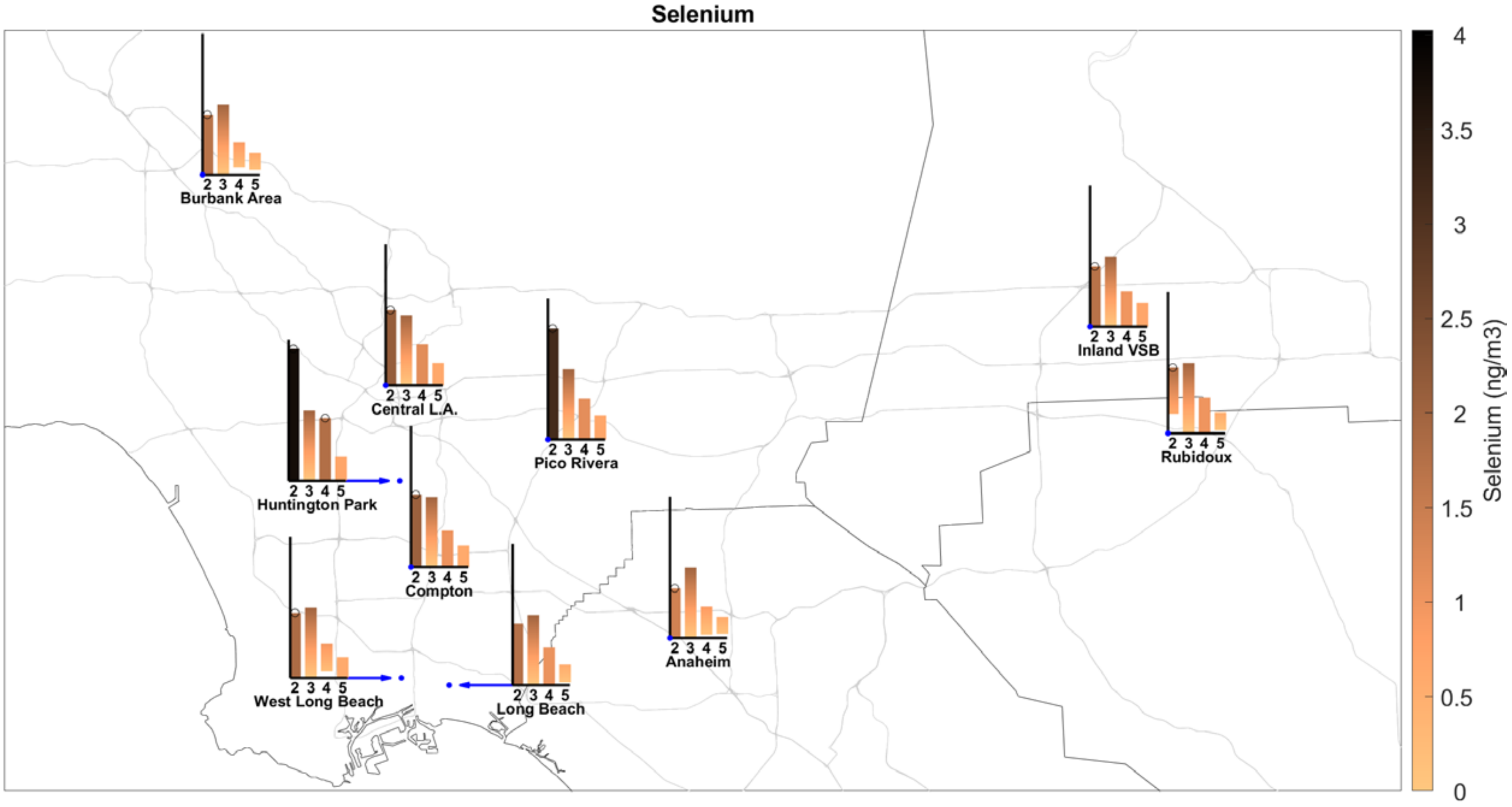


Figure IV-121. Geographic distribution of Selenium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Silicon

Table IV-63. Ambient Concentrations (ng/m^3) of Silicon from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	3770	3200	3960	4810	3340	2690	2870	3020	6200	3900
95% CI LB	2860	2750	3200	3930	2720	2180	2410	2490	5310	3150
95% CI UB	4760	3660	4770	5740	4070	3290	3340	3520	7110	4770
N	45	47	39	41	42	56	51	41	41	39
% < MDL	2.2	0	0	2.4	2.4	0	2	2.4	2.4	0
Max	17200	7520	11500	12000	13000	12800	8210	7860	13600	14900
MATES III										
Average	5130	5330	5790	8300	6760	5170	5870	7040	10000	6730
95% CI LB	4720	5030	5420	7710	6180	4800	5530	6390	9420	6170
95% CI UB	5550	5640	6170	8950	7350	5540	6200	7710	10700	7330
N	232	218	228	224	116	230	229	118	237	227
% < MDL	3	1.4	1.3	1.8	0.9	3	0.9	0	0	0.9
Max	19000	13900	17100	24300	17200	13400	12100	28000	25900	31900
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

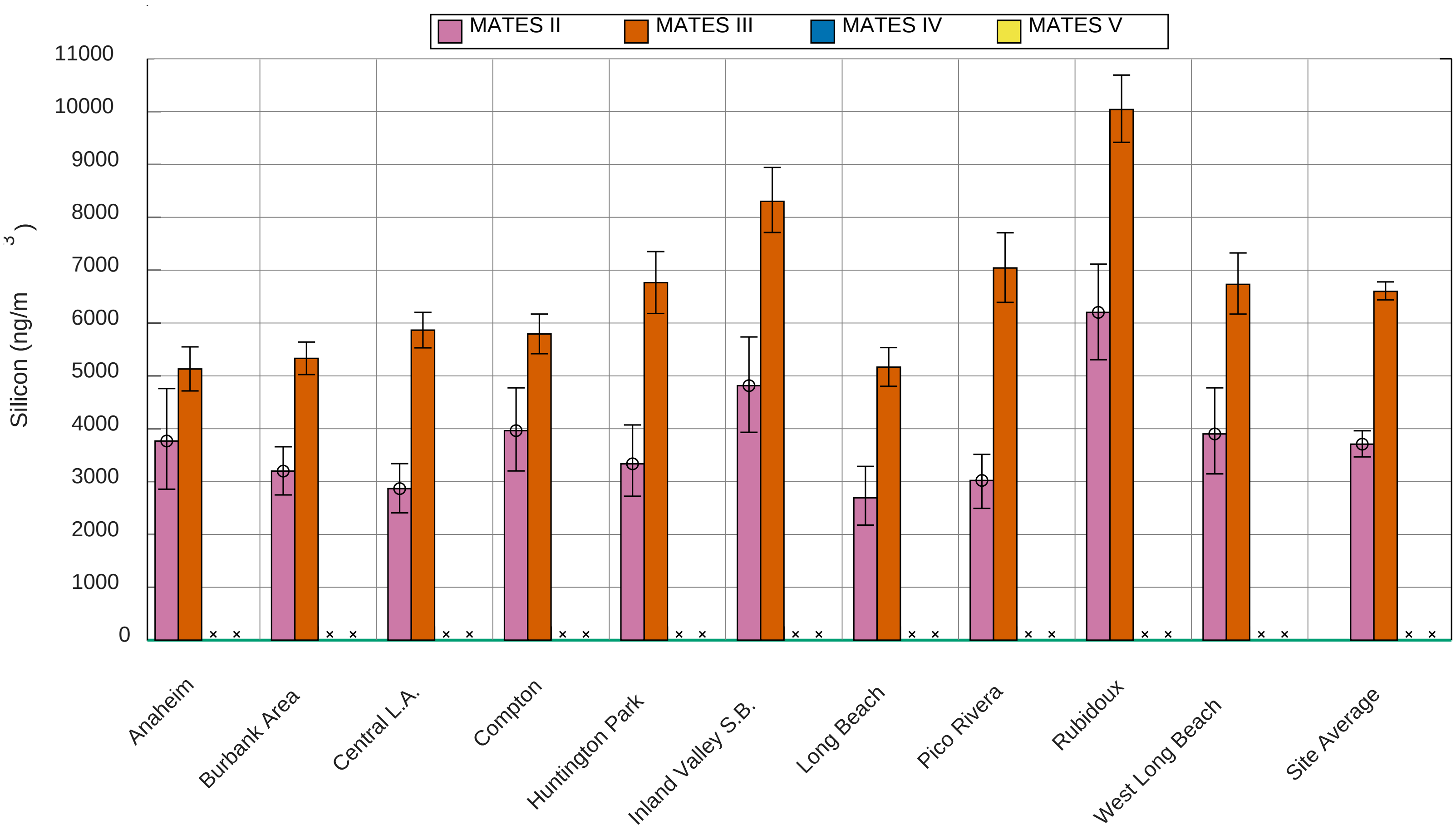


Figure IV-122. Annual Average Concentrations of Silicon in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

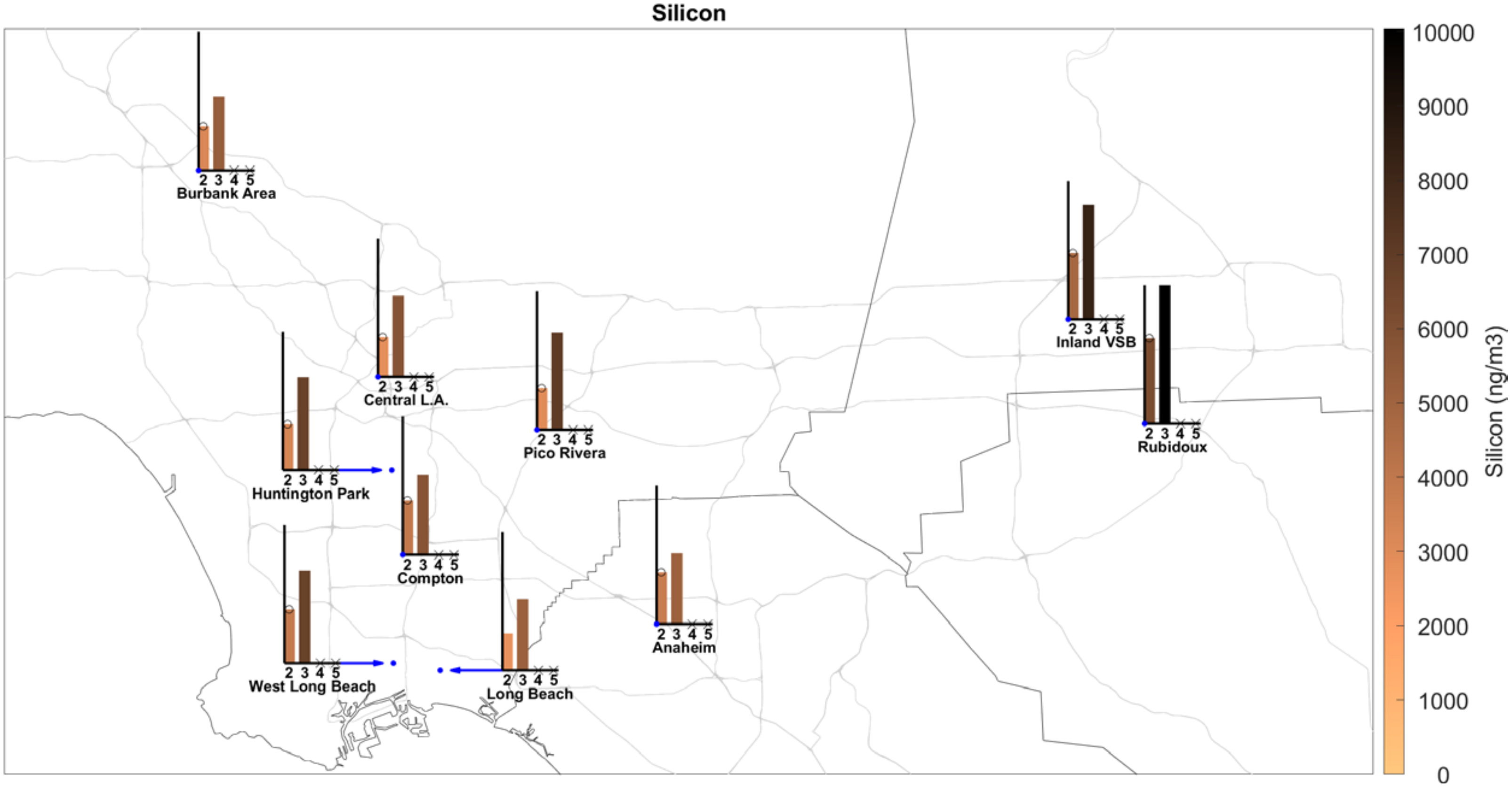


Figure IV-123. Geographic distribution of Silicon from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Silver

Table IV-64. Ambient Concentrations (ng/m^3) of Silver from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 5[a]	0, 5[a]	0, 5[a]	0, 5[a]	0, 5[a]	0, 5[a]	0, 5[a]	0, 5[a]	0, 5[a]	0, 5[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]
N	25[a]	20[a]	18[a]	21[a]	22[a]	26[a]	23[a]	26[a]	21[a]	19[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES III										
Average	0.613, 2.53[a]	0.682, 2.51[a]	0.363, 2.27[a]	0.564, 2.44[a]	0.869, 2.66[a]	0.41, 2.31[a]	0.864, 2.72[a]	0.8, 2.63[a]	0.667, 2.5[a]	0.797, 2.66[a]
95% CI LB	0.262[a]	0.327[a]	0.118[a]	0.219[a]	0.331[a]	0.145[a]	0.432[a]	0.282[a]	0.373[a]	0.392[a]
95% CI UB	2.88[a]	2.87[a]	2.54[a]	2.79[a]	3.22[a]	2.58[a]	3.15[a]	3.19[a]	2.78[a]	3.07[a]
N	232[a]	218[a]	228[a]	224[a]	116[a]	230[a]	229[a]	118[a]	237[a]	227[a]
% < MDL	95.7[a]	91.3[a]	95.6[a]	93.8[a]	89.7[a]	95.2[a]	93[a]	91.5[a]	91.6[a]	93[a]
Max	18.4[a]	17.6[a]	18.4[a]	25.3[a]	18.3[a]	17.6[a]	22[a]	18.1[a]	19.2[a]	18.5[a]
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

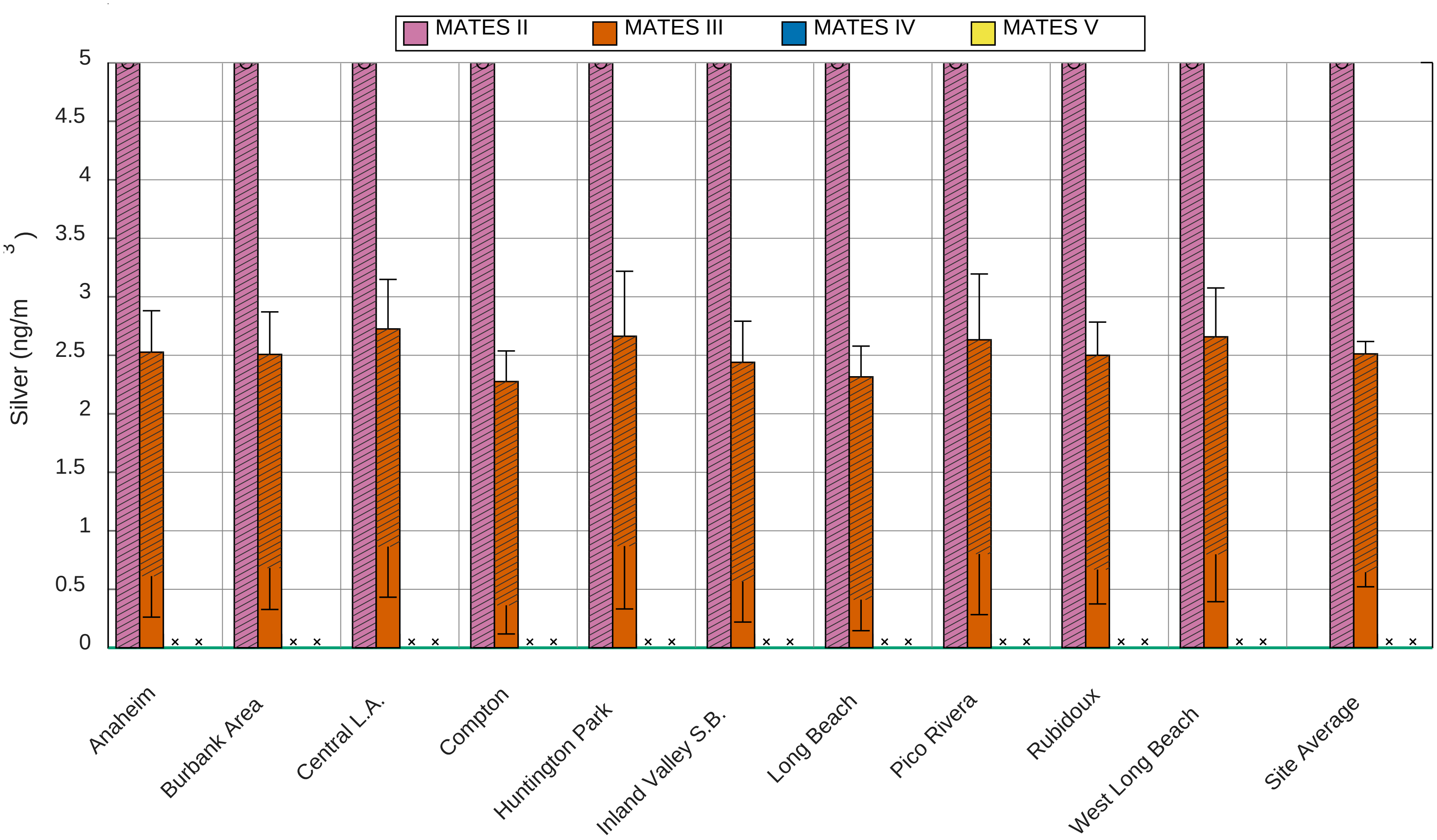


Figure IV-124. Annual Average Concentrations of Silver in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

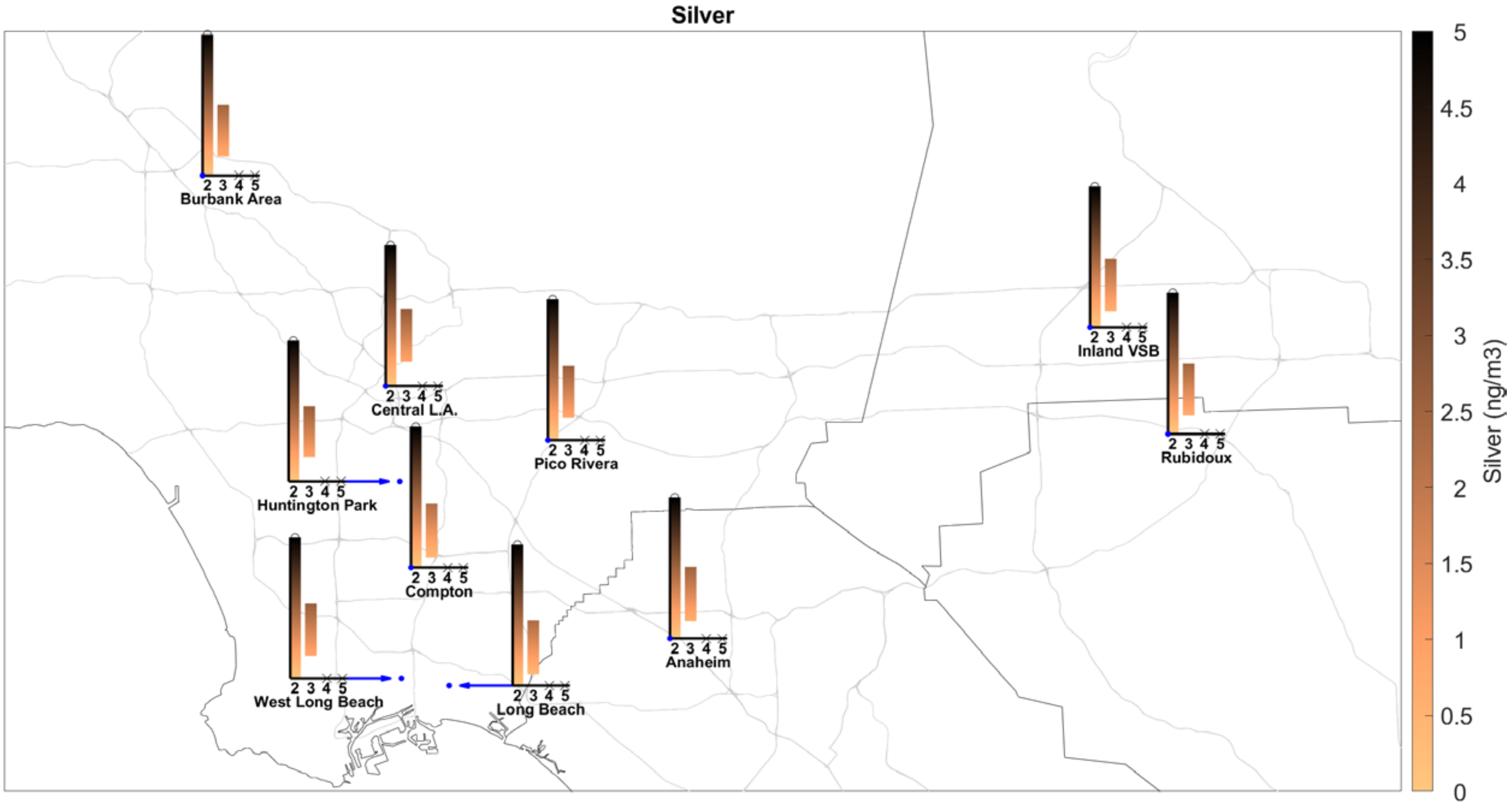


Figure IV-125. Geographic distribution of Silver from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Strontium

Table IV-65. Ambient Concentrations (ng/m^3) of Strontium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	148	107	105	162	197	90.2	111	134	225	107
95% CI LB	96.9	71.1	66.5	104	112	63.6	76.9	90.5	153	67.8
95% CI UB	209	147	147	223	300	119	149	182	307	147
N	45	47	39	41	42	56	51	41	41	39
% < MDL	0	0	0	0	0	0	3.9	0	2.4	0
Max	770	585	474	684	1470	476	546	707	786	524
MATES III										
Average	11.9	13.1	13.1	18.2	18.4	11.4	16.8	14.1	26	15.7
95% CI LB	10.4	12	12.1	15.2	16.6	10.6	15.7	12.7	23.3	14.5
95% CI UB	13.6	14.3	14.1	23.1	20.5	12.2	18	15.5	29.3	17
N	232	218	228	224	116	230	229	118	237	227
% < MDL	4.3	4.1	3.5	5.8	1.7	3.9	1.3	5.9	1.7	1.3
Max	126	95.5	63.6	478	82.5	39.7	91.2	43.8	346	64.4
MATES IV										
Average	7.27	10.9	10.9	17.8	11.9	9.6	16.1	12.7	20.1	15.6
95% CI LB	5.8	9.32	9.37	14.1	10.2	8.09	13.4	10.8	16.1	12.9
95% CI UB	9.01	12.7	12.5	22.2	13.9	11.3	19.2	14.8	24.7	18.8
N	60	58	59	56	55	59	59	60	58	58
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	37.6	34	33	75.3	40.5	28.5	58.8	36.9	83.8	56
MATES V										
Average	9.54	10.2	11.1	16.1	10.4	8.22	12.5	14.6	17.6	11.9
95% CI LB	7.99	8.58	9.16	13.1	8.8	6.71	10.5	12.2	14.8	9.57
95% CI UB	11.3	11.8	13.2	19.3	12.2	10.2	14.5	17	20.4	14.7
N	44	43	43	44	45	42	45	44	43	42
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	31.6	24.1	33	51.3	24.9	37.8	36.8	33.8	44.5	53

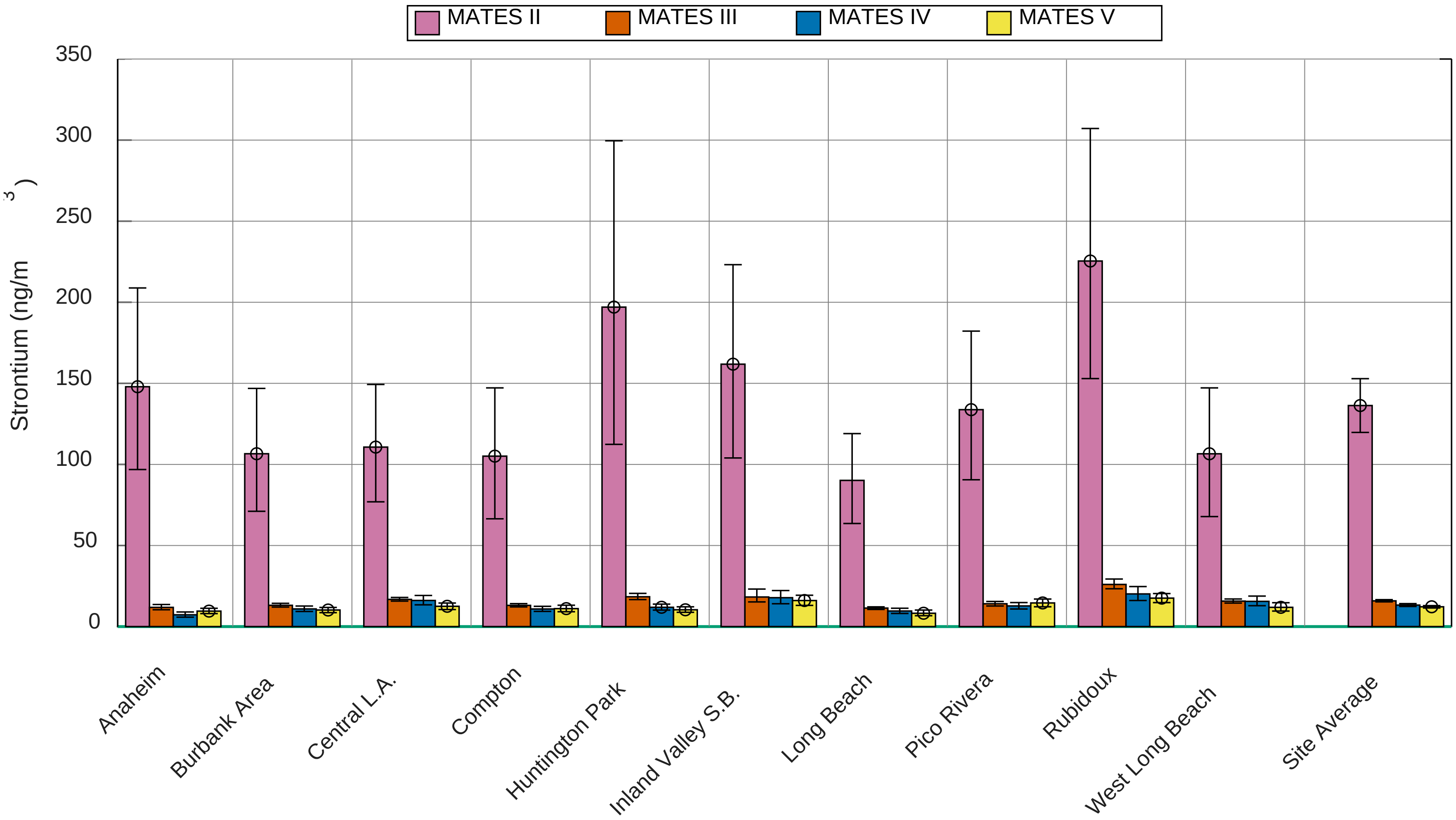


Figure IV-126. Annual Average Concentrations of Strontium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

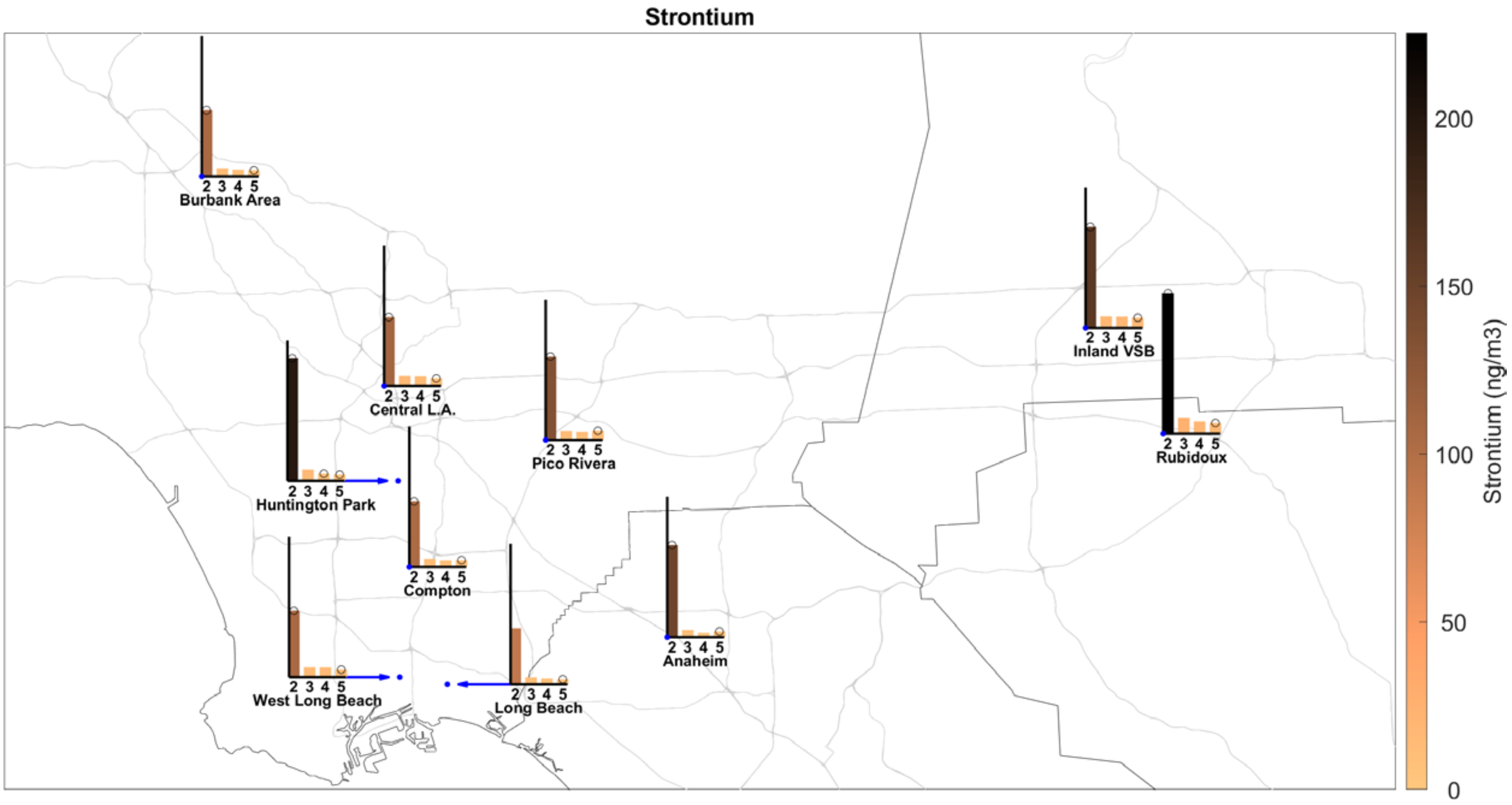


Figure IV-127. Geographic distribution of Strontium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Sulfur

Table IV-66. Ambient Concentrations (ng/m^3) of Sulfur from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1380	1260	1190	1070	1410	1400	1240	1210	1240	1390
95% CI LB	1130	1050	964	857	1120	1170	1020	957	1010	1130
95% CI UB	1650	1490	1430	1310	1710	1640	1480	1470	1490	1690
N	45	47	39	41	42	56	51	41	41	39
% < MDL	0	0	0	2.4	0	0	2	2.4	2.4	0
Max	3430	3310	3910	2940	4350	4140	3190	2940	3320	3990
MATES III										
Average	1570	1500	1720	1020	1900	1830	1570	1530	1270	2000
95% CI LB	1440	1370	1570	916	1670	1680	1420	1350	1170	1850
95% CI UB	1700	1620	1870	1140	2130	1990	1710	1700	1380	2160
N	232	218	228	224	116	230	229	118	237	227
% < MDL	0	0	0.4	0.4	0	0	0	0	0	0
Max	5230	4270	5800	9040	5510	6420	4730	4640	7480	6740
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

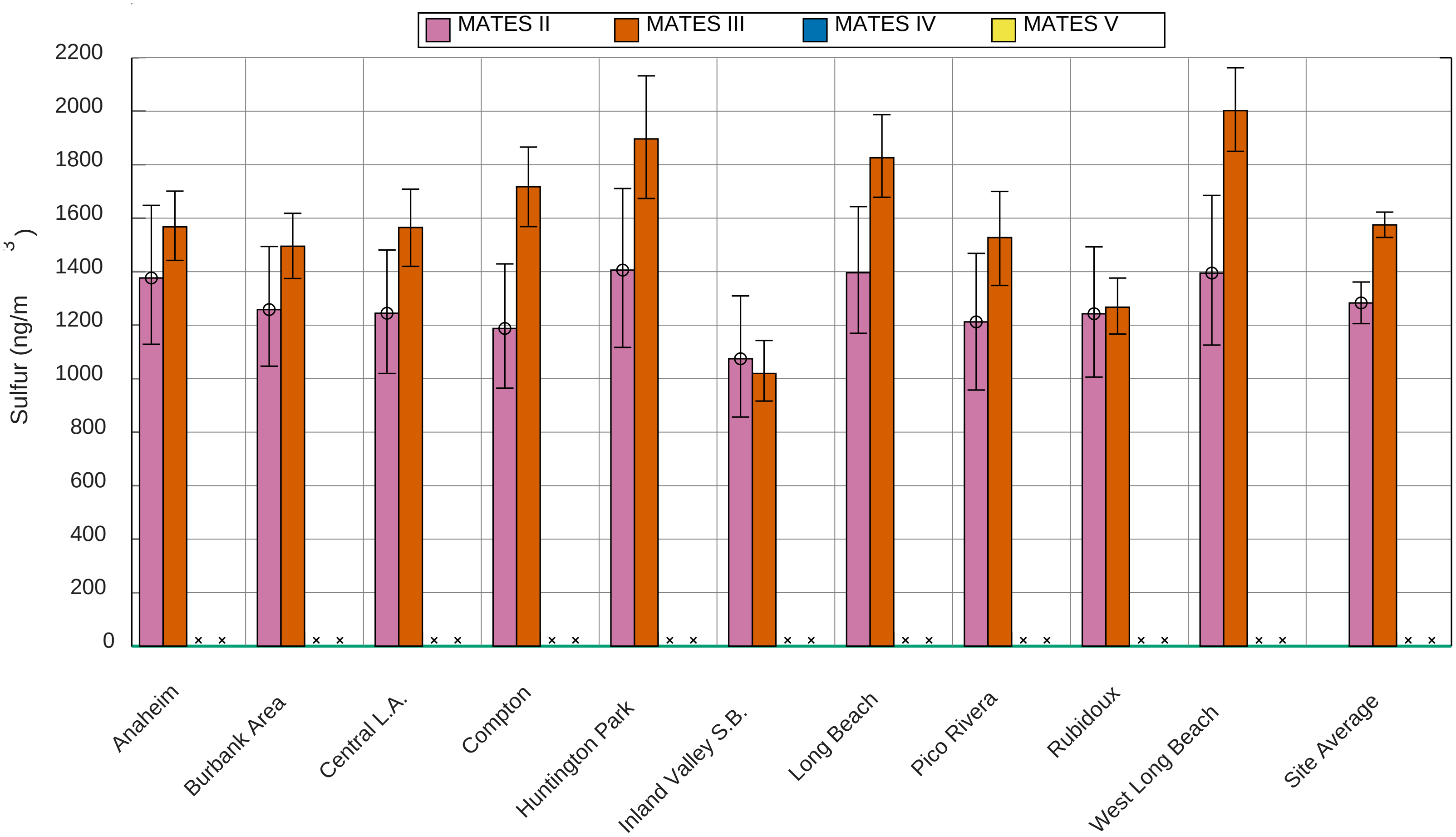


Figure IV-128. Annual Average Concentrations of Sulfur in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

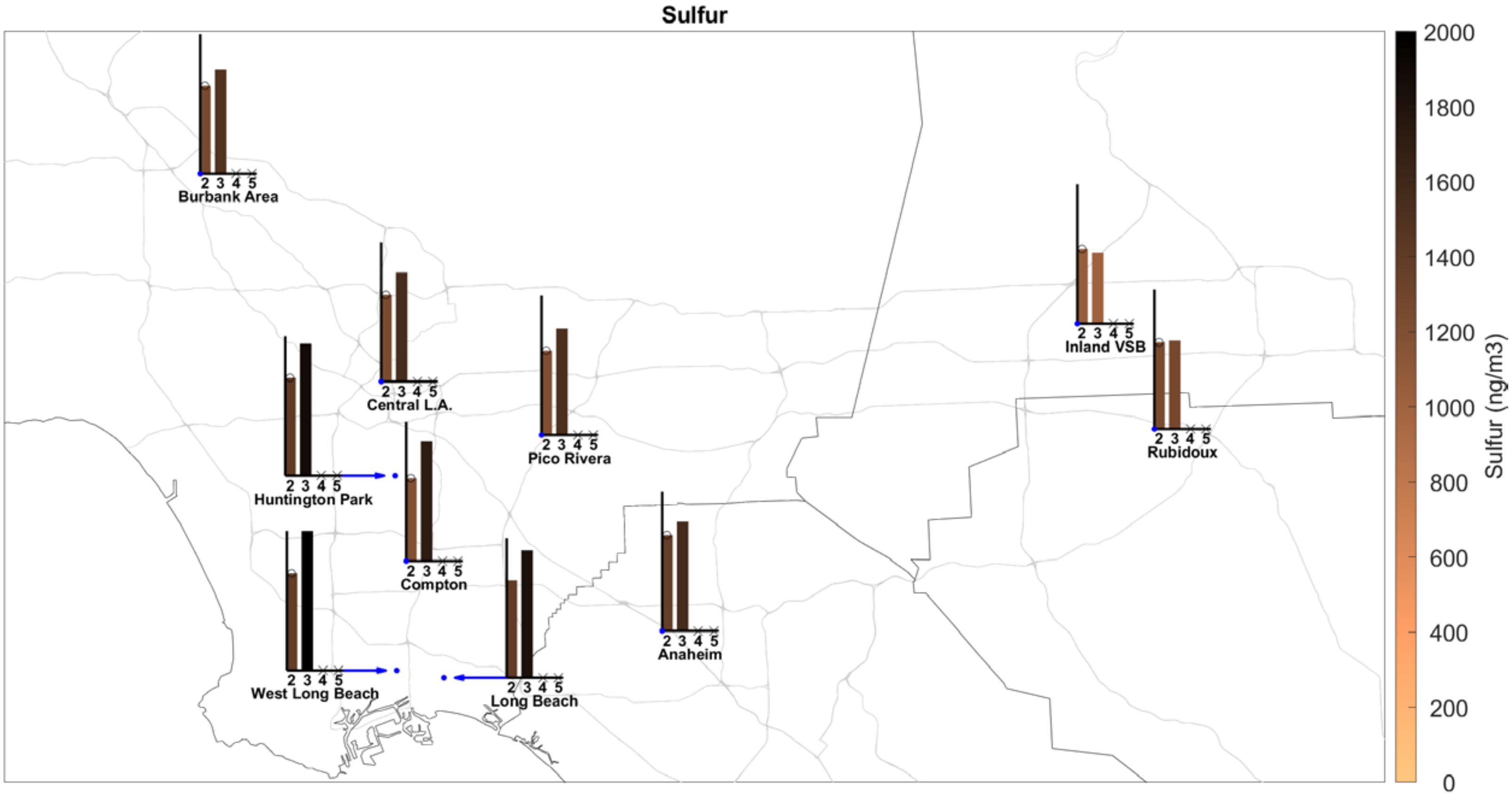


Figure IV-129. Geographic distribution of Sulfur from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Tin

Table IV-67. Ambient Concentrations (ng/m^3) of Tin from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1.31, 5.42[a]	6.05	12.3	7.54	9.45	3.09, 7.2[a]	6.32	574	2.22, 6.24[a]	7.03
95% CI LB	0.489[a]	5.38	8.48	6.18	7.6	1.18[a]	5.57	71.3	0.829[a]	5.95
95% CI UB	5.84[a]	6.91	16.2	8.98	11.5	9.12[a]	7.21	1260	7.35[a]	8.43
N	45[a]	47	39	41	42	56[a]	51	41	41[a]	39
% < MDL	82.2[a]	72.3	66.7	63.4	57.1	82.1[a]	68.6	43.9	80.5[a]	71.8
Max	11[a]	20.5	45.7	24	37	43.1[a]	17	9200	18.3[a]	23.2
MATES III										
Average	3.51	4.75	4.18	3.58	5.47	4.31	4.91	15.8	3.31	4.16
95% CI LB	3.35	4.41	3.87	3.42	4.76	3.96	4.6	10.5	3.22	3.82
95% CI UB	3.67	5.1	4.52	3.76	6.23	4.7	5.23	22	3.41	4.56
N	232	218	228	224	116	230	229	118	237	227
% < MDL	74.6	35.3	67.1	69.2	45.7	66.1	40.6	25.4	74.7	68.3
Max	10.8	26.7	17.5	10.8	21.7	19.4	15.4	245	8.83	19.1
MATES IV										
Average	1.9	5.26	2.86	3.98	5.83	3.25	6.5	20	2.89	2.55
95% CI LB	1.53	4.43	2.37	3.19	4.28	2.32	5.23	8.27	2.36	2.07
95% CI UB	2.27	6.17	3.38	4.87	7.62	4.55	7.95	40.3	3.55	3.07
N	60	58	59	56	55	59	59	60	58	58
% < MDL	1.7	0	0	1.8	0	0	0	0	0	0
Max	7.7	18.4	8.93	17.7	33.5	32.8	31.1	549	13.2	8.63
MATES V										
Average	2.92	3.5	3.25	4.17	3.72	2.44	5.16	4.63	2.69	2.54
95% CI LB	2.26	3.04	2.51	3.62	2.77	1.87	4.34	3.83	2.25	1.92
95% CI UB	3.68	3.99	4.12	4.73	4.78	3.07	6.05	5.45	3.13	3.23
N	60	57	60	58	60	59	59	60	58	58
% < MDL	0	0	0	0	13.3	0	1.7	0	0	0
Max	15.8	9.28	13	9.47	16.6	10.1	14.5	12.8	8.16	11

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

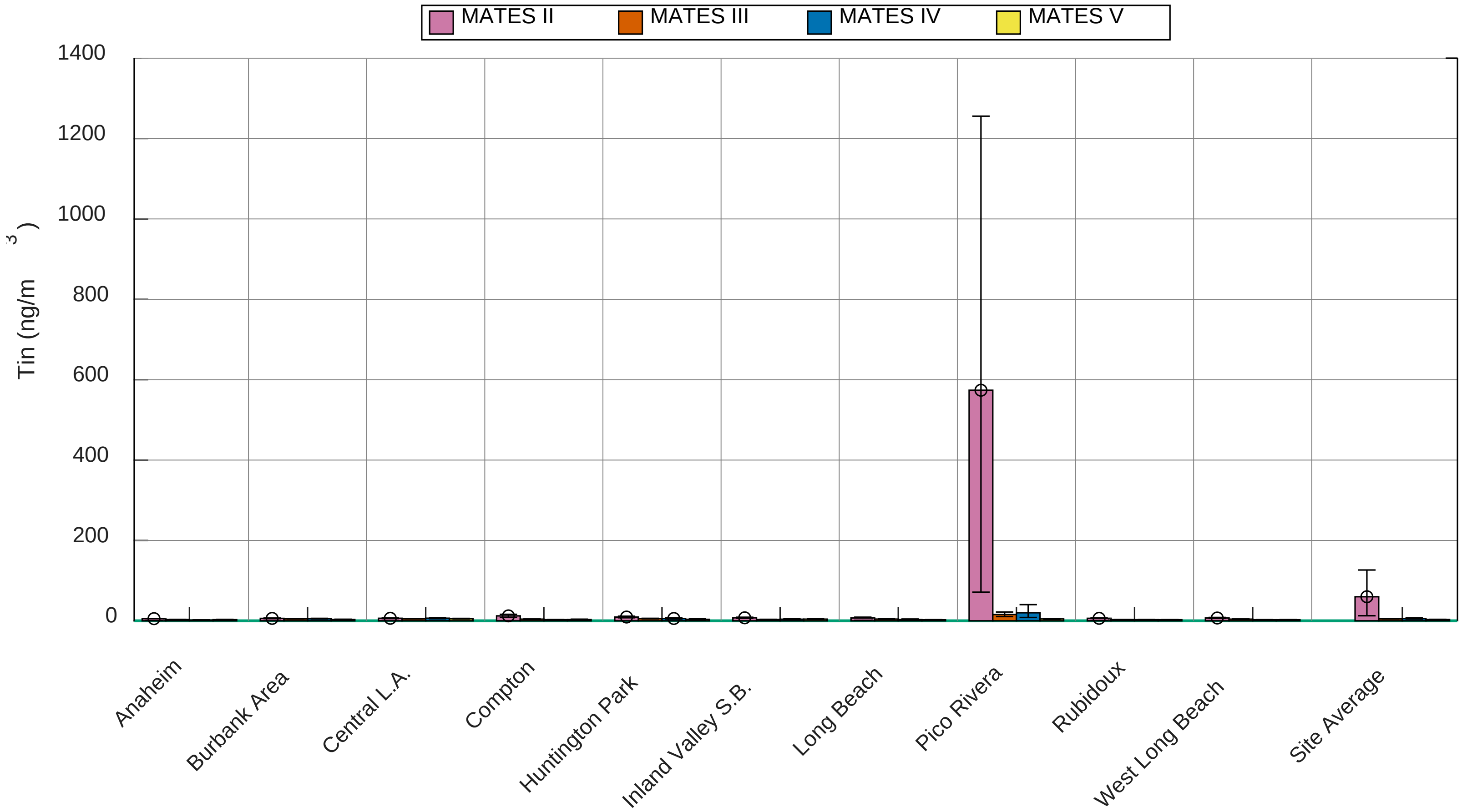


Figure IV-130. Annual Average Concentrations of Tin in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

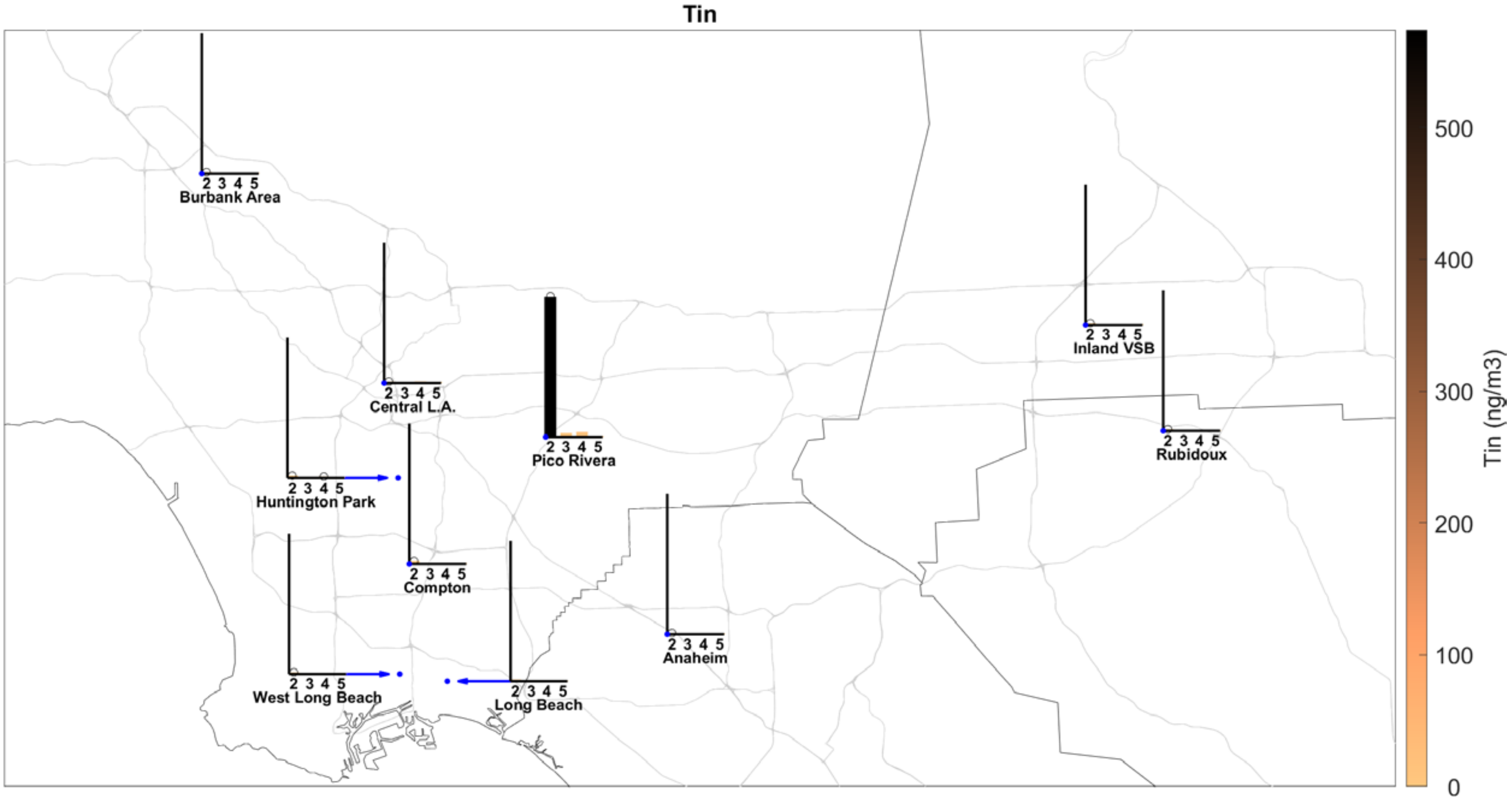


Figure IV-131. Geographic distribution of Tin from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Titanium

Table IV-68. Ambient Concentrations (ng/m^3) of Titanium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	114	116	165	171	119	80.9	81.9	154	214	94.8
95% CI LB	87.3	94.9	127	133	92.1	63.1	63.1	123	171	70.2
95% CI UB	144	140	206	211	146	100	101	187	260	120
N	45	48	39	41	42	56	51	41	41	39
% < MDL	26.7	18.8	15.4	17.1	26.2	25	33.3	12.2	12.2	28.2
Max	388	396	445	478	334	318	285	470	530	316
MATES III										
Average	150	166	178	252	213	149	181	191	301	188
95% CI LB	137	156	166	235	195	137	172	173	282	168
95% CI UB	163	177	191	272	230	161	191	211	321	213
N	232	218	228	224	116	230	229	118	237	227
% < MDL	0.4	0	0	0.4	0	0	0	0	0	0
Max	620	476	504	786	511	500	378	788	693	1870
MATES IV										
Average	30	53.9	58.8	146	56.2	51.6	59.7	71.5	133	73.1
95% CI LB	23.7	45.9	50.4	114	47.7	41.4	49.3	59.6	105	58.6
95% CI UB	38	62.4	67.8	183	65.7	63.2	71.3	84.5	165	89.6
N	60	58	59	56	55	59	59	60	58	58
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	183	147	145	636	169	215	221	238	554	324
MATES V										
Average	52.5	66.3	62	134	49.7	49	54.8	103	112	65.2
95% CI LB	44.7	56.5	50.4	109	41.4	38.2	47.7	88.4	95.7	51.2
95% CI UB	61.3	76.7	75.2	163	58.2	64.3	62.1	119	127	84.5
N	59	57	59	58	58	58	59	59	60	57
% < MDL	0	0	0	0	0	0	1.7	0	0	0
Max	175	166	283	657	135	384	134	298	298	476

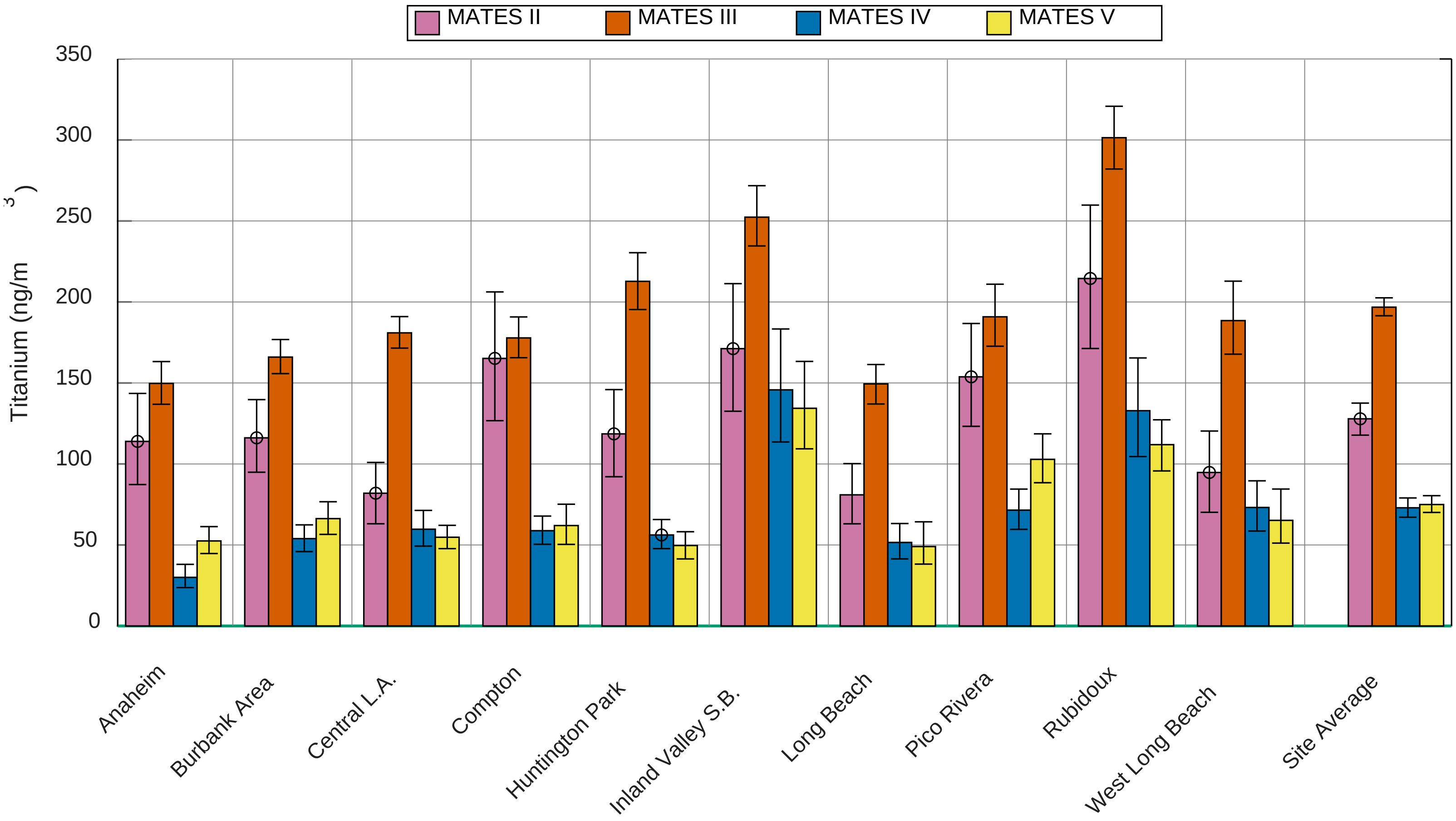


Figure IV-132. Annual Average Concentrations of Titanium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

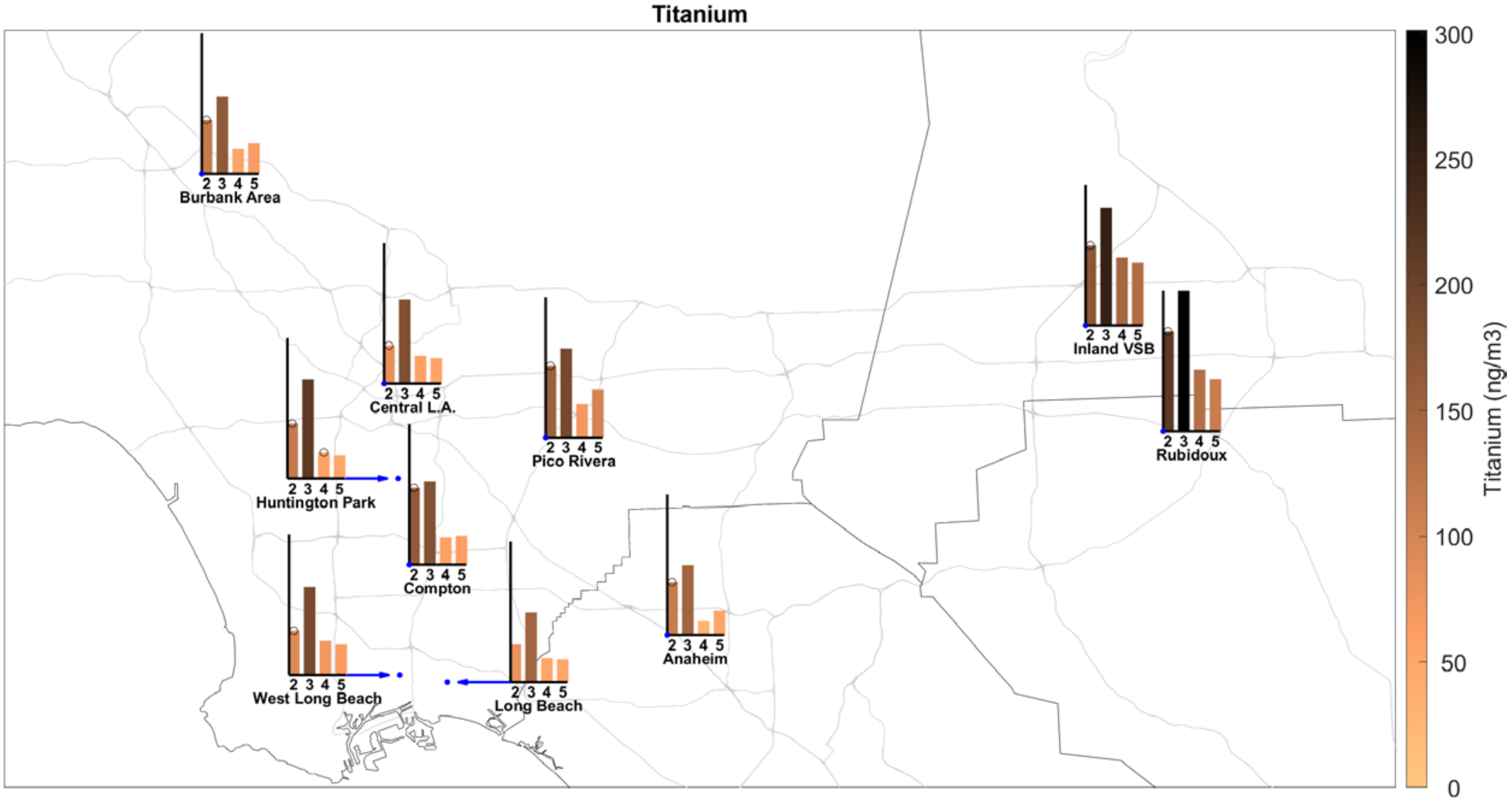


Figure IV-133. Geographic distribution of Titanium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Uranium

Table IV-69. Ambient Concentrations (ng/m^3) of Uranium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0, 4.67[a]	0.191, 4.28[a]	0.0769, 4.38[a]	0, 4.54[a]	0, 4.57[a]	0, 4.39[a]	0, 4.35[a]	0.0732, 4.9[a]	0, 4.54[a]	0, 4.46[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	5.07[a]	4.72[a]	4.85[a]	4.98[a]	5[a]	4.77[a]	4.76[a]	5.34[a]	4.98[a]	4.92[a]
N	45[a]	47[a]	39[a]	41[a]	42[a]	56[a]	51[a]	41[a]	41[a]	39[a]
% < MDL	100[a]	93.6[a]	97.4[a]	100[a]	100[a]	100[a]	100[a]	97.6[a]	100[a]	100[a]
Max	< MDL[a]	3[a]	3[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	3[a]	< MDL[a]	< MDL[a]
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	0.0178, 0.0897[a]	0.0128, 0.0857[a]	0.0112, 0.0856[a]	0.122	0.00727, 0.0827[a]	0.00881, 0.0846[a]	0.0254, 0.093[a]	0.0248, 0.0953[a]	0.123	0.0169, 0.0898[a]
95% CI LB	0.00617[a]	0.00379[a]	0.0022[a]	0.104	0.00164[a]	0.00169[a]	0.0112[a]	0.00767[a]	0.103	0.00466[a]
95% CI UB	0.0972[a]	0.0903[a]	0.0924[a]	0.145	0.0842[a]	0.0891[a]	0.103[a]	0.113[a]	0.147	0.0995[a]
N	60[a]	58[a]	59[a]	56	55[a]	59[a]	59[a]	60[a]	58	58[a]
% < MDL	88.3[a]	89.7[a]	91.5[a]	51.8	92.7[a]	93.2[a]	83.1[a]	86.7[a]	55.2	89.7[a]
Max	0.24[a]	0.18[a]	0.24[a]	0.54	0.11[a]	0.19[a]	0.25[a]	0.46[a]	0.61	0.29[a]
MATES V										
Average	0.0561	0.0577	0.0453	0.0944	0.0376	0.036	0.0465	0.0664	0.0908	0.0475
95% CI LB	0.0476	0.0488	0.037	0.0772	0.0308	0.0284	0.04	0.0564	0.078	0.0361
95% CI UB	0.0658	0.0675	0.0571	0.114	0.0459	0.0472	0.0542	0.0781	0.105	0.0647
N	59	56	59	57	59	58	58	59	59	57
% < MDL	5.1	5.4	5.1	5.3	22	6.9	5.2	5.1	1.7	5.3
Max	0.22	0.21	0.28	0.4	0.18	0.29	0.17	0.26	0.26	0.43

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

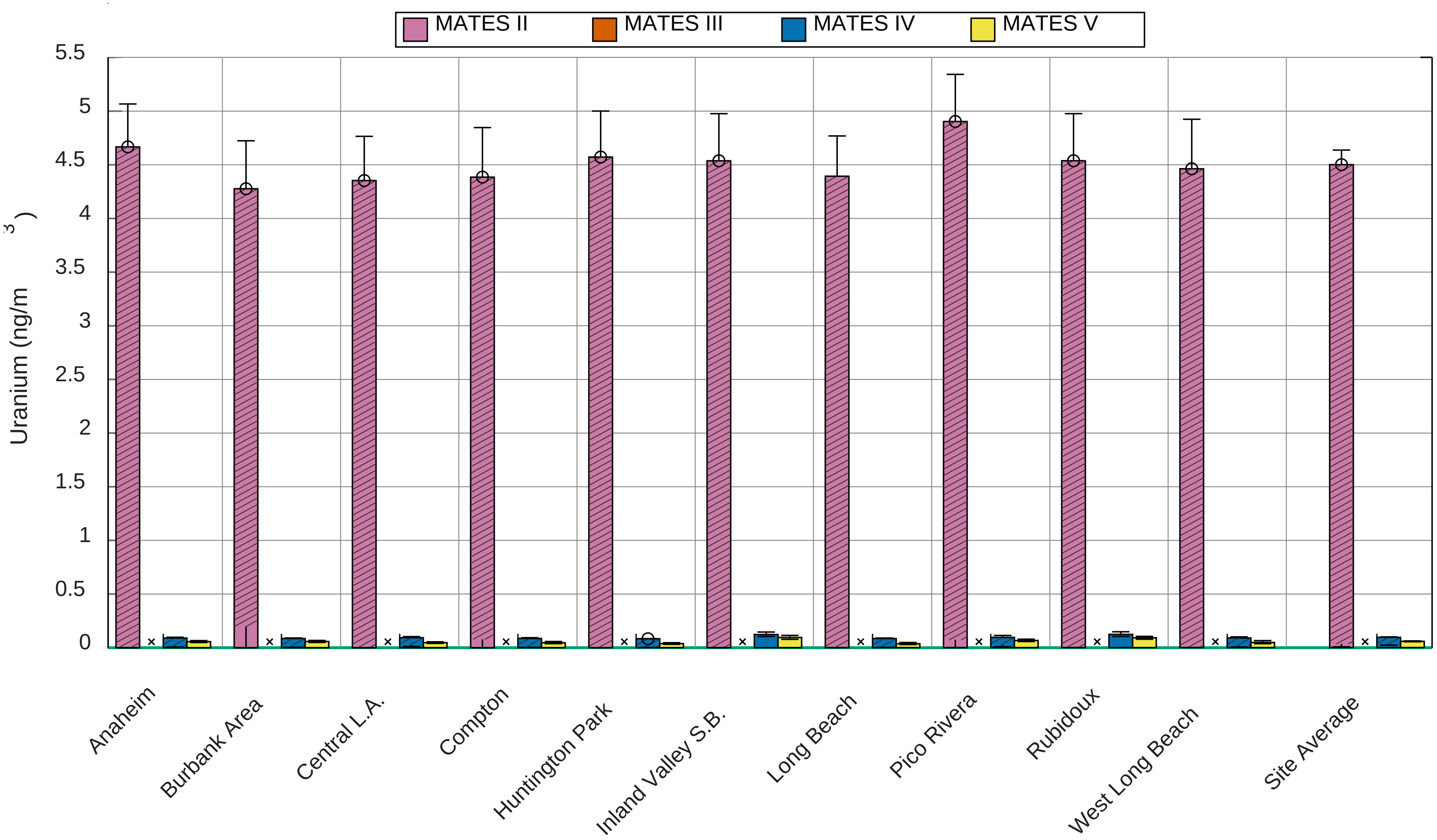


Figure IV-134. Annual Average Concentrations of Uranium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

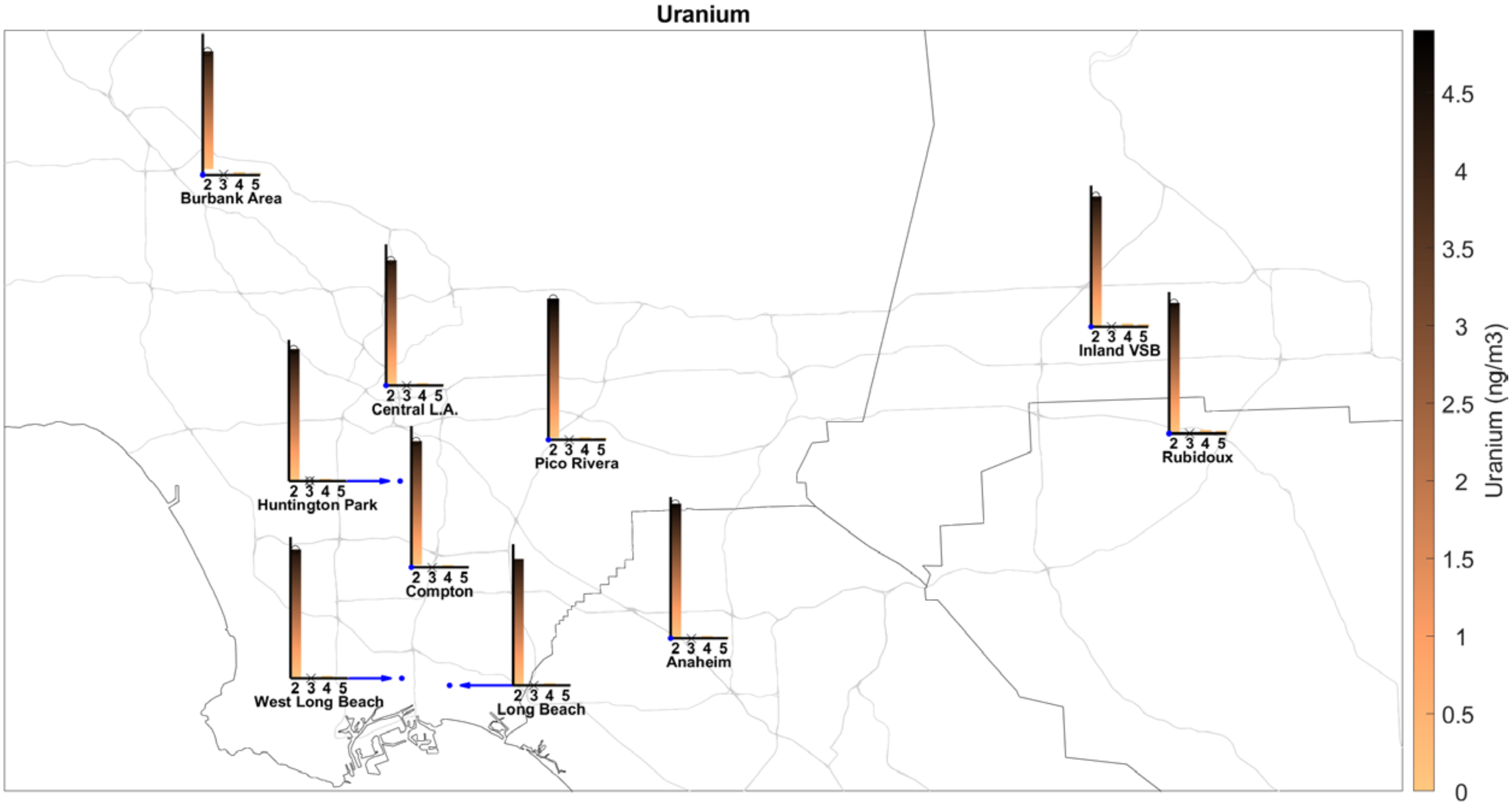


Figure IV-135. Geographic distribution of Uranium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Vanadium

Table IV-70. Ambient Concentrations (ng/m^3) of Vanadium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	12.7	9.15	16	16.3	14.1	13.7	9.12	14	19.6	19.7
95% CI LB	9.47	6.63	11.5	11.5	9.69	10.9	6.79	10.1	14	14.9
95% CI UB	16.4	12.2	20.4	21.5	19.4	16.7	11.7	18.4	25.8	24.8
N	45	47	39	41	42	56	51	41	41	39
% < MDL	48.9	66	28.2	41.5	50	35.7	58.8	41.5	31.7	25.6
Max	44	39.3	58.8	54.7	67.7	48.2	34.7	51.8	68.8	66
MATES III										
Average	9.06	6.01	10.7	6.43	9.06	15.8	6.9	7.72	7.76	26.6
95% CI LB	8.21	5.47	9.82	5.88	7.95	14.5	6.22	6.77	7.1	24.3
95% CI UB	9.94	6.58	11.6	7.01	10.2	17.2	7.58	8.72	8.44	29
N	232	218	228	224	116	230	229	118	237	227
% < MDL	12.9	26.6	8.8	25.4	17.2	5.2	28.4	14.4	14.3	3.1
Max	34.9	24.5	40.8	22.8	36.5	59.5	26.4	30.4	31.5	99.6
MATES IV										
Average	1.82	2.1	3.14	5.63	2.67	3.53	2.64	3.11	4.72	4.58
95% CI LB	1.26	1.78	2.73	4.31	2.28	2.8	2.18	2.55	3.63	3.78
95% CI UB	2.64	2.43	3.59	7.16	3.08	4.34	3.16	3.73	5.94	5.49
N	60	58	59	56	55	59	59	60	58	58
% < MDL	5	0	0	0	0	1.7	0	0	0	0
Max	21.1	6.09	8.5	28.1	8.08	12.3	10	11.1	22.3	18
MATES V										
Average	1.94	2.22	2.4	4.78	1.85	2.21	1.9	3.41	3.66	3.06
95% CI LB	1.69	1.85	2.04	3.75	1.54	1.9	1.64	2.81	3.06	2.59
95% CI UB	2.19	2.57	2.78	5.83	2.16	2.54	2.16	4.04	4.24	3.55
N	45	44	44	41	41	42	36	40	41	42
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	4.2	5.85	6.25	15.8	3.96	6.03	3.81	10.9	7.09	8.29

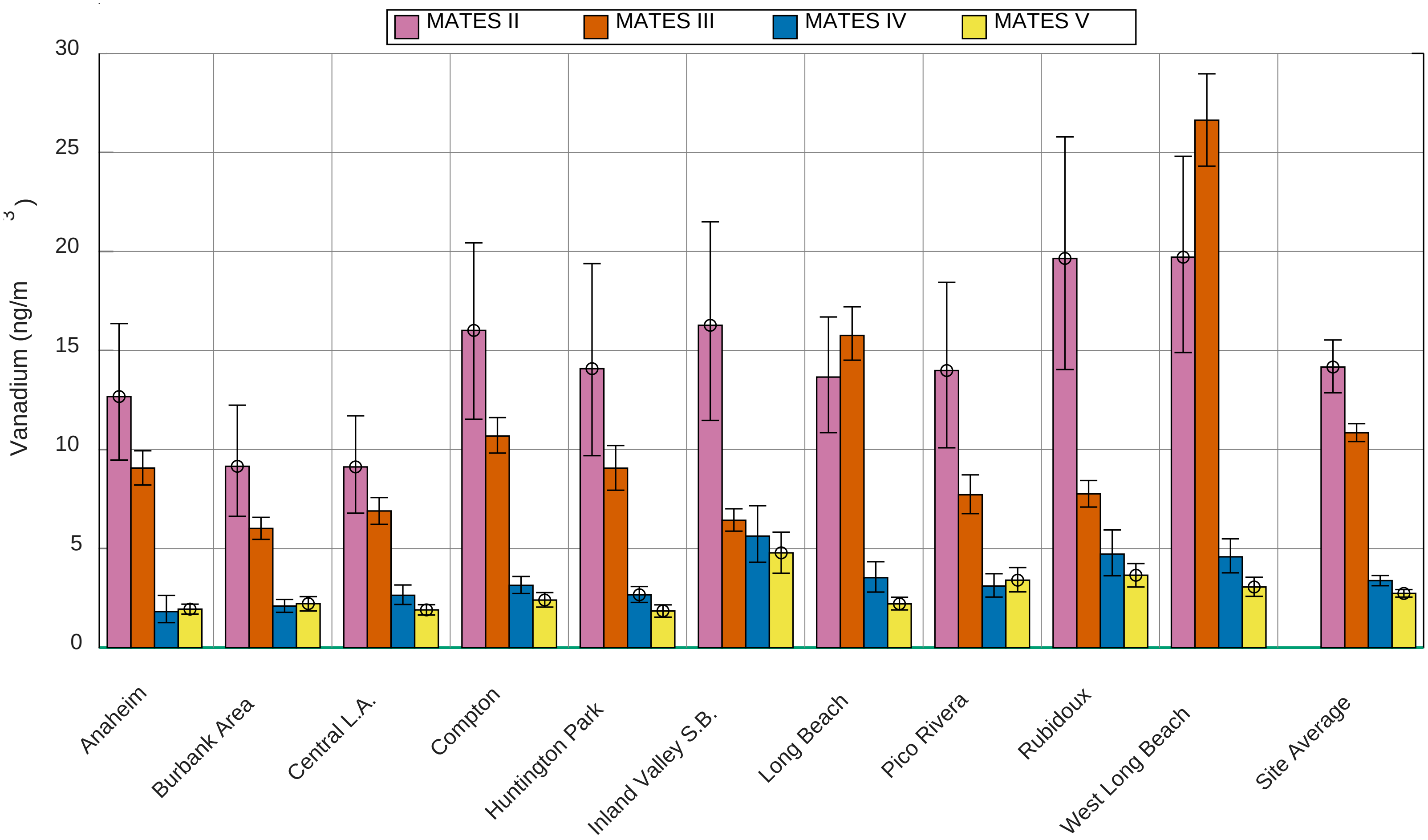


Figure IV-136. Annual Average Concentrations of Vanadium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

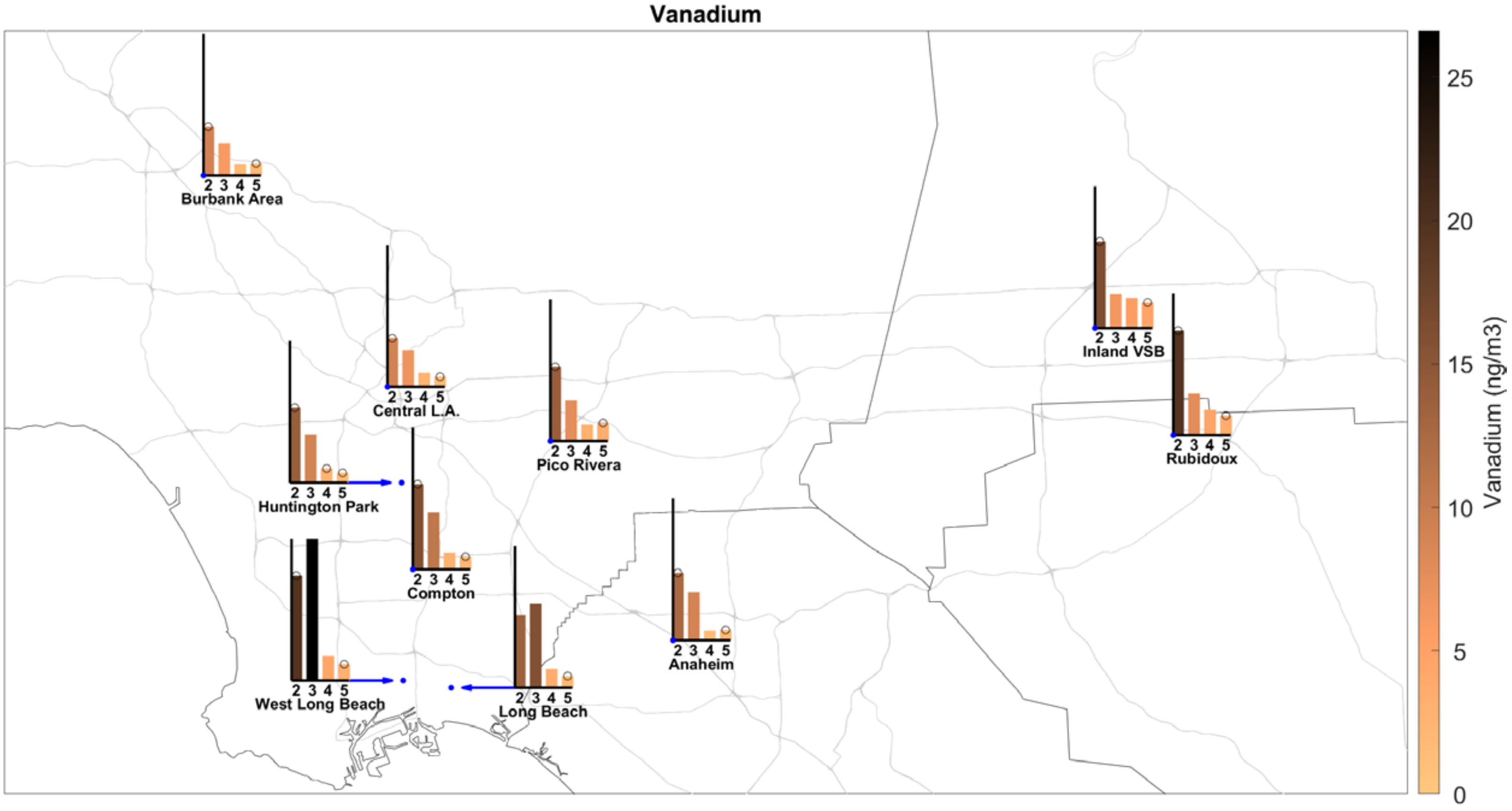


Figure IV-137. Geographic distribution of Vanadium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Yttrium

Table IV-71. Ambient Concentrations (ng/m^3) of Yttrium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	1.88	1.54	1.42	2.15	2.35	1.64	0.519, 1.87[a]	1.97	2.47	1.41
95% CI LB	1.51	1.41	1.34	1.69	1.66	1.43	0.204[a]	1.55	1.98	1.33
95% CI UB	2.33	2.25	1.91	2.65	3.23	2.17	2.11[a]	2.46	2.97	1.95
N	45	47	39	41	42	56	51[a]	41	41	39
% < MDL	64.4	78.7	79.5	53.7	57.1	75	84.3[a]	65.9	46.3	79.5
Max	7.21	8.42	5.06	6.16	12.6	8.9	4.69[a]	6.35	6.69	4.45
MATES III										
Average	0.231, 1.07[a]	0.213, 1.08[a]	0.161, 1.04[a]	1.13	0.197, 1.04[a]	0.163, 1.04[a]	0.166, 1.04[a]	0.192, 1.06[a]	1.12	0.231, 1.08[a]
95% CI LB	0.166[a]	0.13[a]	0.106[a]	1.09	0.111[a]	0.109[a]	0.11[a]	0.102[a]	1.08	0.158[a]
95% CI UB	1.1[a]	1.17[a]	1.07[a]	1.17	1.07[a]	1.06[a]	1.06[a]	1.09[a]	1.15	1.12[a]
N	232[a]	218[a]	228[a]	224	116[a]	230[a]	229[a]	118[a]	237	227[a]
% < MDL	84.1[a]	86.2[a]	88.2[a]	74.1	84.5[a]	87.4[a]	87.8[a]	86.4[a]	71.3	84.6[a]
Max	2.69[a]	8.83[a]	1.92[a]	2.81	1.9[a]	1.96[a]	1.94[a]	1.93[a]	2.48	3.88[a]
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

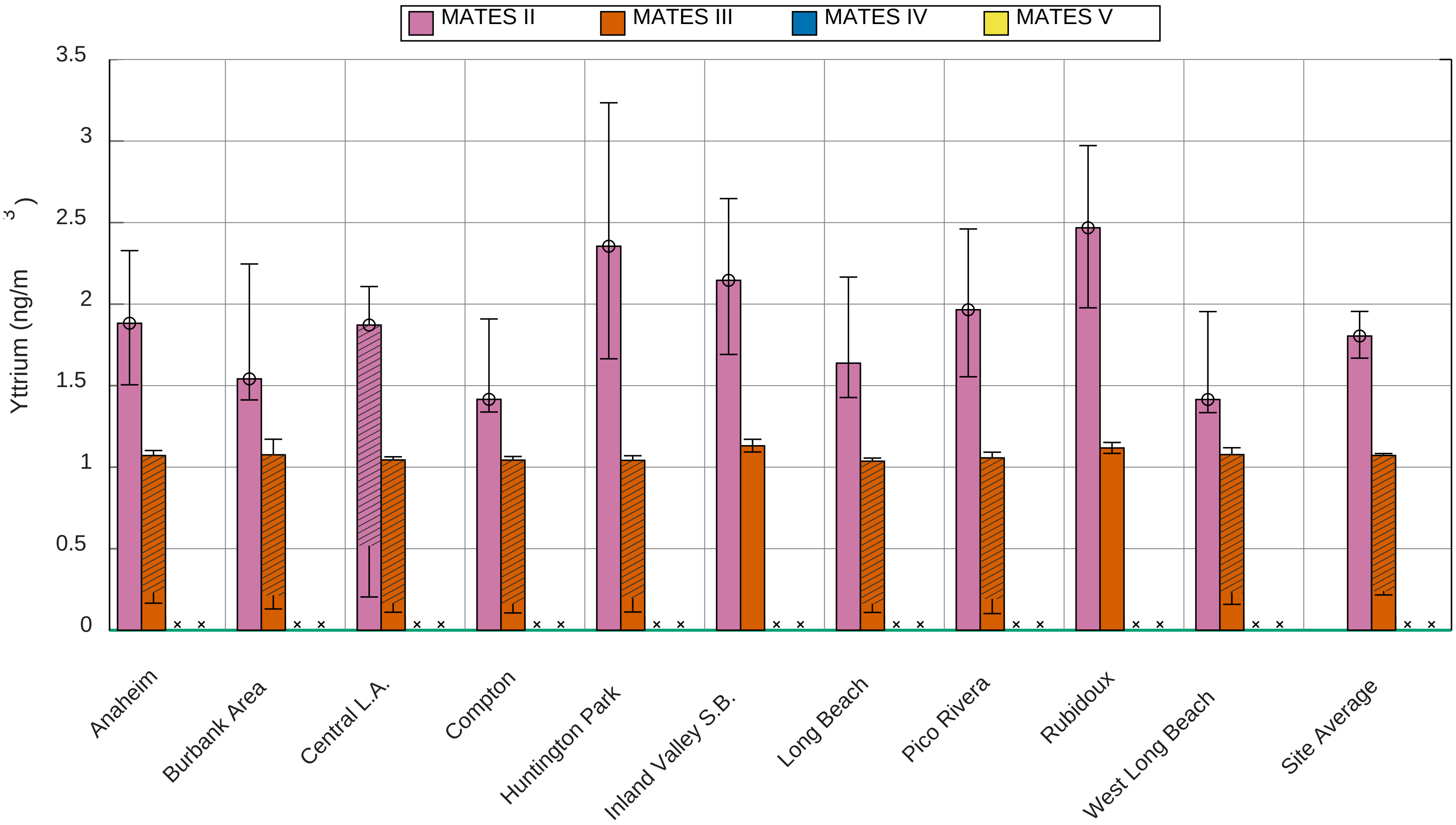


Figure IV-138. Annual Average Concentrations of Yttrium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

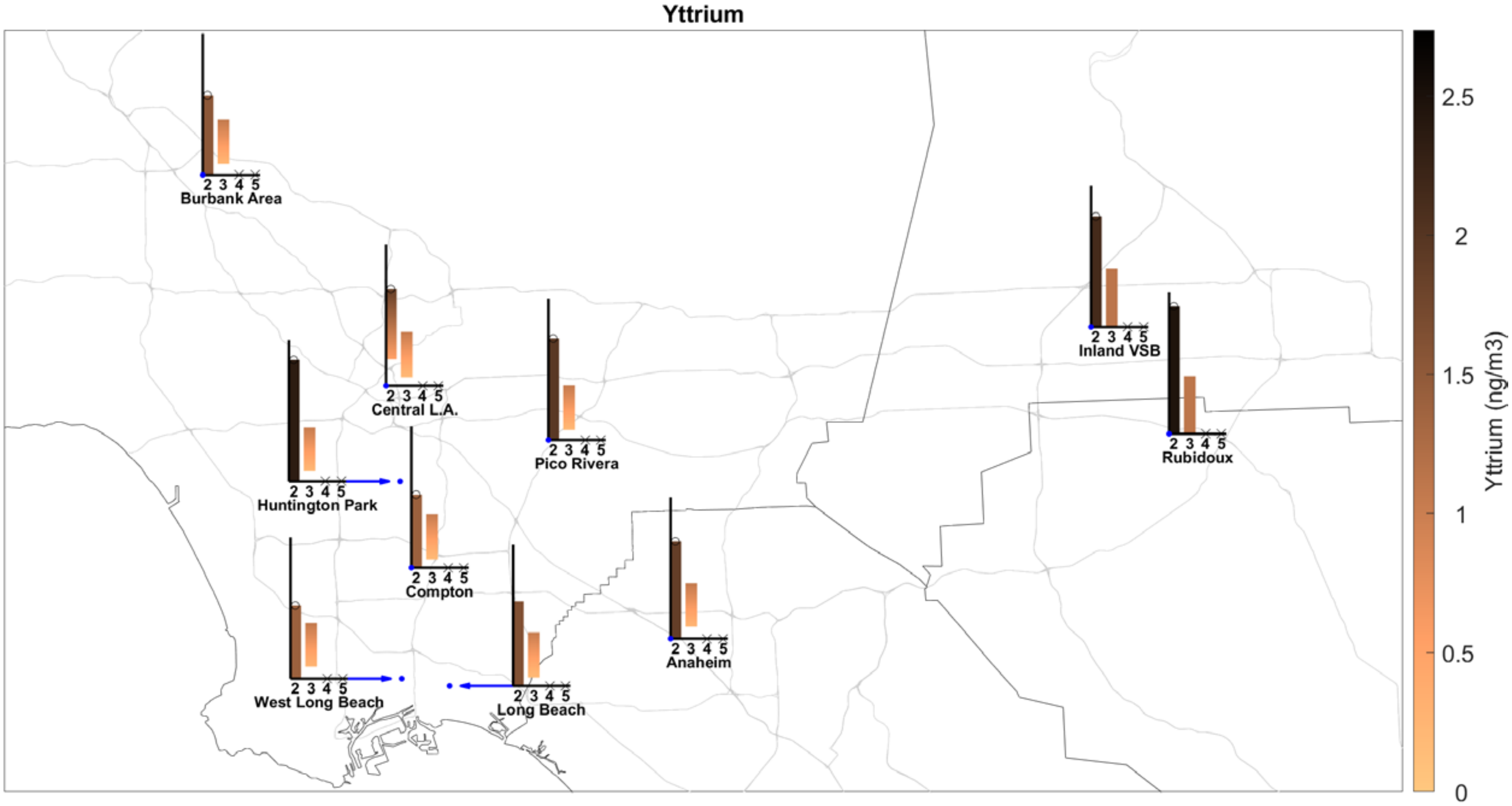


Figure IV-139. Geographic distribution of Yttrium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Zinc

Table IV-72. Ambient Concentrations (ng/m^3) of Zinc from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	77.1	87.6	105	128	136	85.1	88.6	158	114	101
95% CI LB	65.5	70.6	82.1	106	114	71.8	75	97.3	91.3	81.1
95% CI UB	89.2	108	133	150	161	98.9	103	255	137	122
N	45	47	39	41	42	56	51	41	41	39
% < MDL	0	0	0	0	0	0	3.9	2.4	2.4	0
Max	181	348	390	343	335	246	228	1830	309	325
MATES III										
Average	58.6	66.1	66.7	102	104	70.7	78.5	86.1	85.6	80.3
95% CI LB	53.3	62.1	61.1	95	92.6	65.5	73.7	75.5	78.5	72.9
95% CI UB	64.4	70.7	72.7	110	117	76.3	84.3	98.1	93	88.2
N	232	218	228	224	116	230	229	118	237	227
% < MDL	0	0	0	0.4	0	0	0	0	0	0
Max	246	181	252	312	364	207	433	362	351	352
MATES IV										
Average	43.4	53.7	54.1	110	74.1	61	72.4	73	64.3	71.7
95% CI LB	33.1	45.9	46	87.8	60	49.3	60	59.6	53.7	59.8
95% CI UB	55	62.4	62.6	135	90	74.8	86.2	89	76	85.1
N	60	58	59	56	55	59	59	60	58	58
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	219	162	138	496	305	267	264	351	250	225
MATES V										
Average	59.1	40.5	52.3	63.9	56.1	50.5	58.8	56.8	54.6	60.2
95% CI LB	42.8	32.7	41	53	45	39.7	48	45.8	43.2	46.3
95% CI UB	79.9	48.7	64.6	75	68.2	62.4	69.9	68	66.7	75.8
N	23	20	25	24	24	24	25	23	24	23
% < MDL	0	5	4	4.2	4.2	0	4	4.3	0	4.3
Max	236	84.3	141	112	121	129	119	114	121	162

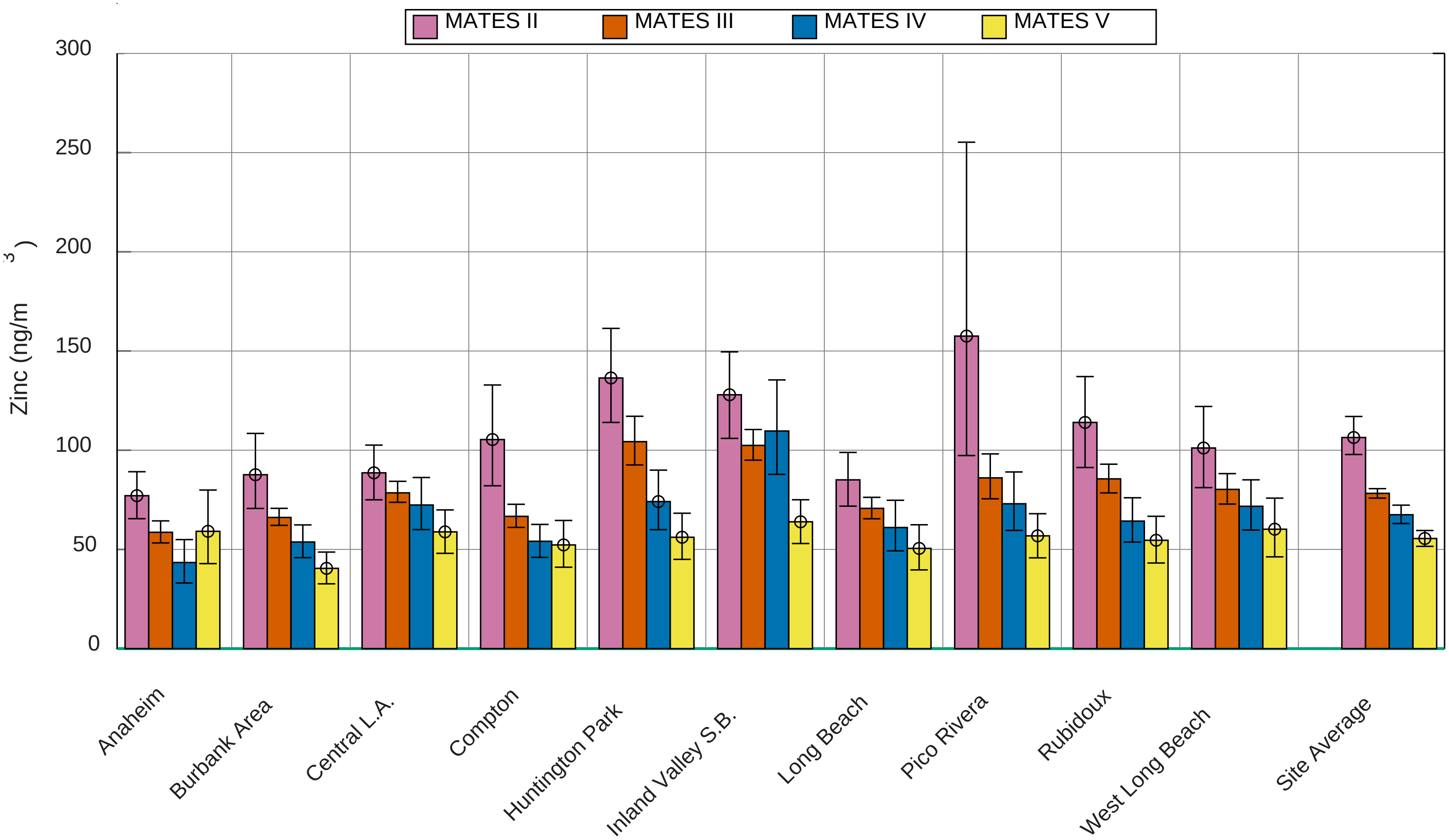


Figure IV-140. Annual Average Concentrations of Zinc in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

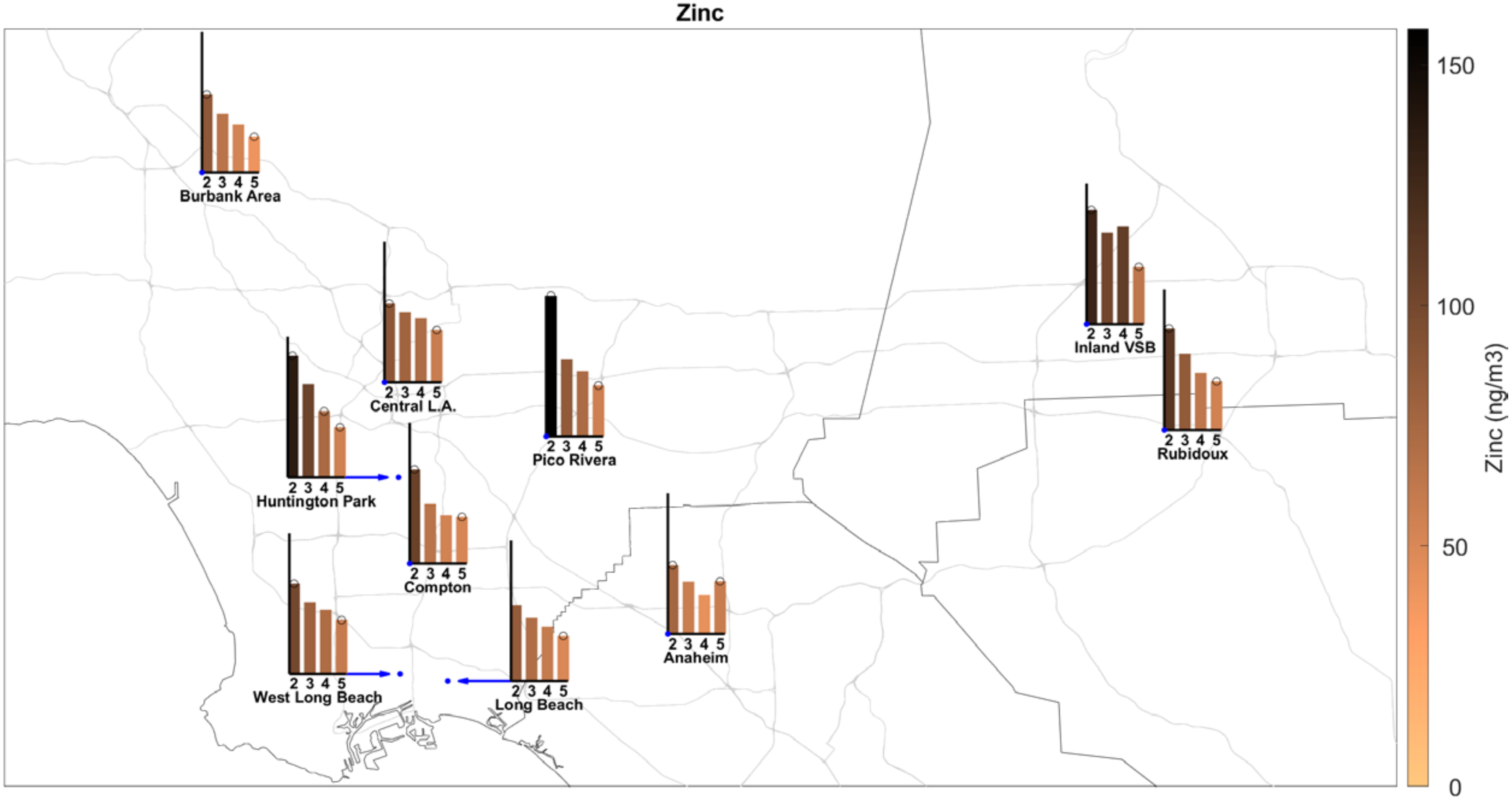


Figure IV-141. Geographic distribution of Zinc from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Zirconium

Table IV-73. Ambient Concentrations (ng/m^3) of Zirconium from the TSP Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	5.8	4.26	10.3	7.85	9.6	4.23	5.21	6.53	6.8	5.2
95% CI LB	4.45	3.78	7.71	5.9	6.65	3.33	4.29	5.13	5.65	4.05
95% CI UB	7.35	4.81	13.1	9.85	13.1	5.3	6.27	7.93	7.95	6.55
N	20	27	21	20	20	30	28	15	20	20
% < MDL	5	3.7	4.8	10	0	20	7.1	13.3	5	10
Max	15	7	25	15	32	13	14	12	11	14
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

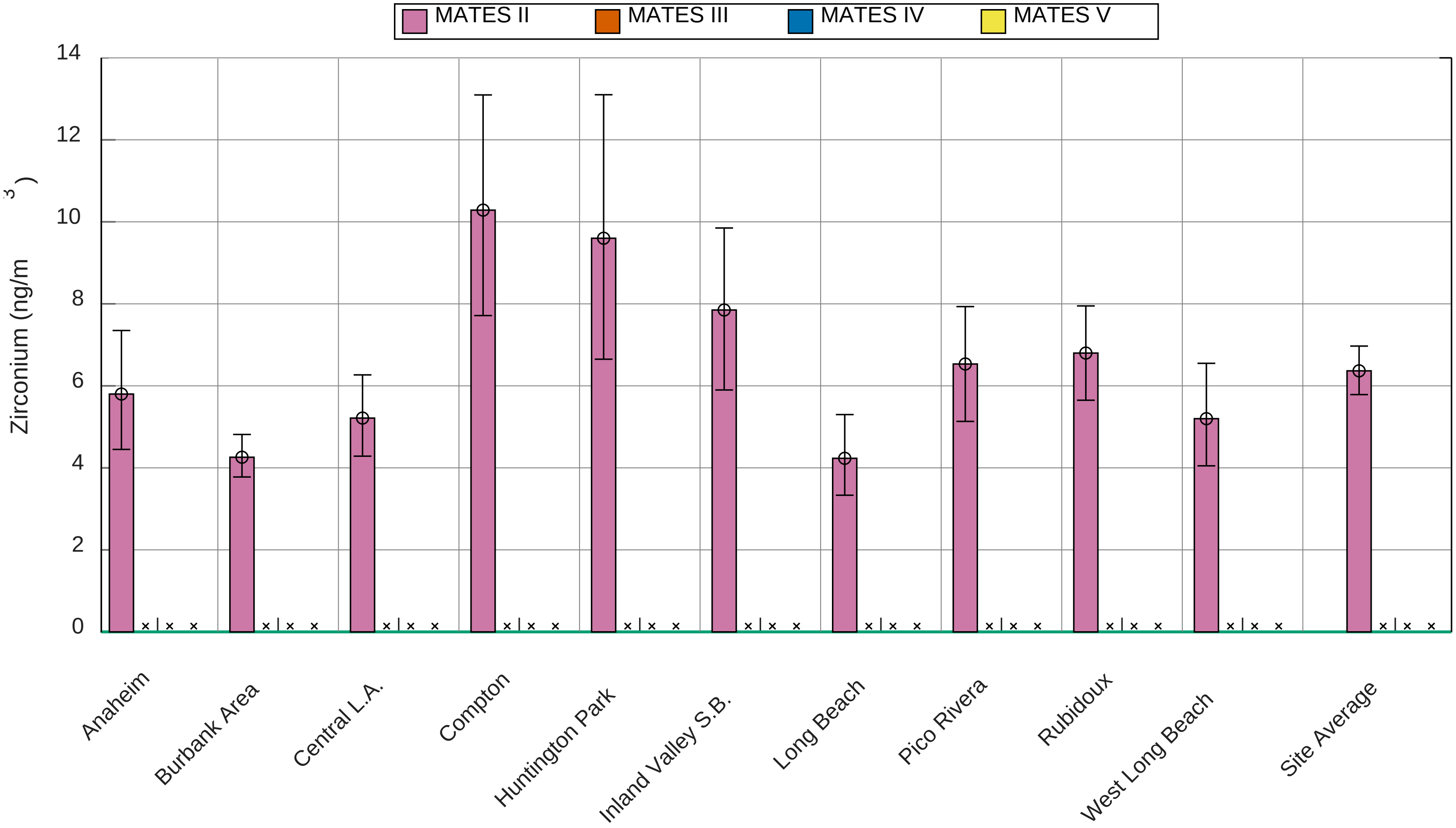


Figure IV-142. Annual Average Concentrations of Zirconium in the TSP Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

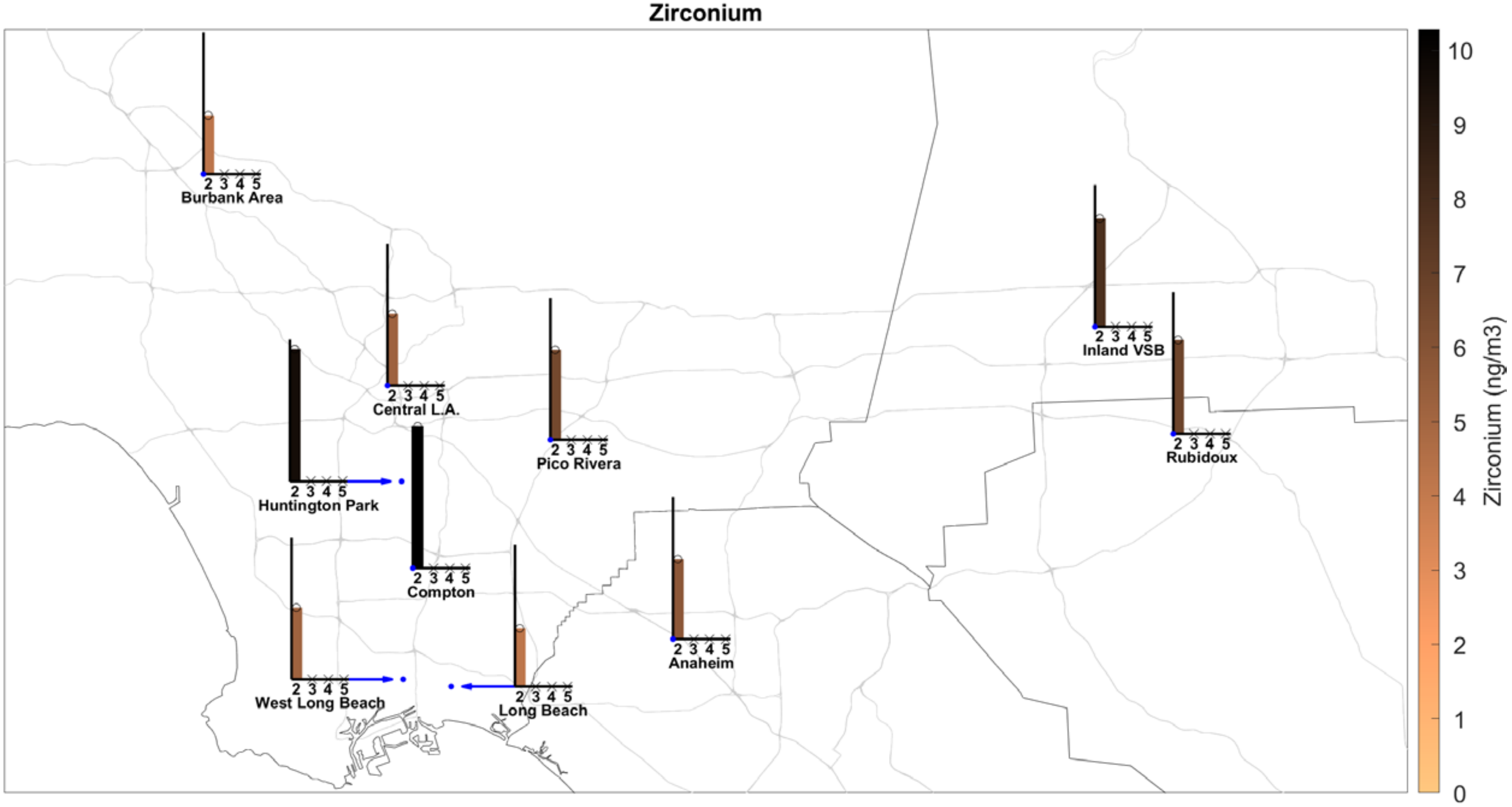


Figure IV-143. Geographic distribution of Zirconium from the TSP Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

PM10 Mass Analysis

PM10 Mass

Table IV-74. Ambient Concentrations (µg/m) of PM10 Mass from the PM10 Mass analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	37.8	39.2		54.8	54.7	35	41.7	61.9	66.4	
95% CI LB	34.2	35.9		48.5	49.6	31.9	37.7	55.1	60	
95% CI UB	41.6	42.5		61.3	59.5	38.1	46.1	69	73.5	
N	58	53	0	59	46	58	59	38	62	0
% < MDL	15.5	15.1		10.2	2.2	20.7	11.9	0	4.8	
Max	81	69		101	104	69	88	115	119	
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	22.5	26.2	26.3	35.6	27.4	22.4	27.3	27.3	33.5	30
95% CI LB	20.7	23.9	24.1	31.7	25.1	20.5	25	24.8	30.2	26.5
95% CI UB	24.2	28.3	28.7	39.3	29.5	24.2	29.5	29.6	36.7	34.2
N	61	57	57	61	52	60	60	50	60	51
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	43	40	52	63	41	36	45	48	66	78
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

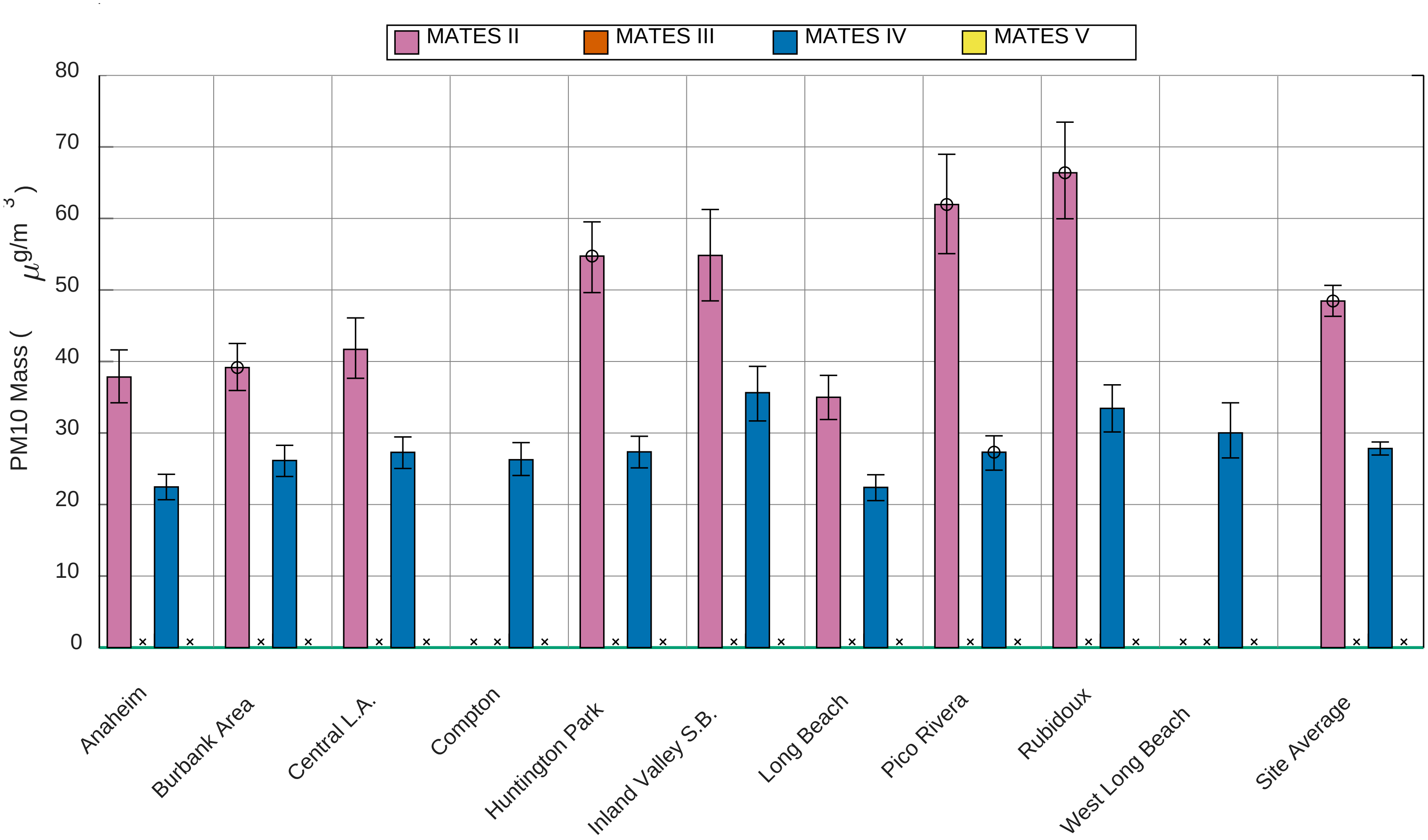


Figure IV-144. Annual Average Concentrations of PM10 Mass in the PM10 Mass Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

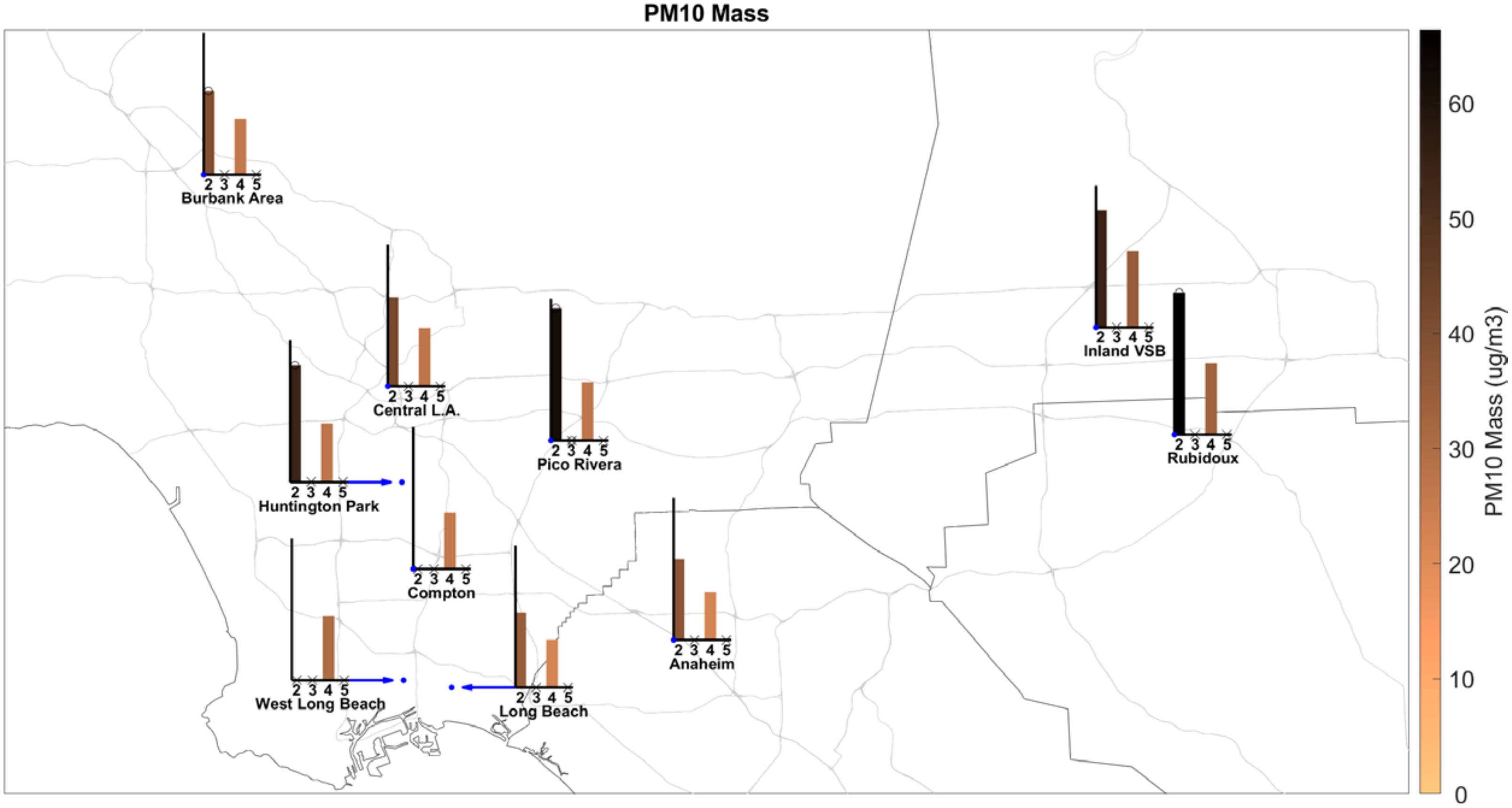


Figure IV-145. Geographic distribution of PM10 Mass from the PM10 Mass Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

PM10 Carbon Analysis

Elemental Carbon

Table IV-75. Ambient Concentrations (ng/m^3) of Elemental Carbon from the PM10 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	2320	3190		3110	4530	2570	3530	4350	3420	
95% CI LB	1980	2710		2680	3870	2170	3080	3680	2970	
95% CI UB	2700	3680		3570	5240	3000	4000	5090	3920	
N	58	53	0	59	46	58	59	38	62	0
% < MDL	12.1	3.8		5.1	0	20.7	1.7	0	12.9	
Max	7760	8410		6860	10600	7700	8160	10200	8290	
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	1170	1740	1500	1740	1650	1290	1670	1870	1480	1780
95% CI LB	951	1480	1210	1540	1380	1060	1440	1590	1300	1440
95% CI UB	1400	2010	1820	1940	1950	1520	1910	2140	1680	2180
N	61	57	57	61	52	58	60	50	59	51
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	4760	4540	4680	3980	5150	3690	4240	4390	3960	5980
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

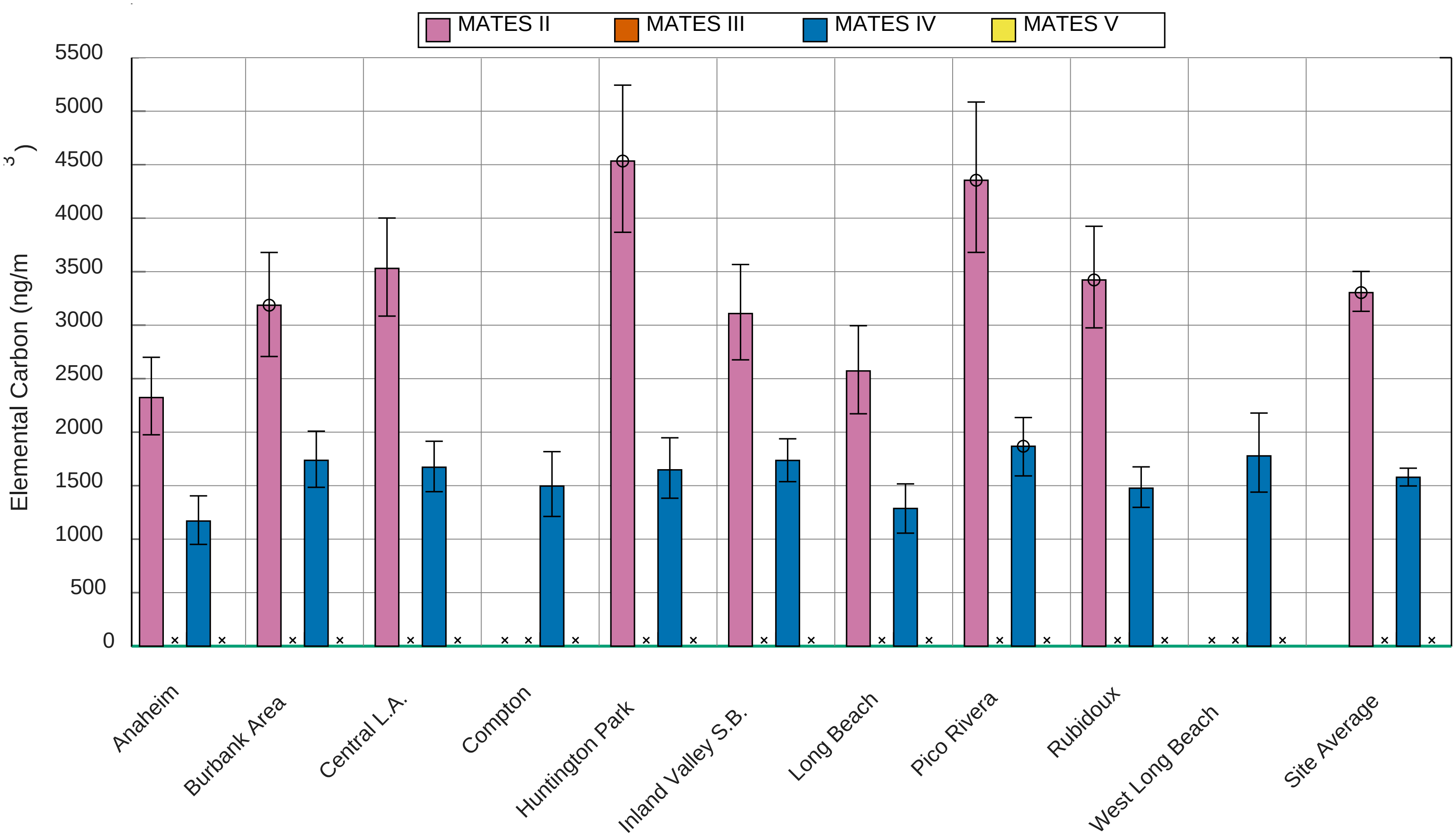


Figure IV-146. Annual Average Concentrations of Elemental Carbon in the PM10 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

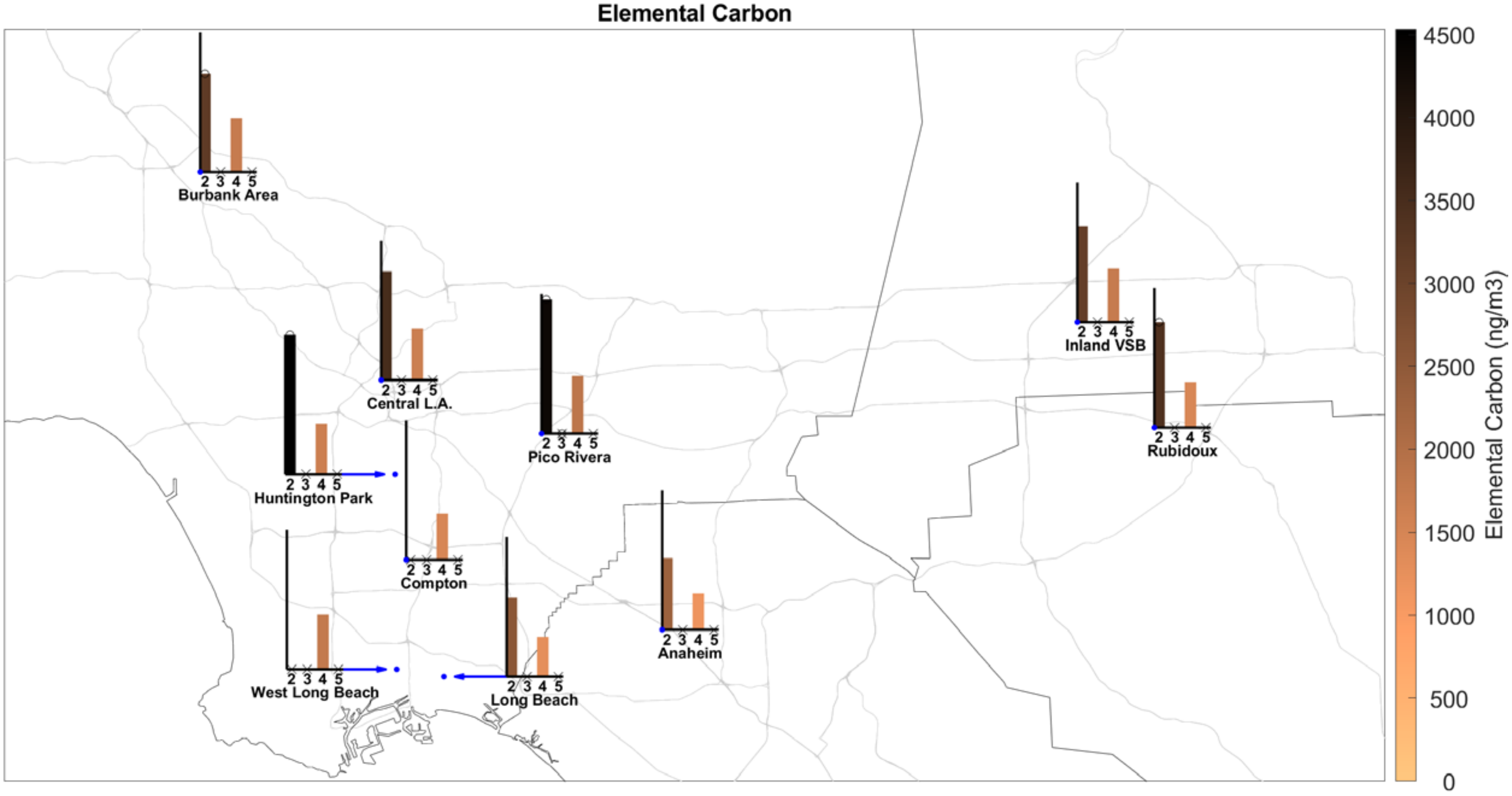


Figure IV-147. Geographic distribution of Elemental Carbon from the PM10 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Organic Carbon

Table IV-76. Ambient Concentrations (ng/m^3) of Organic Carbon from the PM10 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	4970	5980		6440	8150	4870	6140	8030	7460	
95% CI LB	4500	5320		5740	6970	4390	5520	7090	6720	
95% CI UB	5500	6710		7170	9500	5380	6810	9050	8230	
N	58	53	0	59	46	58	59	38	62	0
% < MDL	31	17		18.6	0	39.7	13.6	0	9.7	
Max	12600	13800		15200	26100	11600	14400	16700	14600	
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	3710	4860	4440	5320	4540	3640	4440	4820	5290	4450
95% CI LB	3320	4410	3860	4880	4090	3260	4080	4410	4900	3820
95% CI UB	4100	5340	5090	5740	5030	4060	4830	5270	5700	5160
N	61	57	57	61	52	58	60	50	59	51
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	9320	10300	12100	9270	9260	7960	8220	9280	9170	12200
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

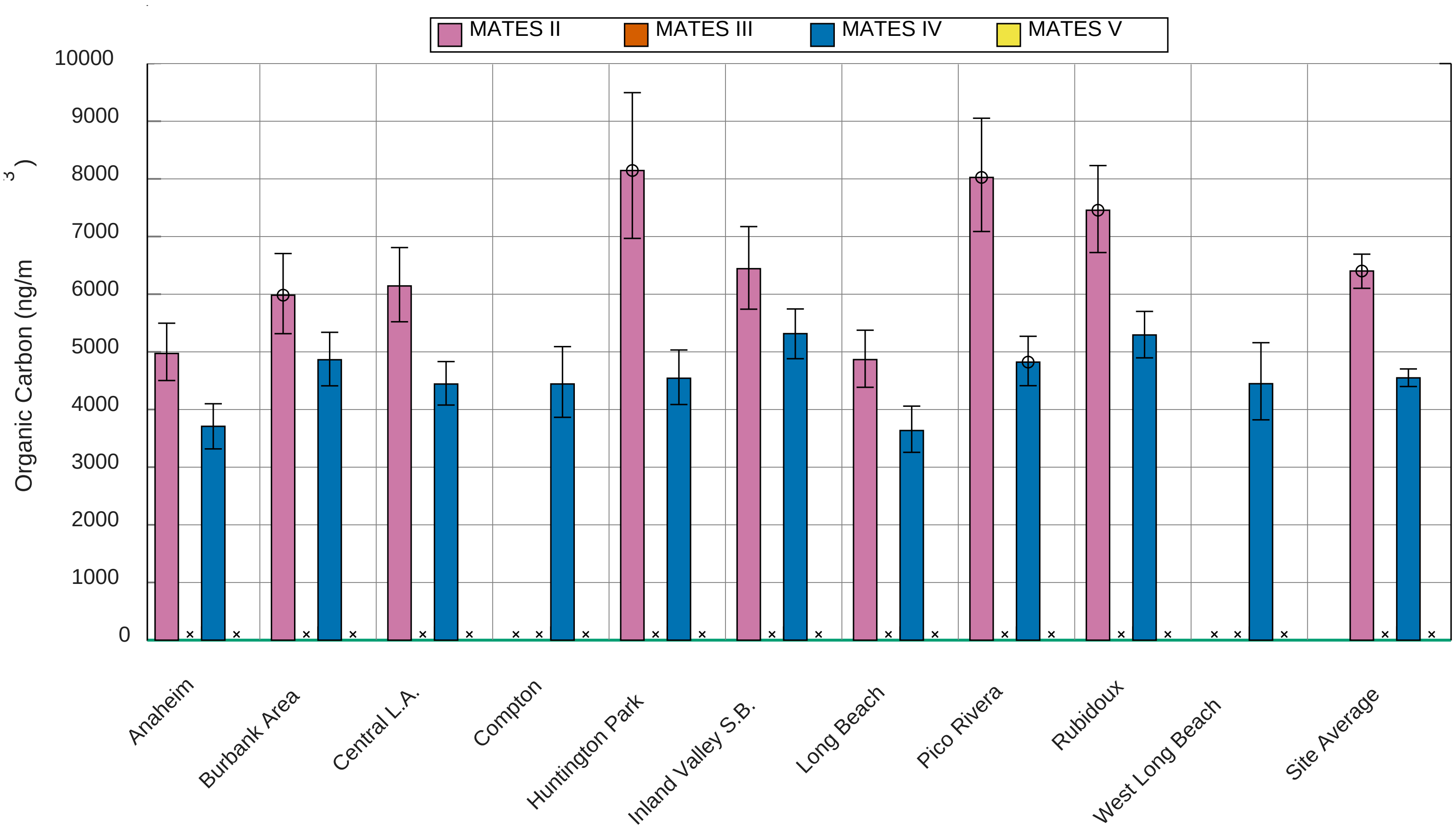


Figure IV-148. Annual Average Concentrations of Organic Carbon in the PM10 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

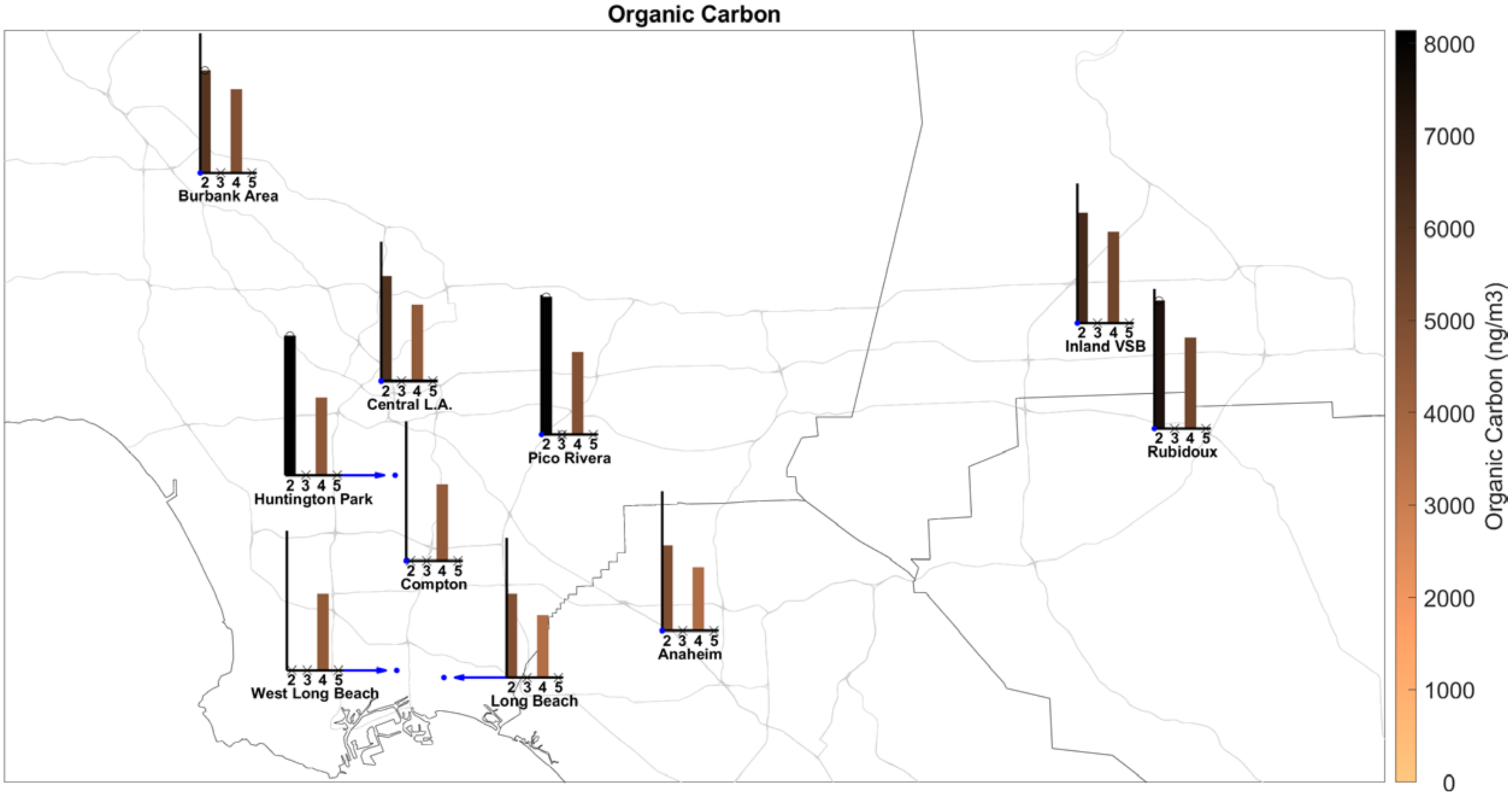


Figure IV-149. Geographic distribution of Organic Carbon from the PM10 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Total Carbon

Table IV-77. Ambient Concentrations (ng/m^3) of Total Carbon from the PM10 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	7470	9290		9640	12700	7630	9730	12400	10900	
95% CI LB	6700	8210		8530	11000	6790	8720	10900	9850	
95% CI UB	8360	10400		10700	14600	8570	10800	14000	12100	
N	58	53	0	59	46	58	59	38	62	0
% < MDL	37.9	24.5		20.3	2.2	39.7	18.6	2.6	14.5	
Max	20300	22200		20300	36700	19300	22500	24100	22100	
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	4880	6600	5940	7050	6190	4920	6120	6690	6770	6230
95% CI LB	4260	5910	5080	6470	5480	4260	5540	6040	6240	5280
95% CI UB	5520	7340	6900	7610	6960	5550	6730	7410	7320	7280
N	61	57	57	61	52	58	60	50	59	51
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	14100	14200	16800	12900	13600	11600	12400	13700	13100	18200
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

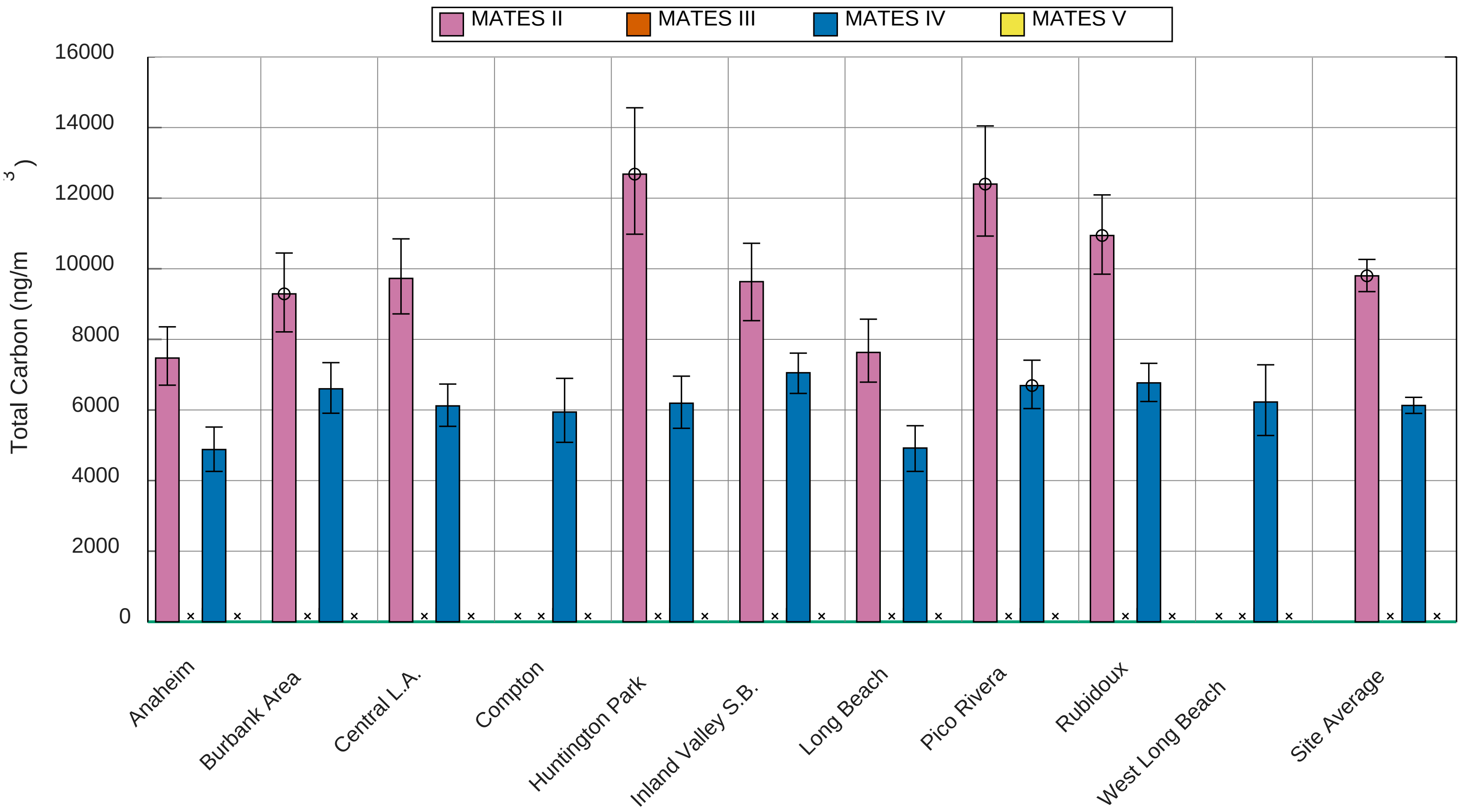


Figure IV-150. Annual Average Concentrations of Total Carbon in the PM10 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

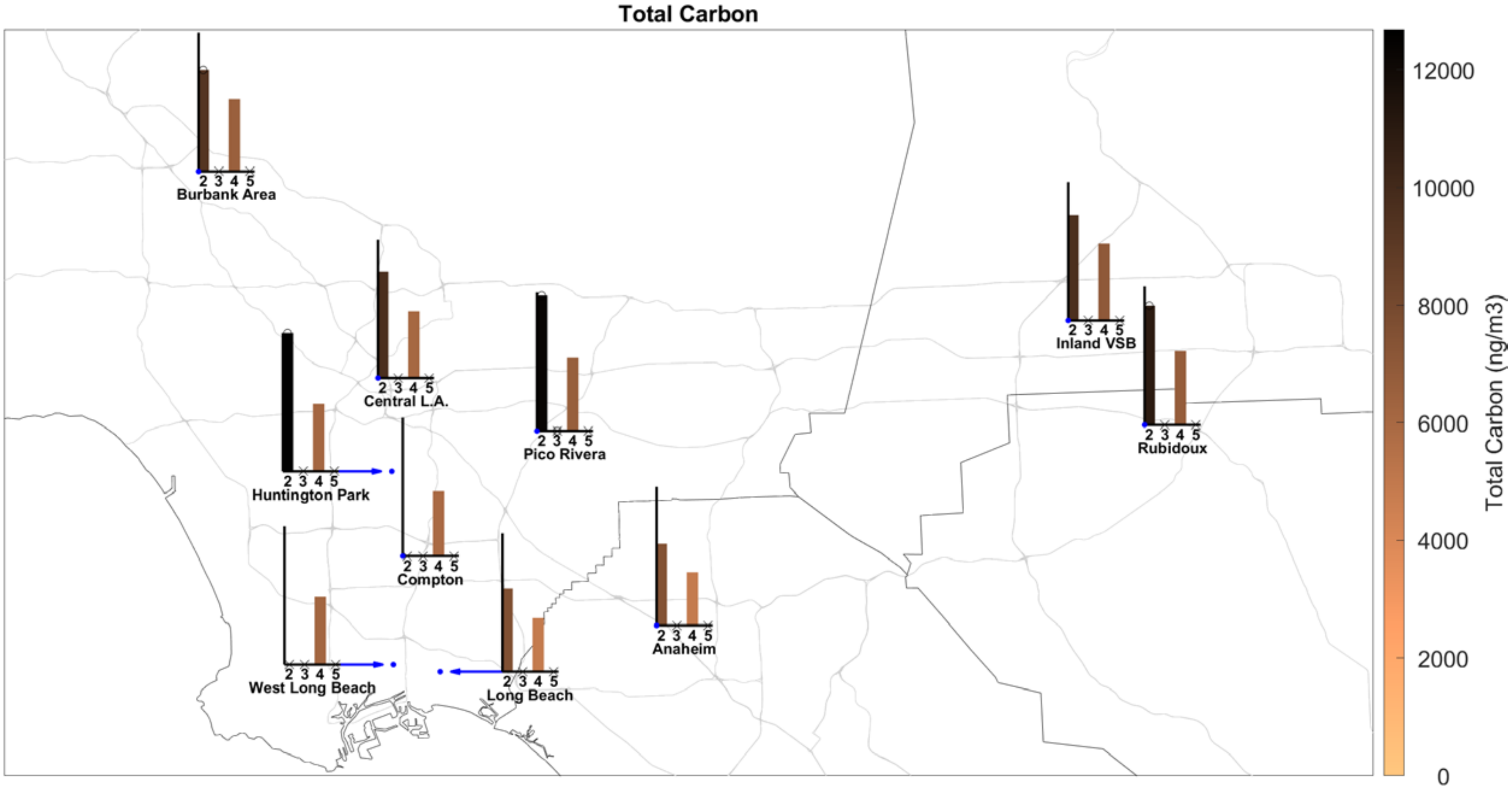


Figure IV-151. Geographic distribution of Total Carbon from the PM10 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

PAH Analysis

Acenaphthene

Table IV-78. Ambient Concentrations (ng/m^3) of Acenaphthene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							7.4		4.31	7.81
95% CI LB							6.56		3.85	6.79
95% CI UB							8.35		4.79	8.87
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							38.1		13.4	34.8
MATES IV										
Average						1.98	5		2.3	
95% CI LB						1.71	4.26		1.98	
95% CI UB						2.26	5.78		2.65	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						0	0		0	
Max						4.37	12.4		6.7	
MATES V										
Average							6.53		1.67	
95% CI LB							5.32		1.35	
95% CI UB							7.84		2.06	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		3.3	
Max							27.1		9.98	

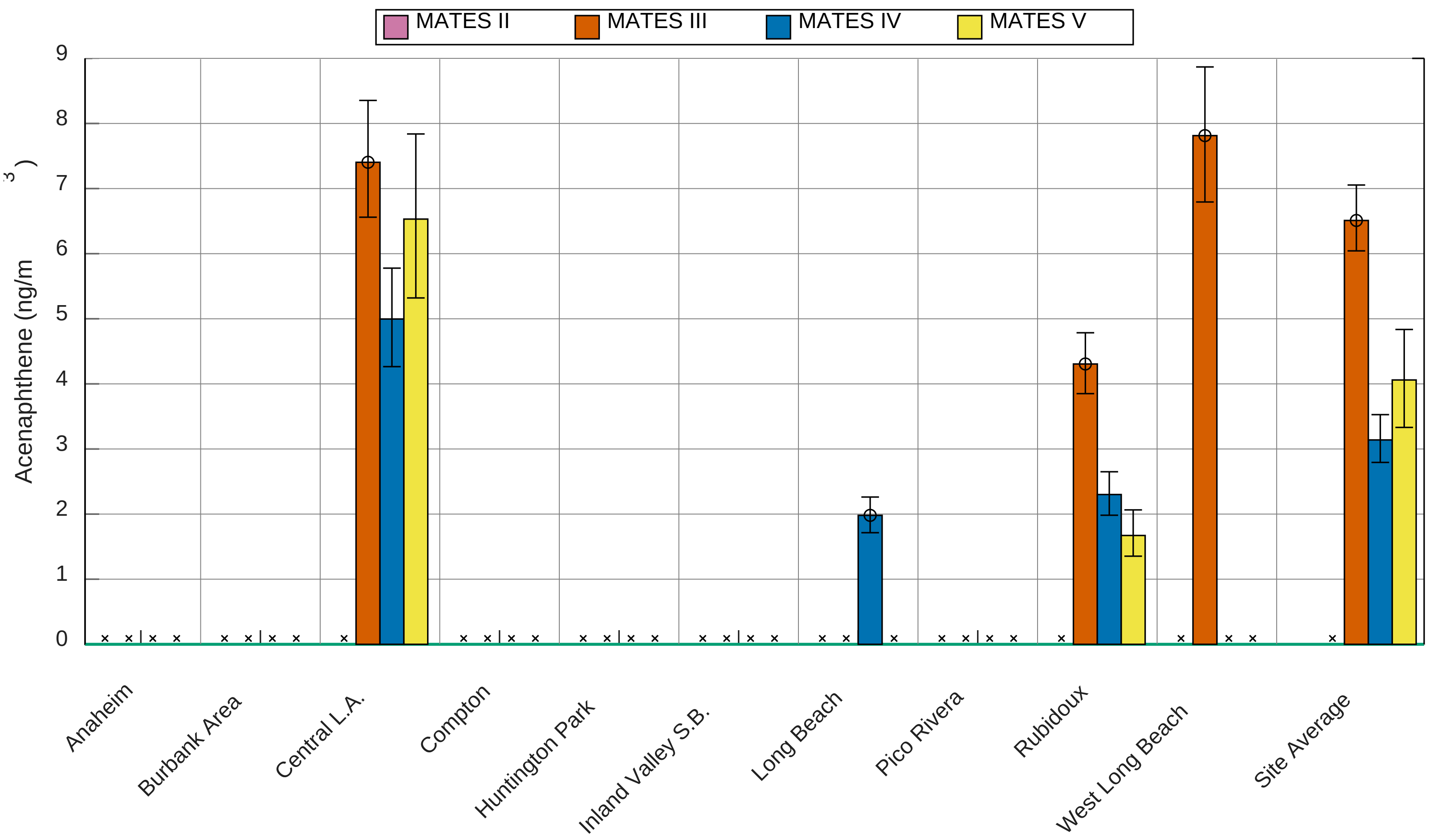


Figure IV-152. Annual Average Concentrations of Acenaphthene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

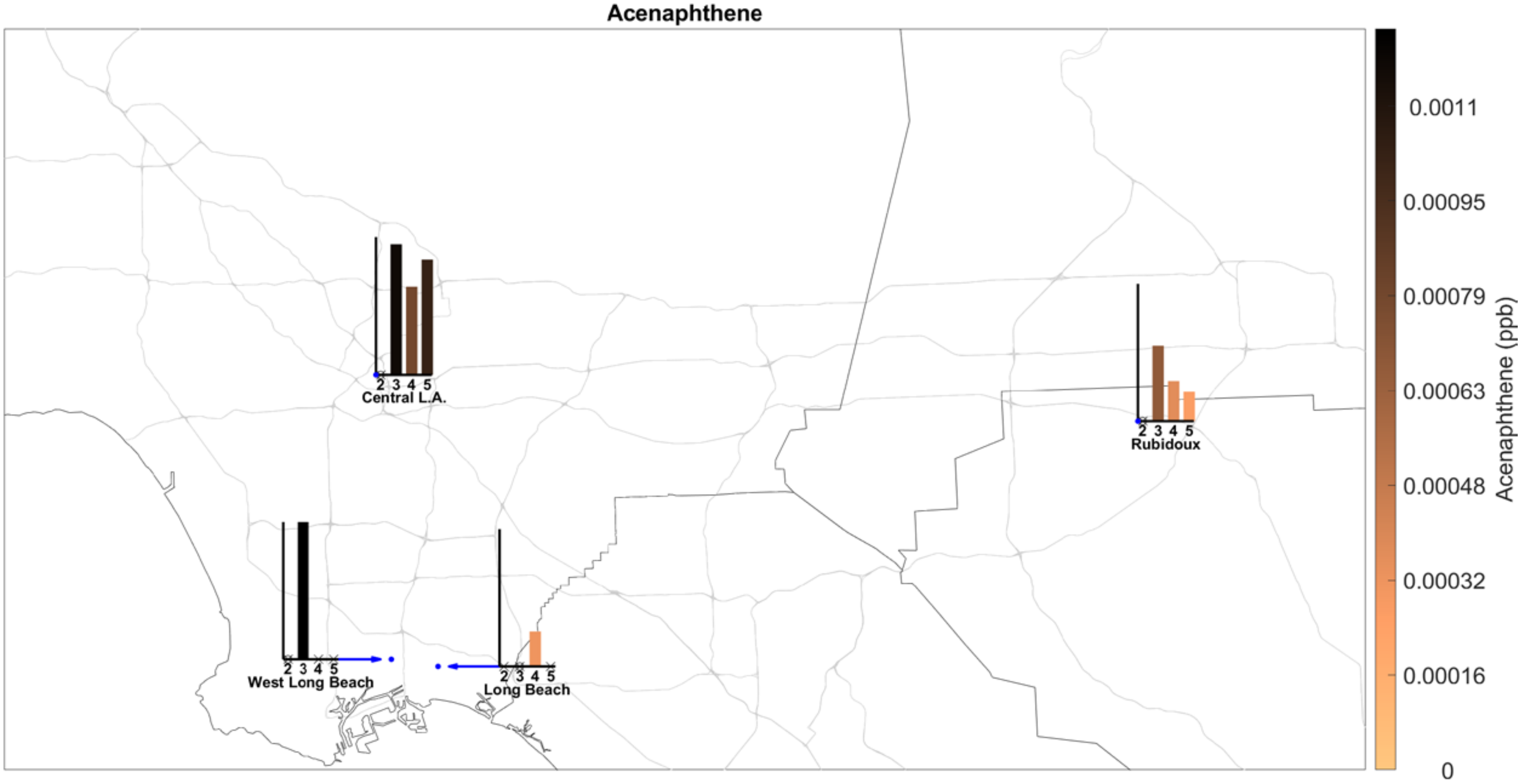


Figure IV-153. Geographic distribution of Acenaphthene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Acenaphthylene

Table IV-79. Ambient Concentrations (ng/m^3) of Acenaphthylene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							5.39		4.6	5.68
95% CI LB							4.72		3.87	4.75
95% CI UB							6.09		5.38	6.63
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							16.6		20.9	24.7
MATES IV										
Average						0.629	0.703		0.467	
95% CI LB						0.349	0.438		0.284	
95% CI UB						0.988	1.01		0.682	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						60.8	56.9		55.2	
Max						5.36	4.64		4.05	
MATES V										
Average							0.447		0.351	
95% CI LB							0.287		0.164	
95% CI UB							0.631		0.59	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							15.5		35	
Max							3.15		5	

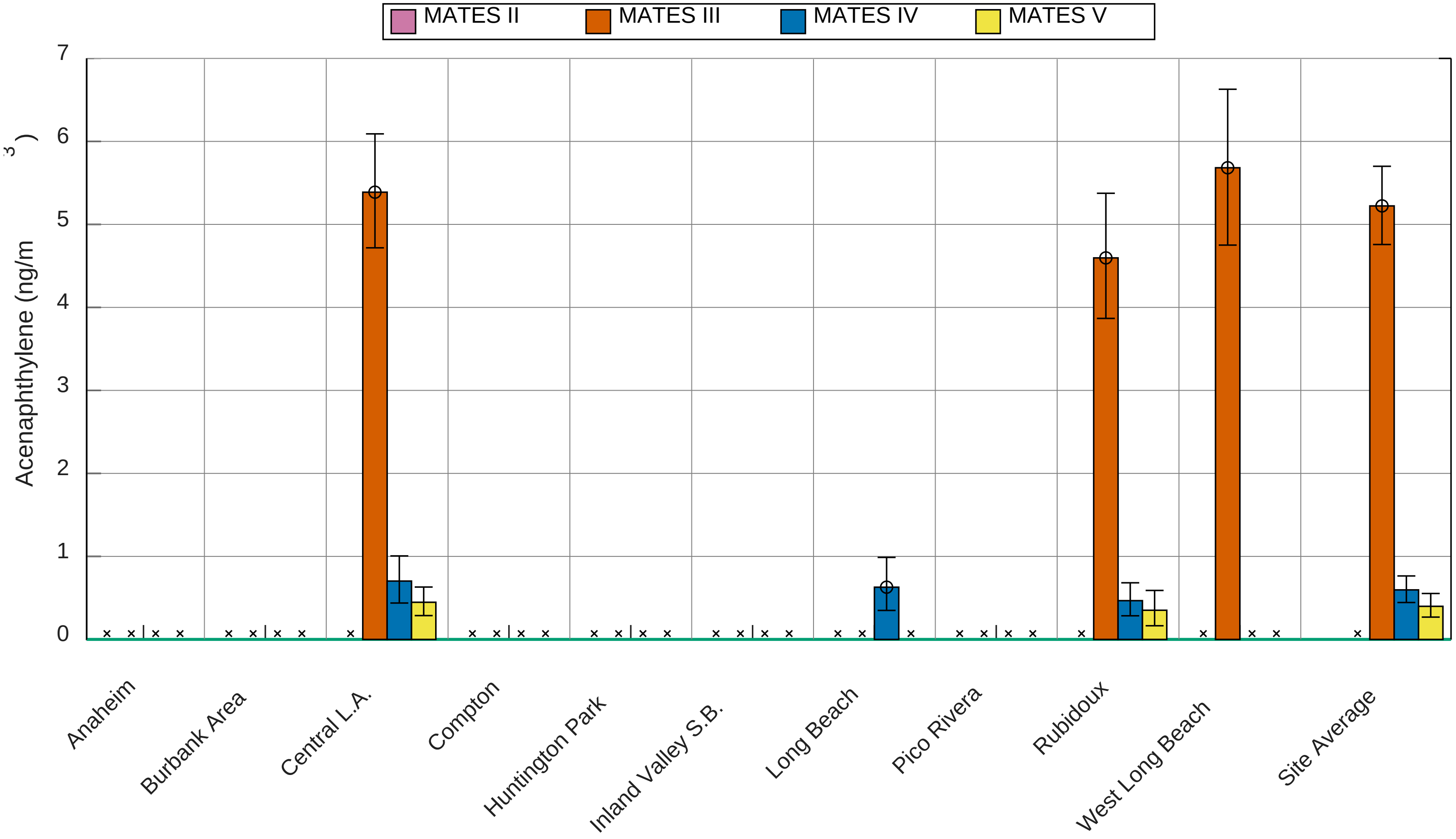


Figure IV-154. Annual Average Concentrations of Acenaphthylene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

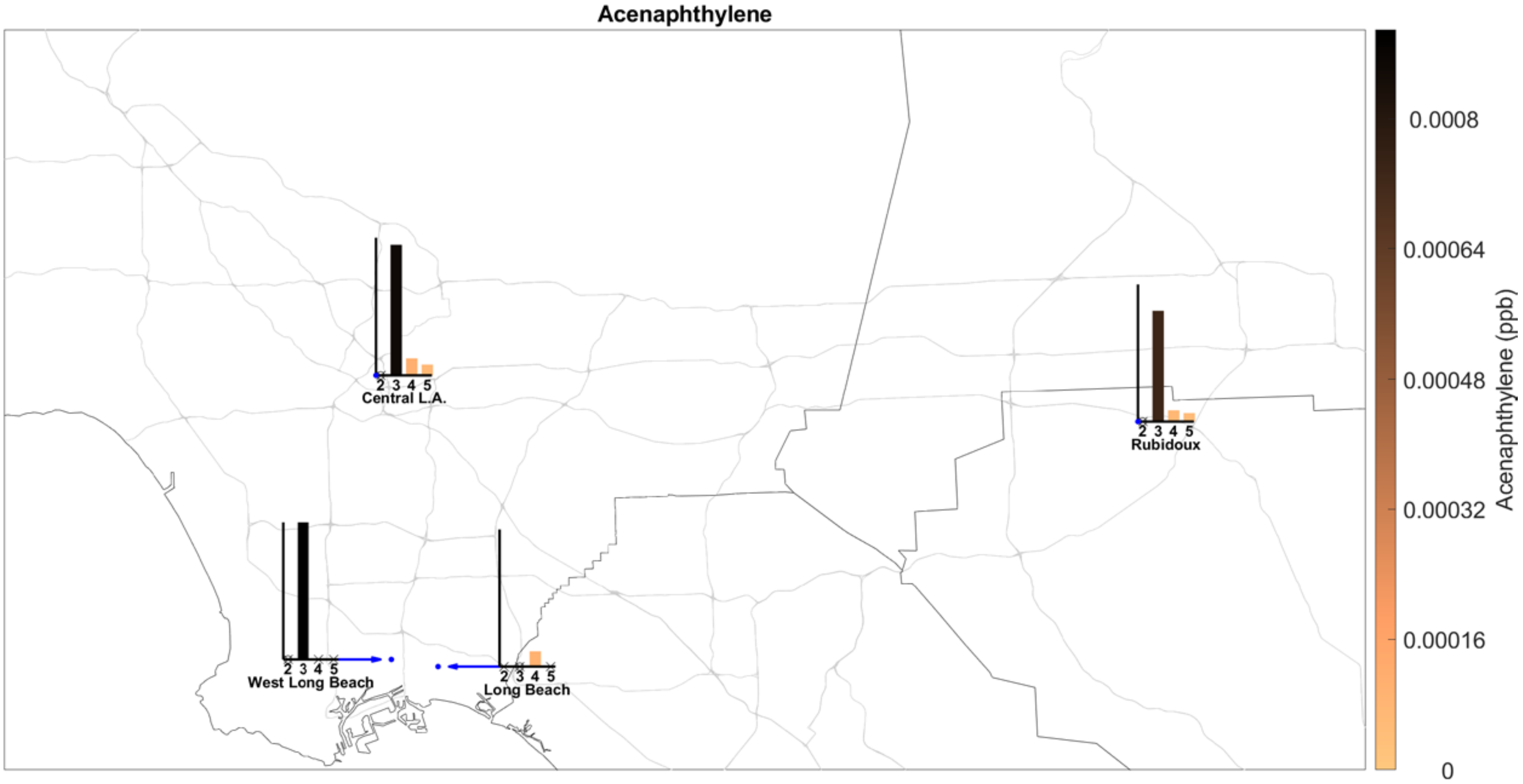


Figure IV-155. Geographic distribution of Acenaphthylene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Anthracene

Table IV-80. Ambient Concentrations (ng/m^3) of Anthracene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							1.11		0.788	0.997
95% CI LB							0.729		0.524	0.697
95% CI UB							1.63		1.12	1.44
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							21.6		11.8	22.3
MATES IV										
Average						0.263	0.474		0.222	
95% CI LB						0.198	0.402		0.164	
95% CI UB						0.339	0.551		0.29	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						19.6	5.2		36.2	
Max						1.15	1.51		1.38	
MATES V										
Average							0.289		0.125	
95% CI LB							0.222		0.0835	
95% CI UB							0.362		0.174	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							15.5		18.3	
Max							1.12		1.04	

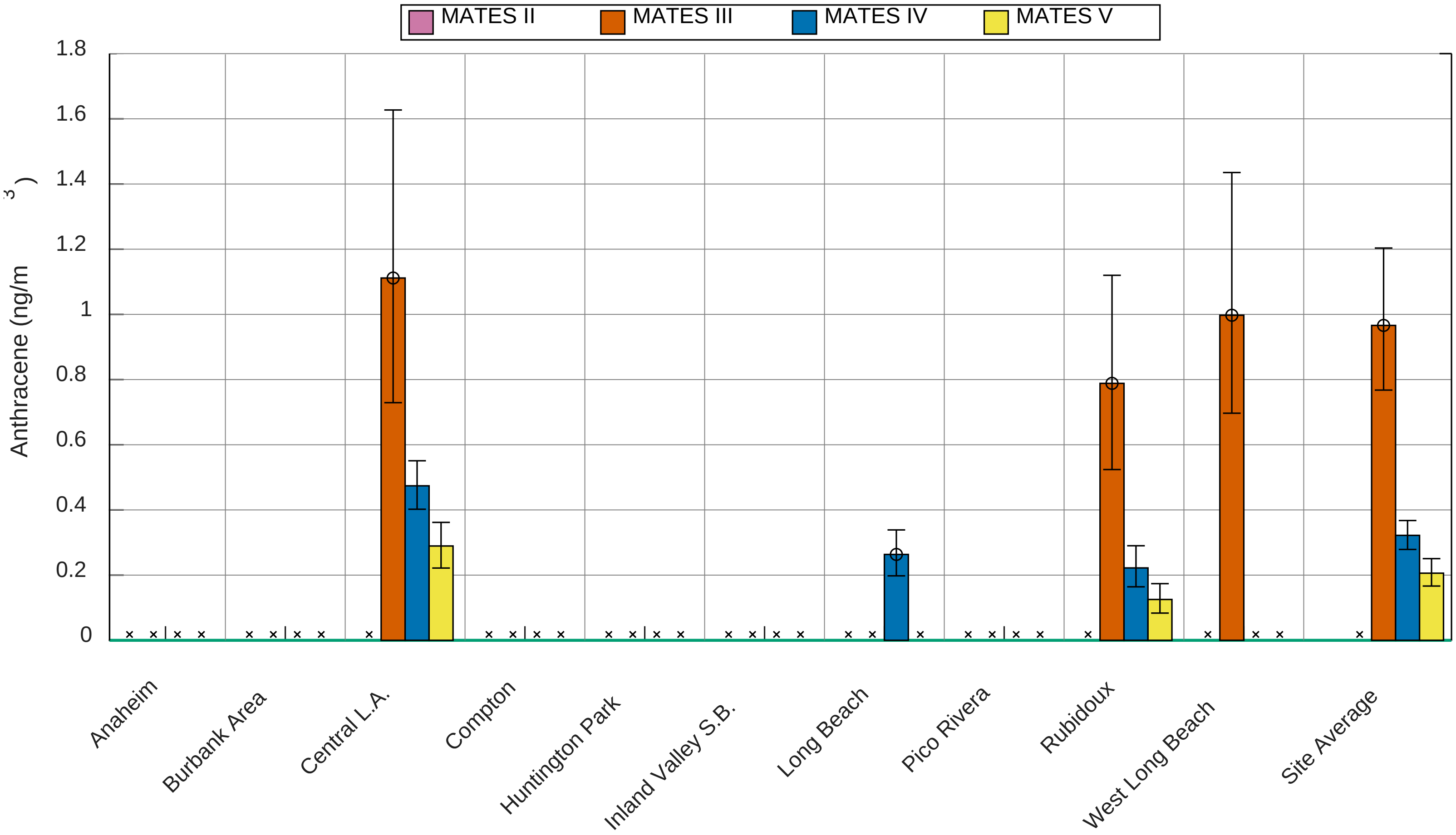


Figure IV-156. Annual Average Concentrations of Anthracene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

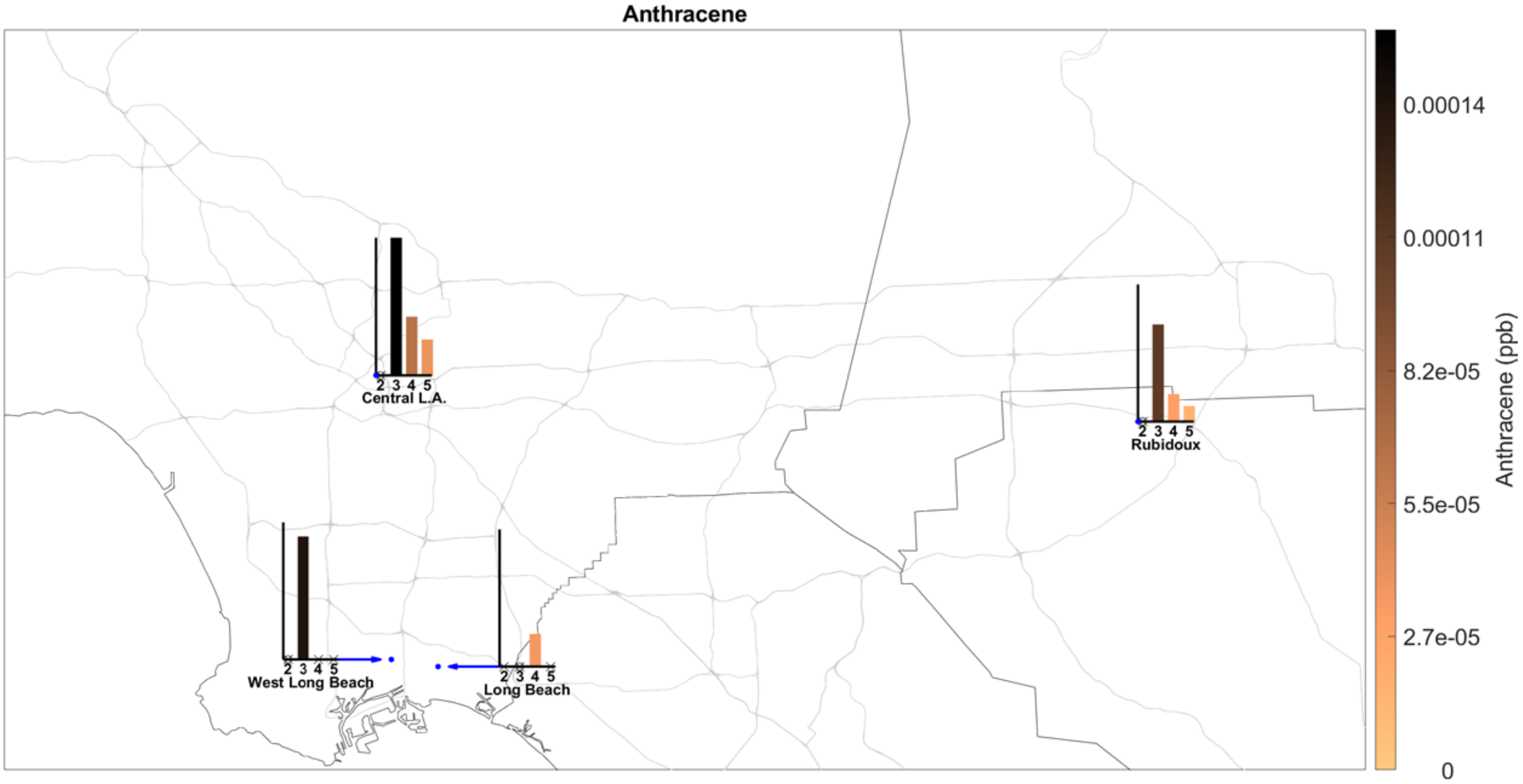


Figure IV-157. Geographic distribution of Anthracene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Benzo(a)anthracene

Table IV-81. Ambient Concentrations (ng/m^3) of Benzo(a)anthracene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							0.112		0.126	0.153
95% CI LB							0.0957		0.104	0.127
95% CI UB							0.128		0.149	0.18
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							0.536		0.696	0.853
MATES IV										
Average						0.107	0.0548		0.074	
95% CI LB						0.0623	0.0479		0.063	
95% CI UB						0.193	0.0822		0.109	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						74.5	74.1		77.6	
Max						1.97	0.248		0.684	
MATES V										
Average							0.0639		0.0613	
95% CI LB							0.0425		0.0408	
95% CI UB							0.0928		0.0855	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		1.7	
Max							0.645		0.548	

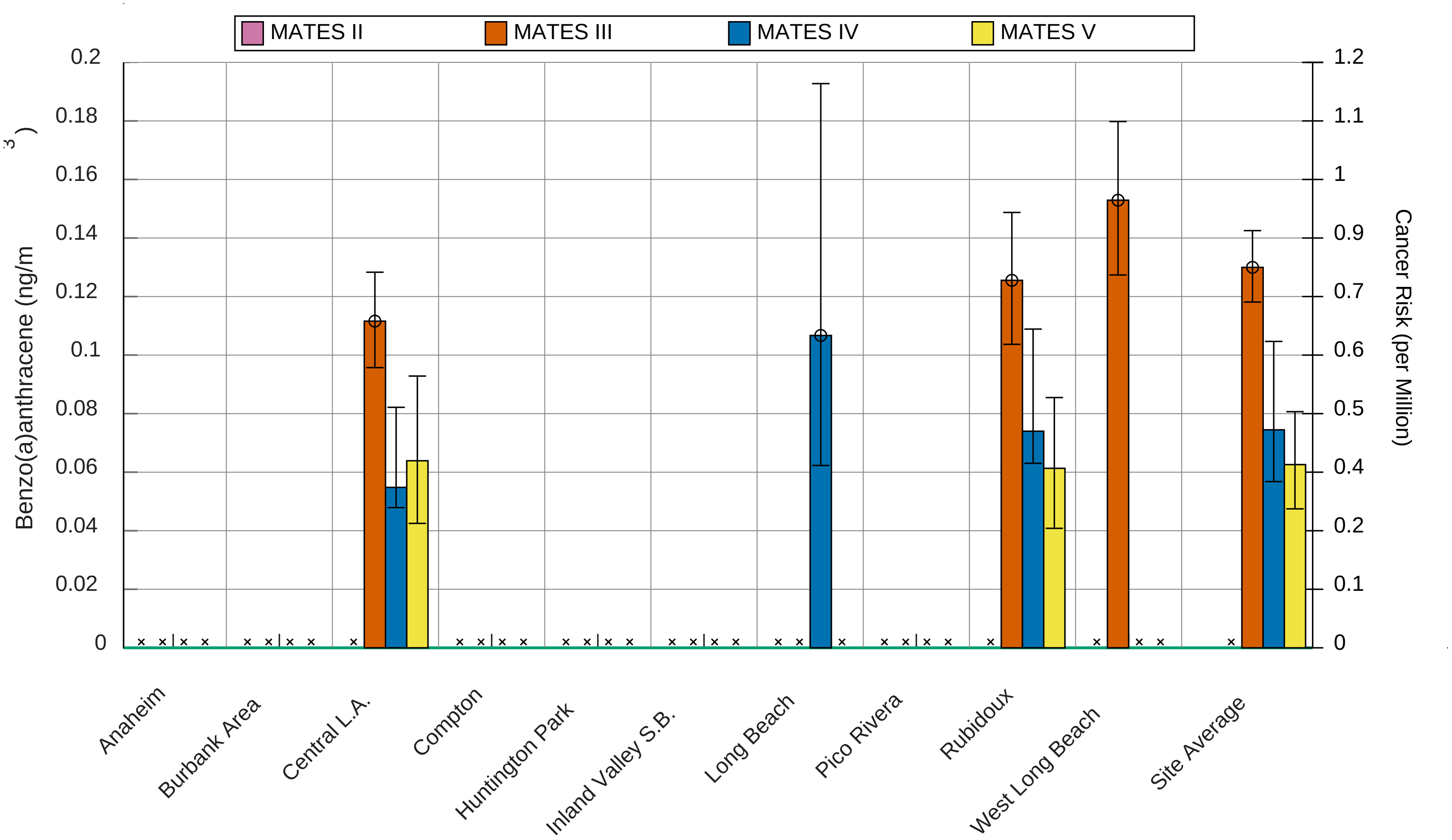


Figure IV-158. Annual Average Concentrations of Benzo(a)anthracene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

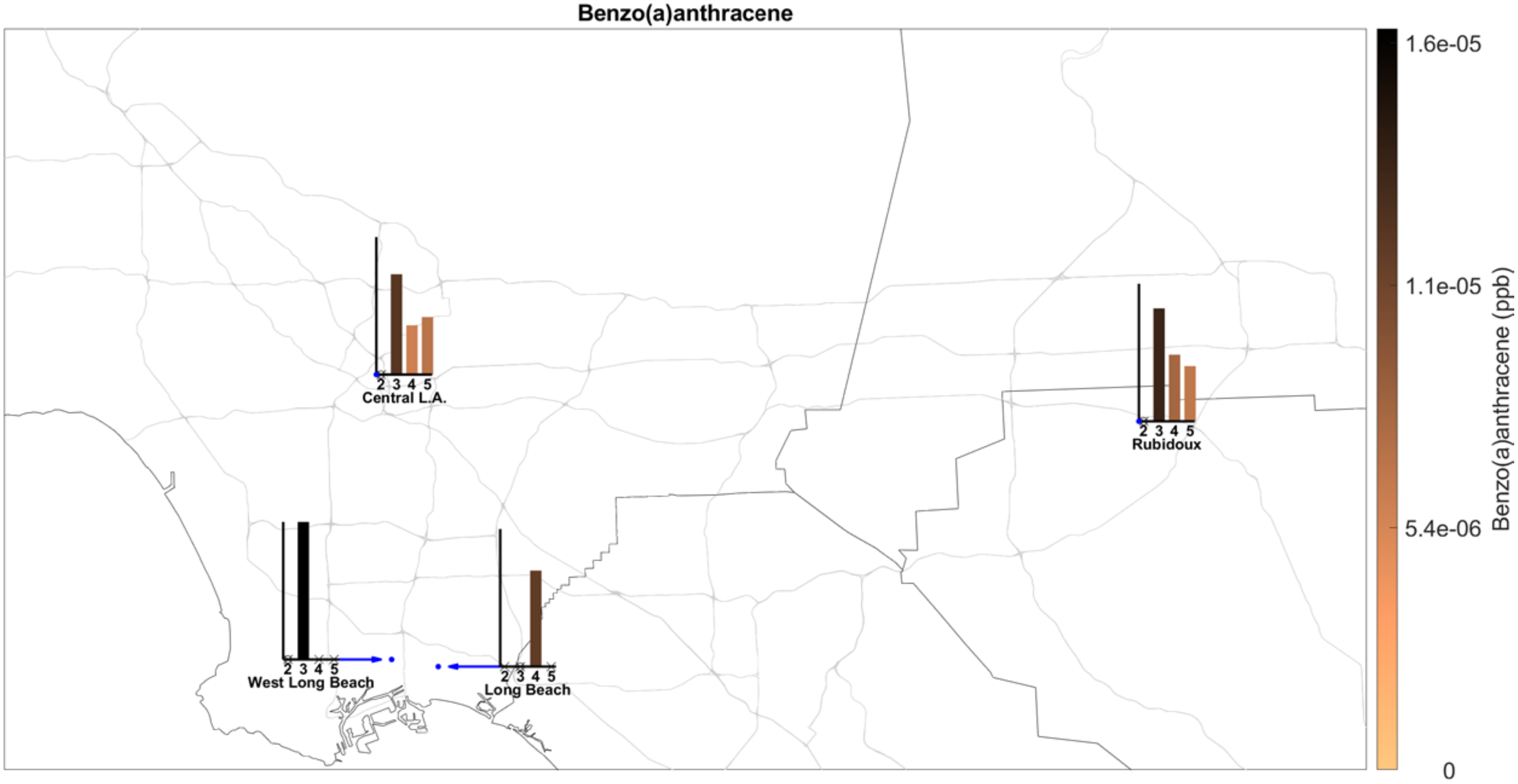


Figure IV-159. Geographic distribution of Benzo(a)anthracene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Benzo(a)pyrene

Table IV-82. Ambient Concentrations (ng/m^3) of Benzo(a)pyrene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.133	0.242		0.0897	0.307	0.173	0.16	0.262	0.126	
95% CI LB	0.0732	0.137		0.0719	0.144	0.0942	0.107	0.131	0.0731	
95% CI UB	0.221	0.378		0.112	0.526	0.29	0.224	0.445	0.2	
N	31	31	0	31	24	31	31	22	30	0
% < MDL	58.1	35.5		45.2	20.8	41.9	32.3	36.4	53.3	
Max	1.3	1.8		0.27	2.3	1.6	0.9	1.9	1	
MATES III										
Average							0.142		0.15	0.212
95% CI LB							0.119		0.123	0.169
95% CI UB							0.169		0.179	0.259
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							1.1		0.76	1.83
MATES IV										
Average						0.0582, 0.108[a]	0.0185, 0.0707[a]		0.0689	
95% CI LB						0.0156[a]	0.0076[a]		0.0614	
95% CI UB						0.169[a]	0.089[a]		0.0952	
N	0	0	0	0	0	51[a]	58[a]	0	58	0
% < MDL						80.4[a]	82.8[a]		79.3	
Max						1.4[a]	0.221[a]		0.519	
MATES V										
Average							0.0584		0.0589	
95% CI LB							0.0362		0.0368	
95% CI UB							0.0865		0.0877	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							10.3		11.7	
Max							0.516		0.654	

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

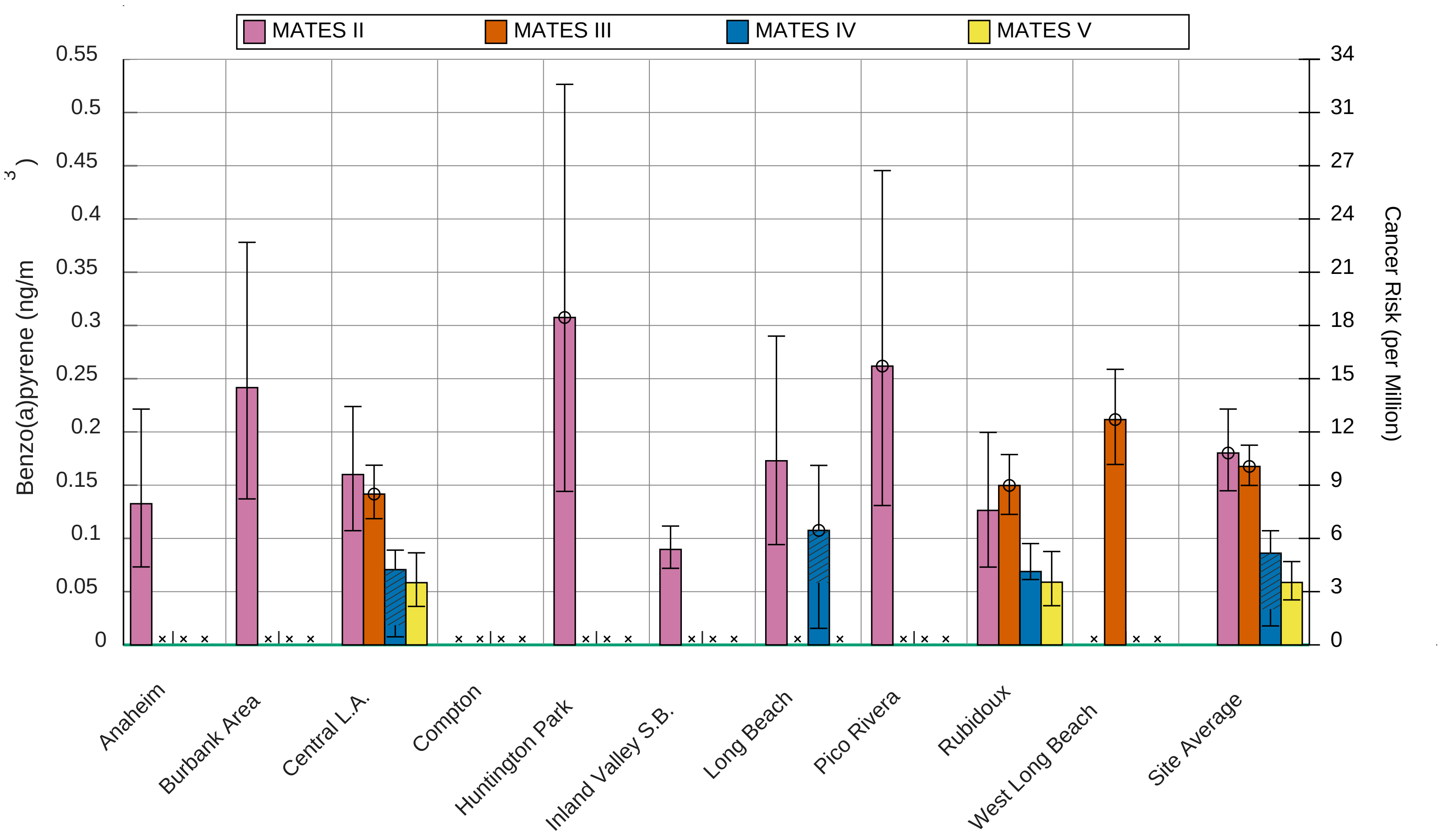


Figure IV-160. Annual Average Concentrations of Benzo(a)pyrene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

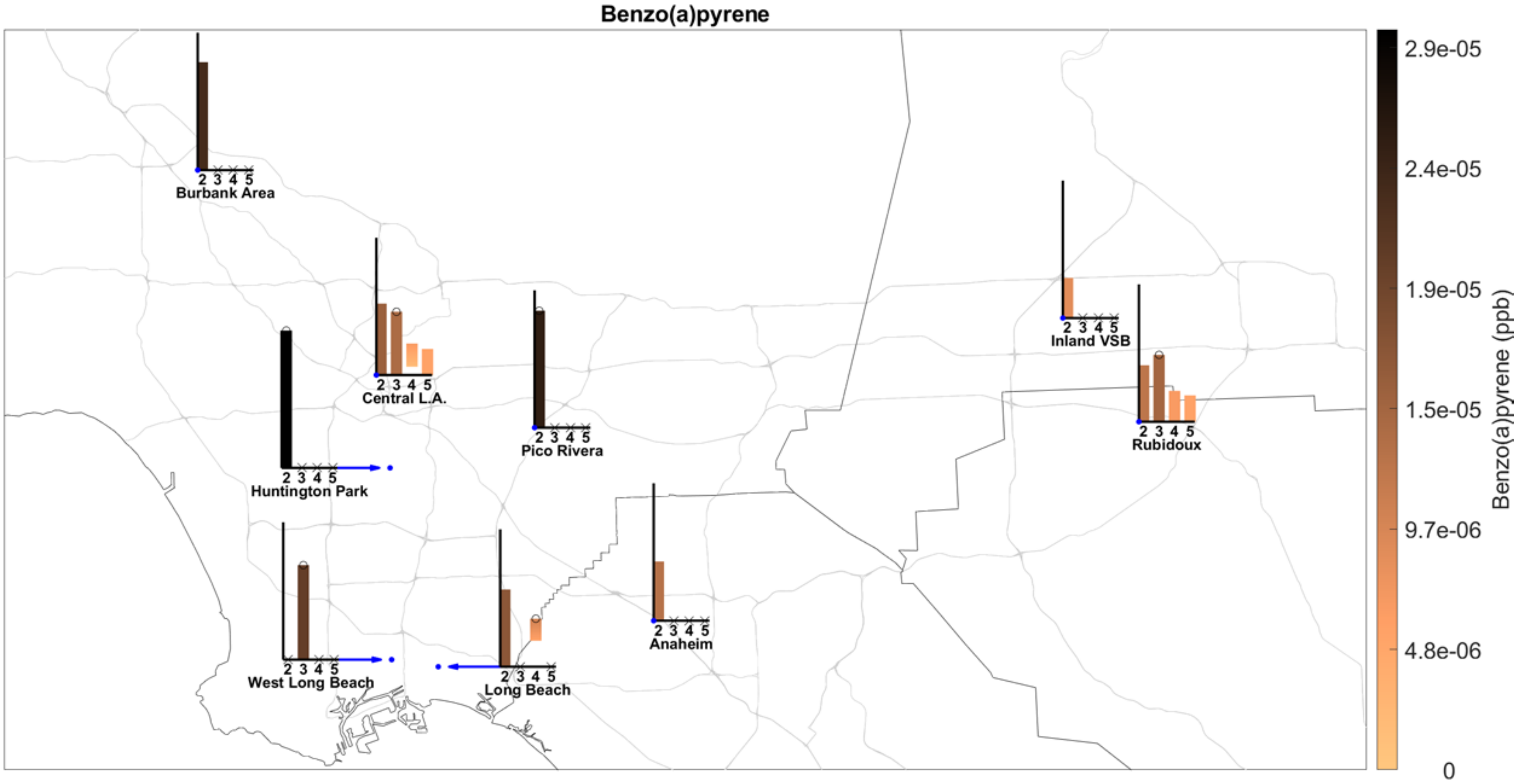
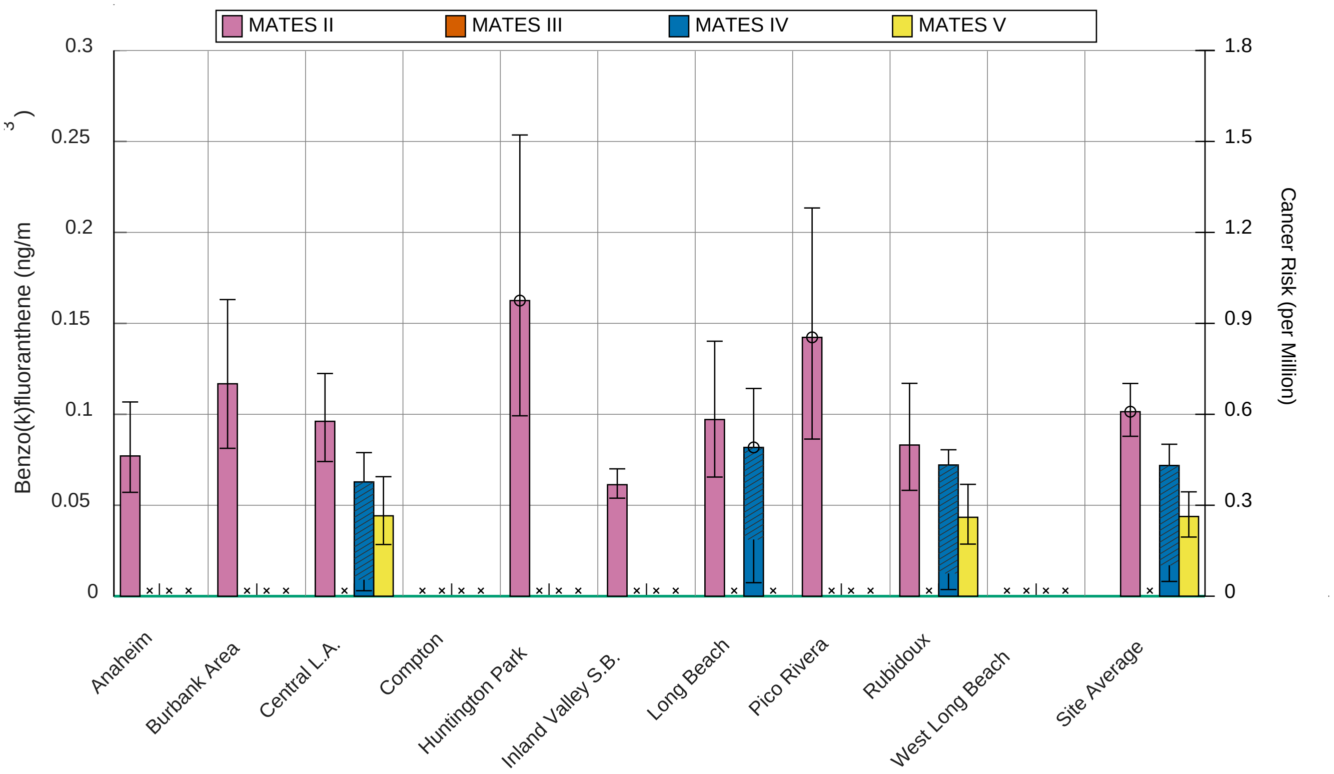


Figure IV-161. Geographic distribution of Benzo(a)pyrene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Benzo(b)fluoranthene

Table IV-83. Ambient Concentrations (ng/m^3) of Benzo(b)fluoranthene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.151	0.267		0.126	0.388	0.208	0.223	0.345	0.169	
95% CI LB	0.091	0.174		0.1	0.225	0.122	0.16	0.199	0.101	
95% CI UB	0.235	0.387		0.156	0.614	0.325	0.3	0.531	0.256	
N	31	31	0	31	24	31	31	22	30	0
% < MDL	38.7	9.7		16.1	16.7	29	19.4	4.5	30	
Max	1.2	1.6		0.38	2	1.6	1	1.9	1.25	
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average						0.169	0.0949		0.115	
95% CI LB						0.0878	0.0715		0.0863	
95% CI UB						0.285	0.123		0.15	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						52.9	32.8		46.6	
Max						2.46	0.577		0.74	
MATES V										
Average							0.162		0.159	
95% CI LB							0.104		0.105	
95% CI UB							0.243		0.221	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		0	
Max							1.86		1.27	


MATES II
MATES III
MATES IV
MATES V
Benzo(k)fluoranthene (ng/m^3)
Cancer Risk (per Million)
0.3
0.25
0.2
0.15
0.1
0.05
0
1.8
1.5
1.2
0.9
0.6
0.3
0
Anaheim
Burbank Area
Central L.A.
Compton
Huntington Park
Inland Valley S.B.
Long Beach
Pico Rivera
Rubidoux
West Long Beach
Site Average

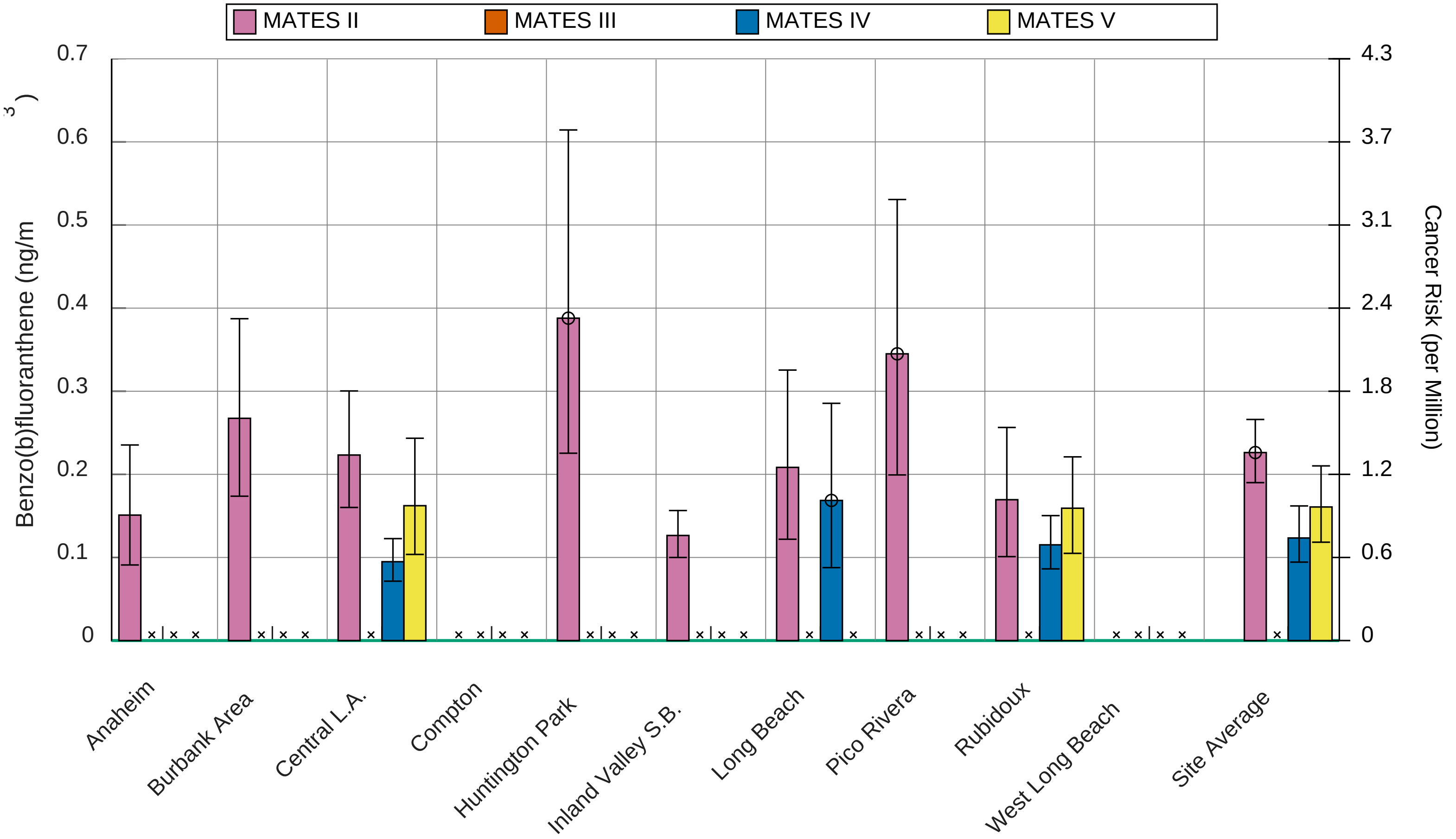


Figure IV-162. Annual Average Concentrations of Benzo(b)fluoranthene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

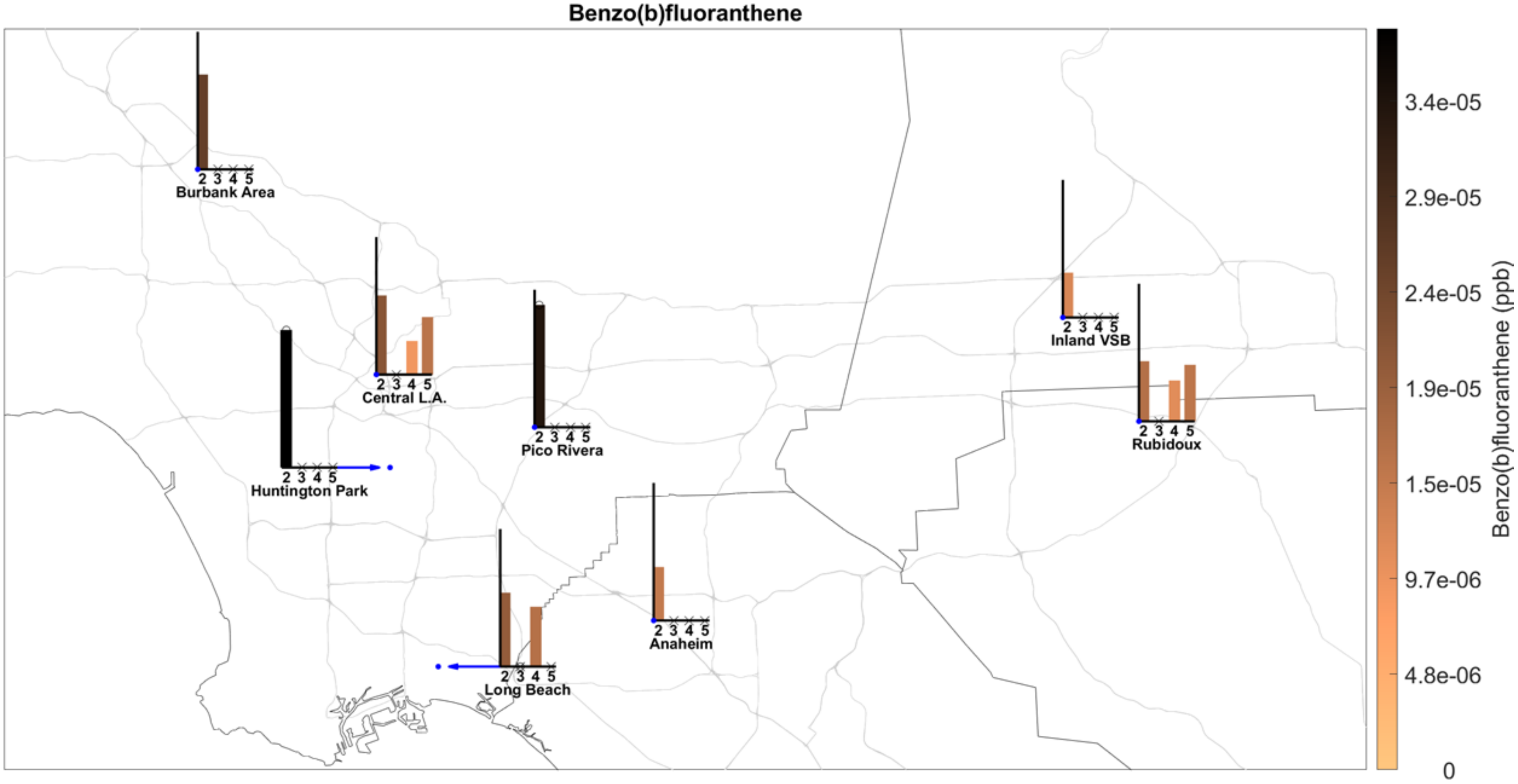


Figure IV-163. Geographic distribution of Benzo(b)fluoranthene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Benzo(b+j+k)Fluoranthene

Table IV-84. Ambient Concentrations (ng/m^3) of Benzo(b+j+k)Fluoranthene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	AN	BU	CP	SB	HP	LB	LA	PR	RU	WLB
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							0.363		0.393	0.419
95% CI LB							0.314		0.331	0.348
95% CI UB							0.414		0.458	0.491
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							1.75		1.58	2.09
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

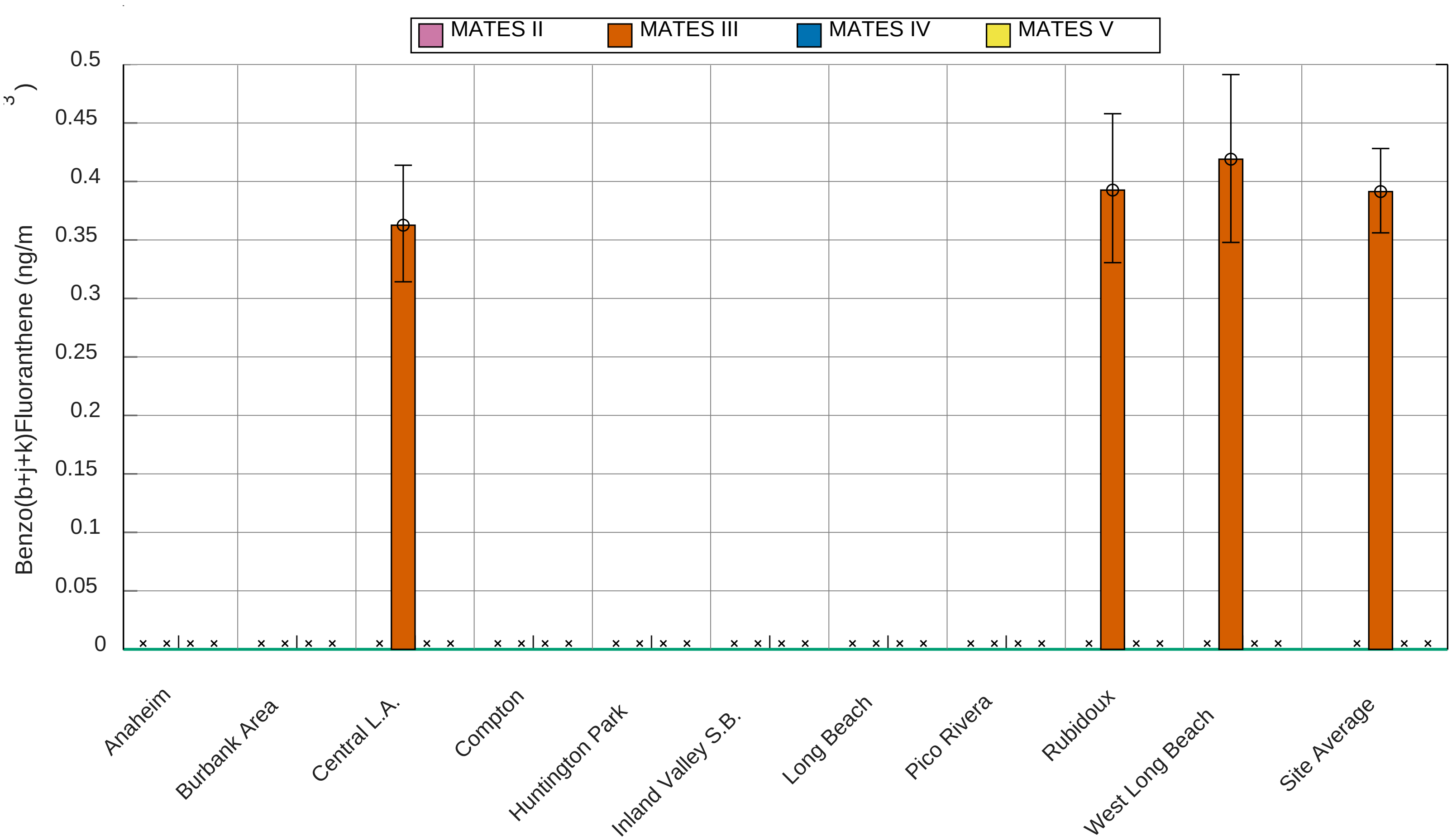


Figure IV-164. Annual Average Concentrations of Benzo(b+j+k)Fluoranthene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

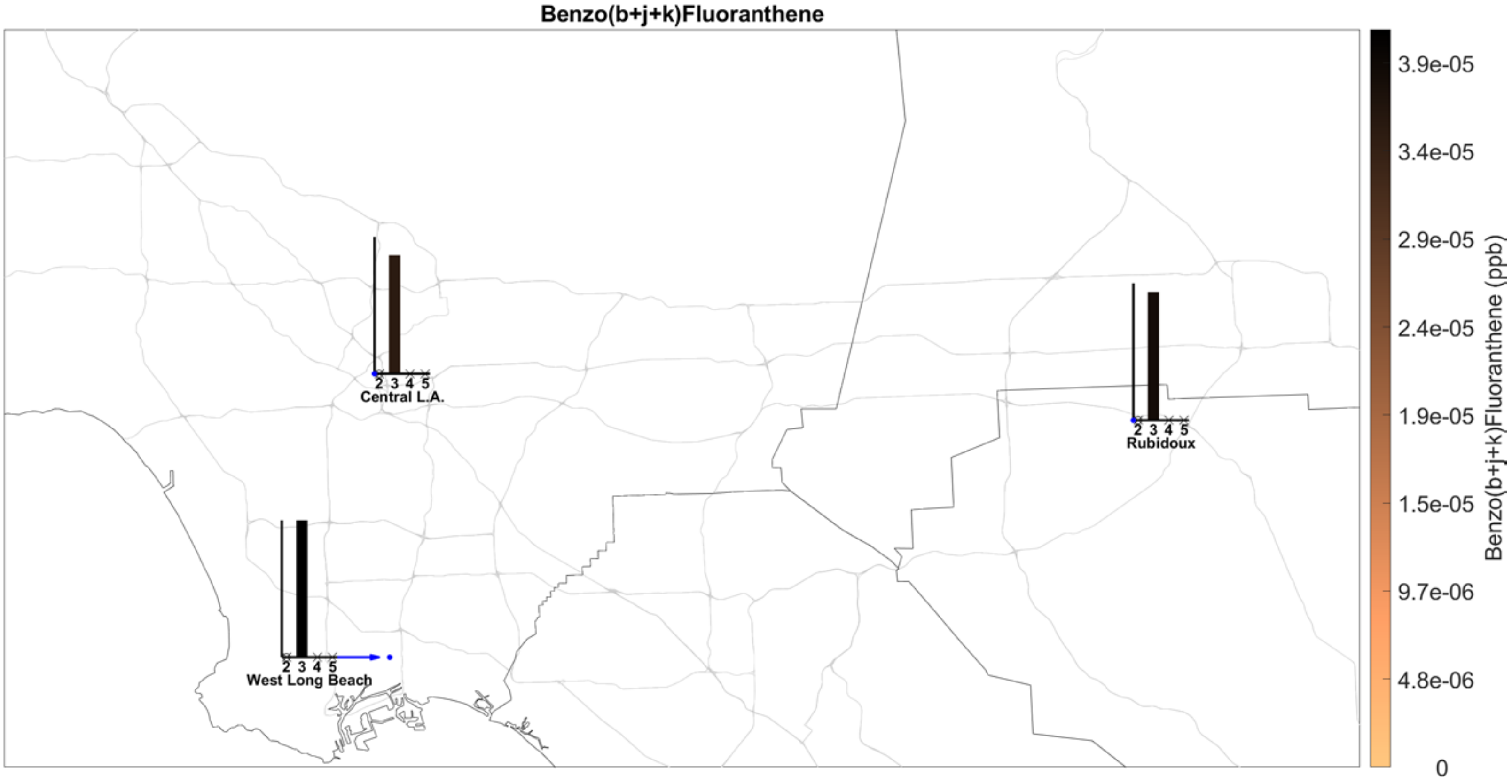


Figure IV-165. Geographic distribution of Benzo(b+j+k)Fluoranthene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Benzo(e)pyrene

Table IV-85. Ambient Concentrations (ng/m^3) of Benzo(e)pyrene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average						0.11	0.0671		0.0744	
95% CI LB						0.0707	0.0548		0.0647	
95% CI UB						0.164	0.0814		0.09	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						62.7	65.5		70.7	
Max						1.13	0.307		0.341	
MATES V										
Average							0.0951		0.0866	
95% CI LB							0.0653		0.0611	
95% CI UB							0.135		0.118	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		0	
Max							0.914		0.641	

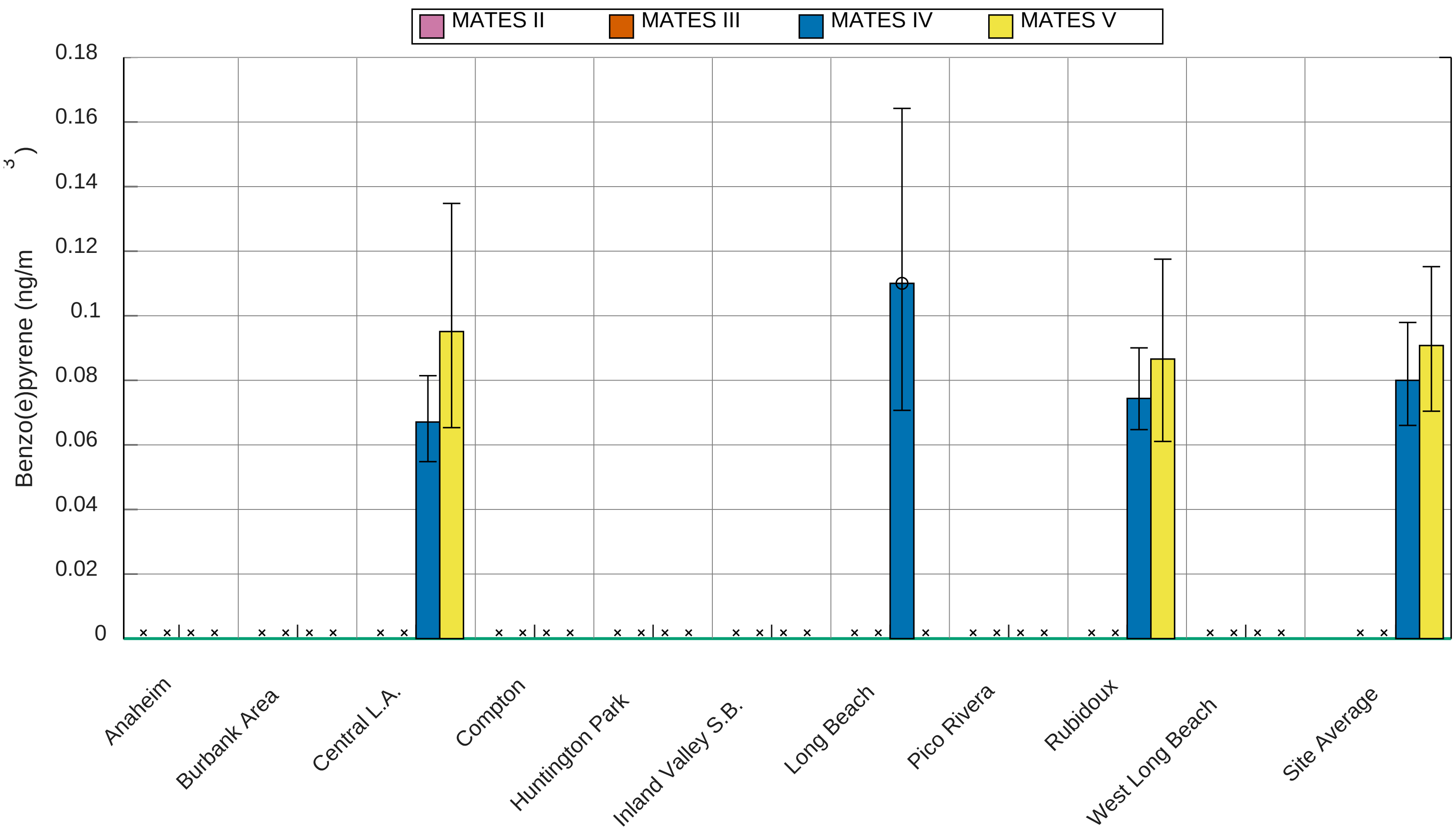


Figure IV-166. Annual Average Concentrations of Benzo(e)pyrene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

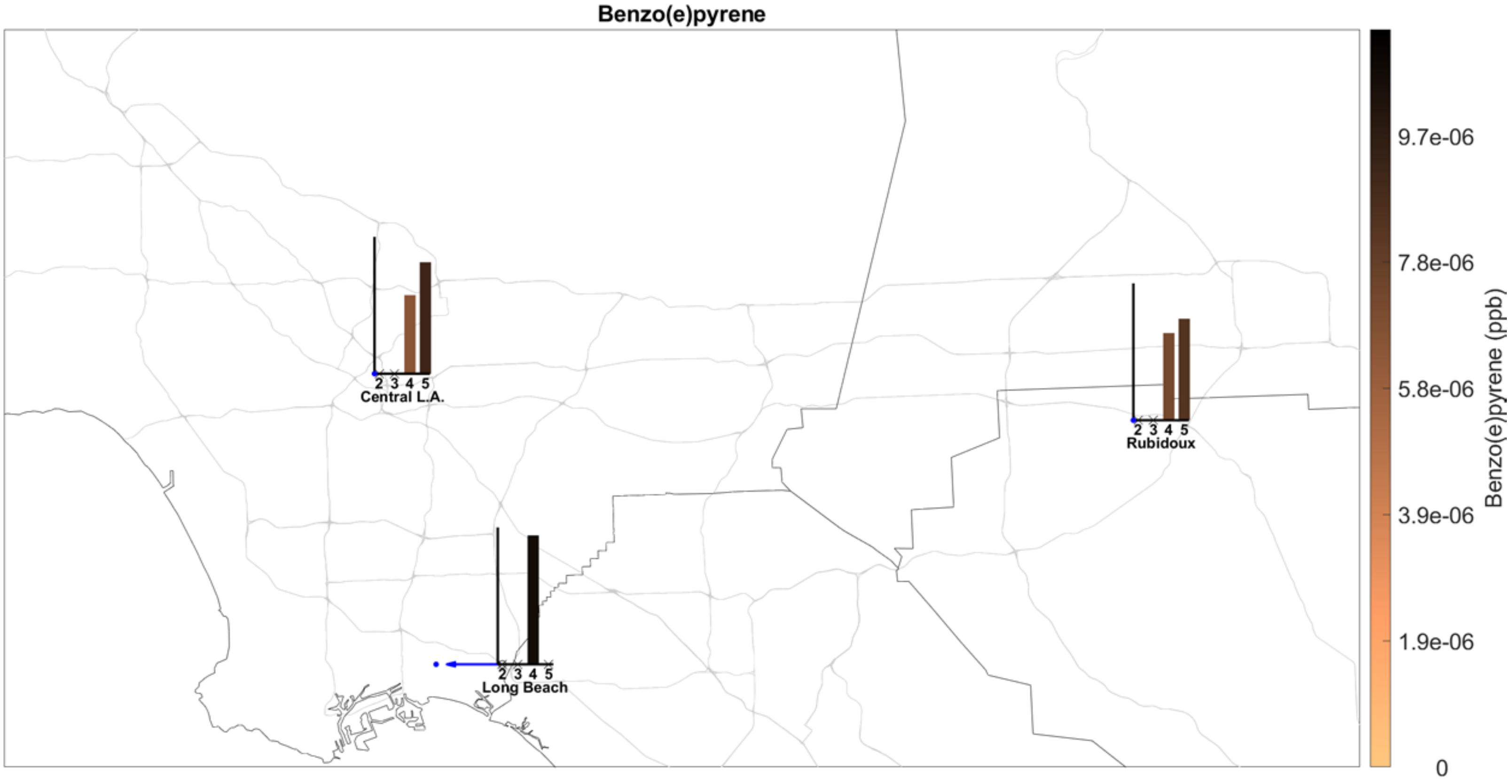


Figure IV-167. Geographic distribution of Benzo(e)pyrene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Benzo(g,h,i)perylene

Table IV-86. Ambient Concentrations (ng/m^3) of Benzo(g,h,i)perylene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.456	0.884		0.339	1.31	0.613	0.629	0.82	0.384	
95% CI LB	0.282	0.573		0.256	0.801	0.383	0.454	0.512	0.238	
95% CI UB	0.662	1.23		0.433	1.87	0.881	0.822	1.17	0.555	
N	31	31	0	31	24	31	31	22	30	0
% < MDL	3.2	0		3.2	0	0	0	0	6.7	
Max	2.4	3.7		1.1	4.3	3	2	3.2	2.2	
MATES III										
Average							0.397		0.34	0.45
95% CI LB							0.347		0.288	0.377
95% CI UB							0.445		0.395	0.526
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							1.38		1.33	1.98
MATES IV										
Average						0.117	0.0841		0.0767	
95% CI LB						0.0761	0.0669		0.0624	
95% CI UB						0.168	0.105		0.0932	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						52.9	32.8		55.2	
Max						0.79	0.39		0.327	
MATES V										
Average							0.122		0.101	
95% CI LB							0.0871		0.0707	
95% CI UB							0.164		0.136	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		1.7	
Max							0.772		0.694	

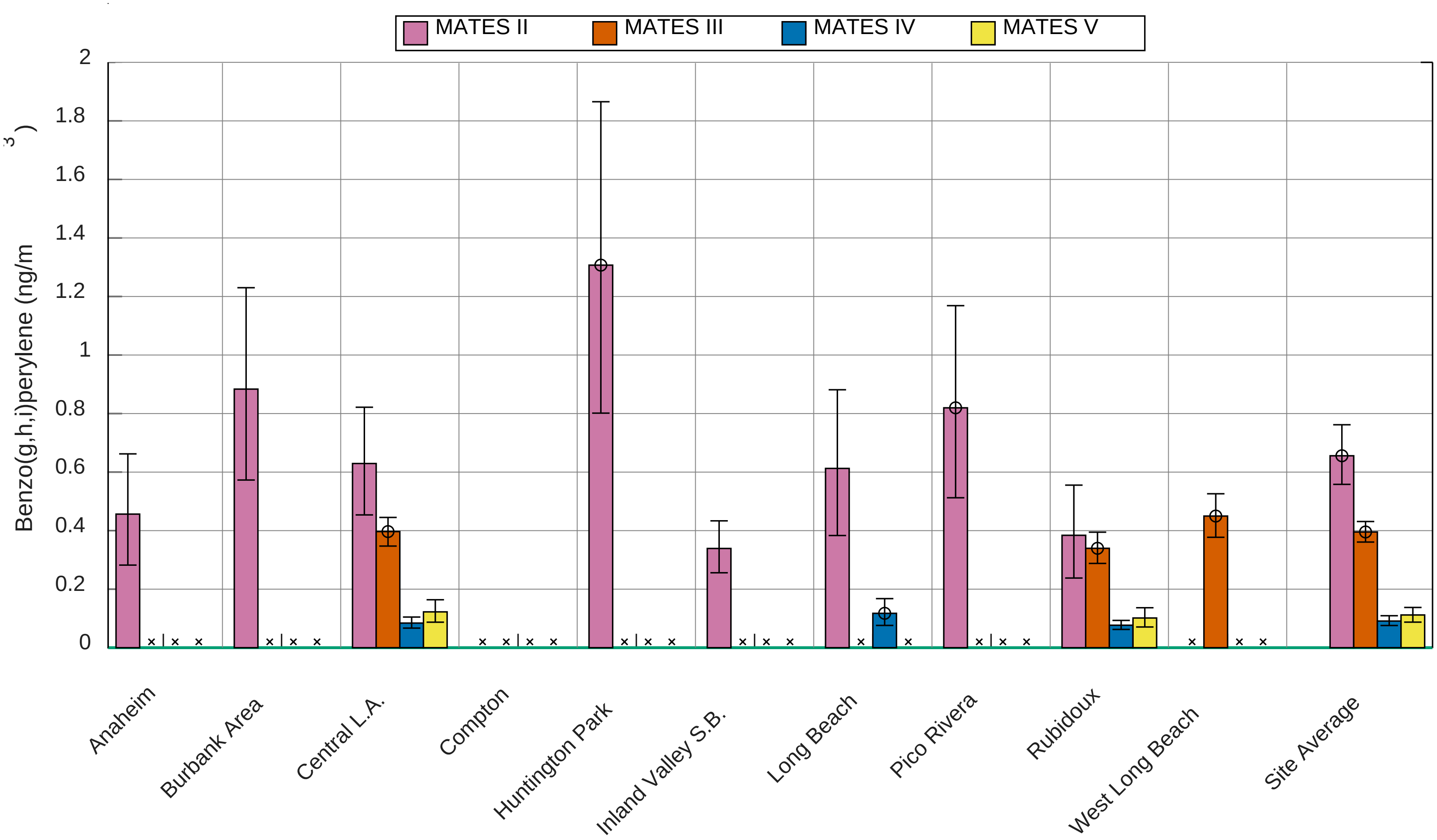


Figure IV-168. Annual Average Concentrations of Benzo(g,h,i)perylene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

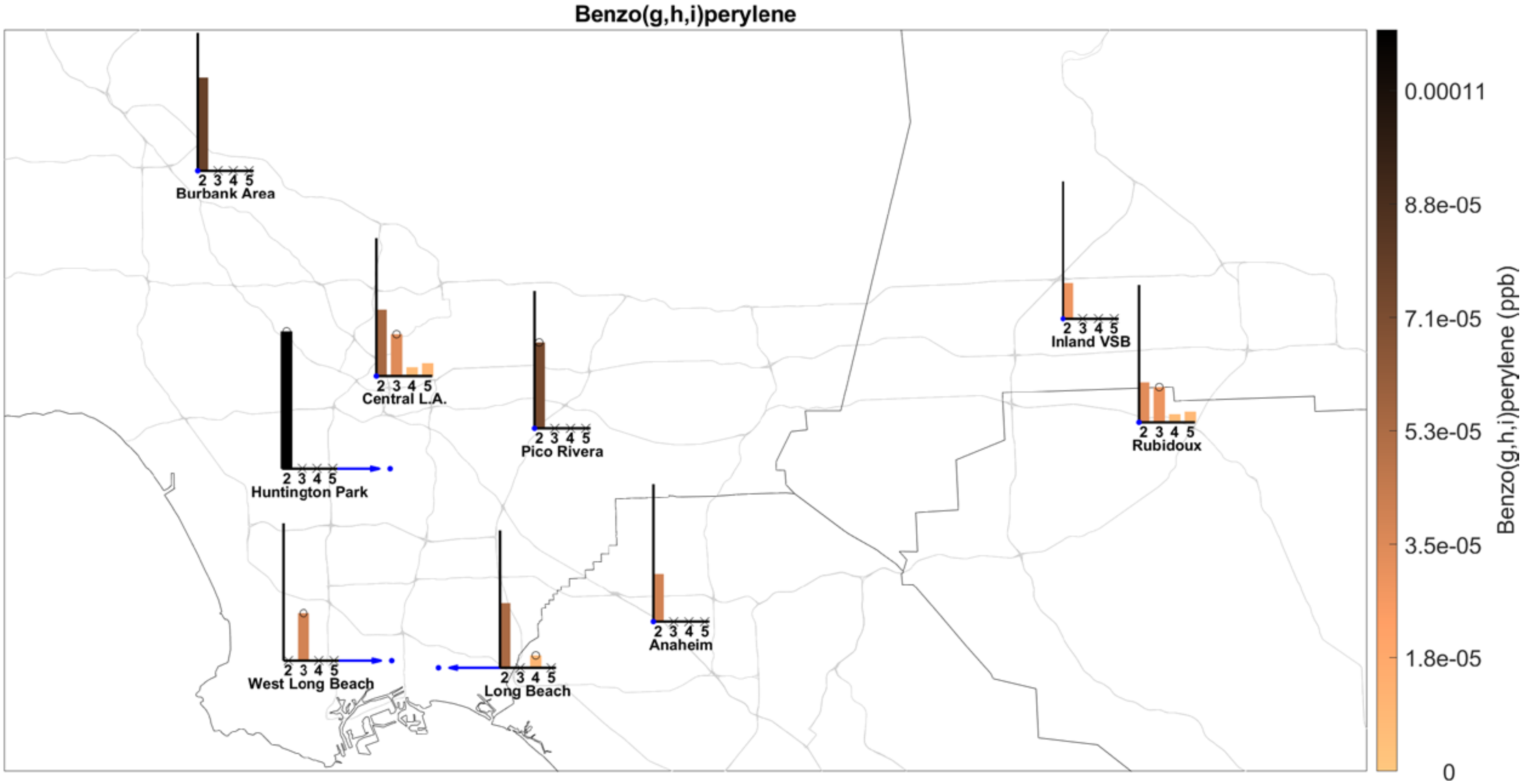


Figure IV-169. Geographic distribution of Benzo(g,h,i)perylene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Benzo(k)fluoranthene

Table IV-87. Ambient Concentrations (ng/m^3) of Benzo(k)fluoranthene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.0771	0.117		0.0613	0.162	0.0971	0.0961	0.142	0.0831	
95% CI LB	0.0571	0.0813		0.0539	0.0992	0.0655	0.074	0.0864	0.0582	
95% CI UB	0.107	0.163		0.07	0.254	0.14	0.122	0.213	0.117	
N	31	31	0	31	24	31	31	22	30	0
% < MDL	67.7	54.8		61.3	37.5	58.1	41.9	45.5	56.7	
Max	0.45	0.65		0.15	0.83	0.65	0.37	0.74	0.515	
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average						0.0311, 0.0818[a]	0.00903, 0.0628[a]		0.0125, 0.0721[a]	
95% CI LB						0.0074[a]	0.00299[a]		0.00363[a]	
95% CI UB						0.114[a]	0.0789[a]		0.0805[a]	
N	0	0	0	0	0	51[a]	58[a]	0	58[a]	0
% < MDL						84.3[a]	87.9[a]		87.9[a]	
Max						0.783[a]	0.14[a]		0.254[a]	
MATES V										
Average							0.0442		0.0434	
95% CI LB							0.0284		0.0286	
95% CI UB							0.0657		0.0615	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							15.5		21.7	
Max							0.479		0.37	

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

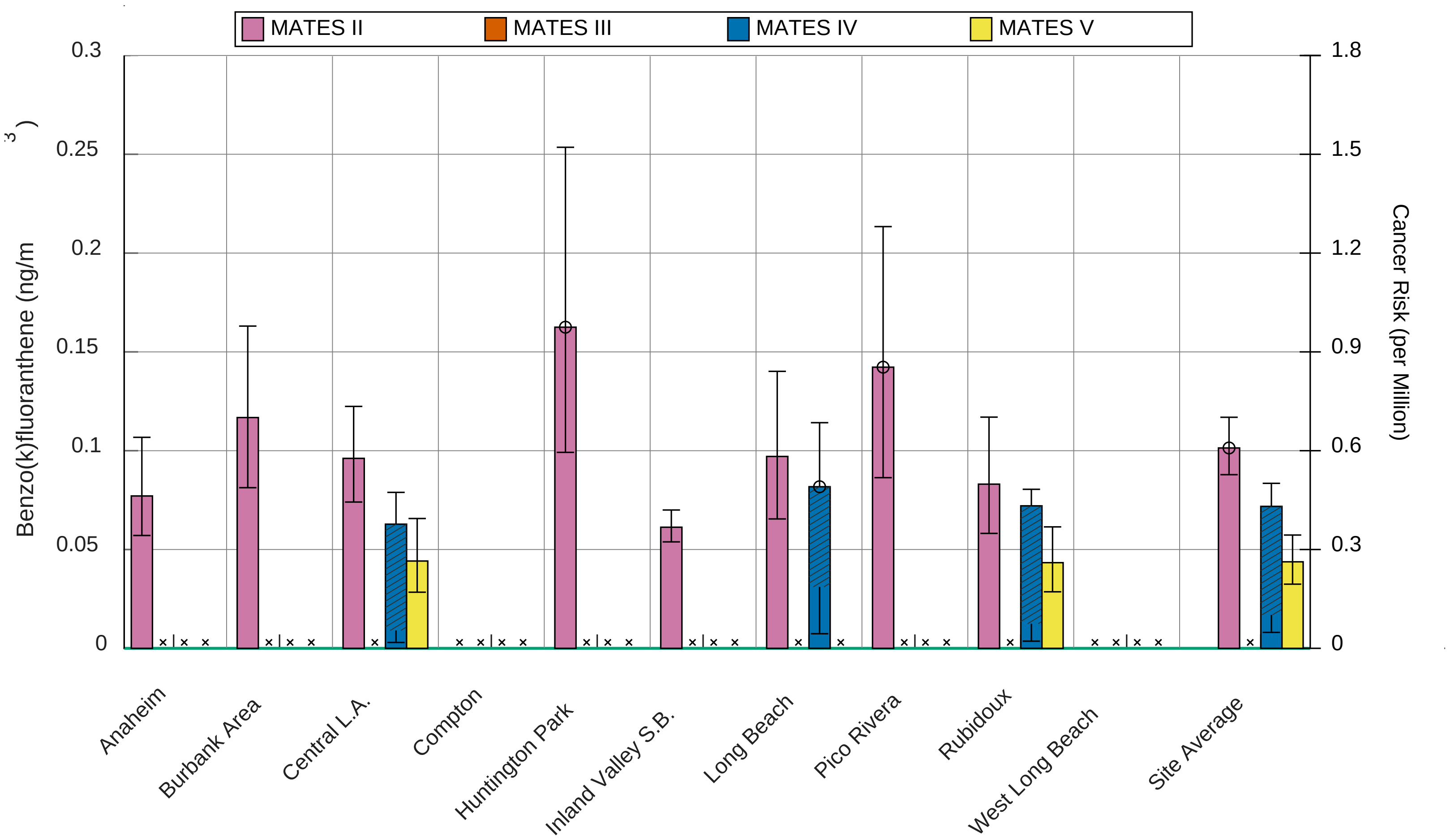


Figure IV-170. Annual Average Concentrations of Benzo(k)fluoranthene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

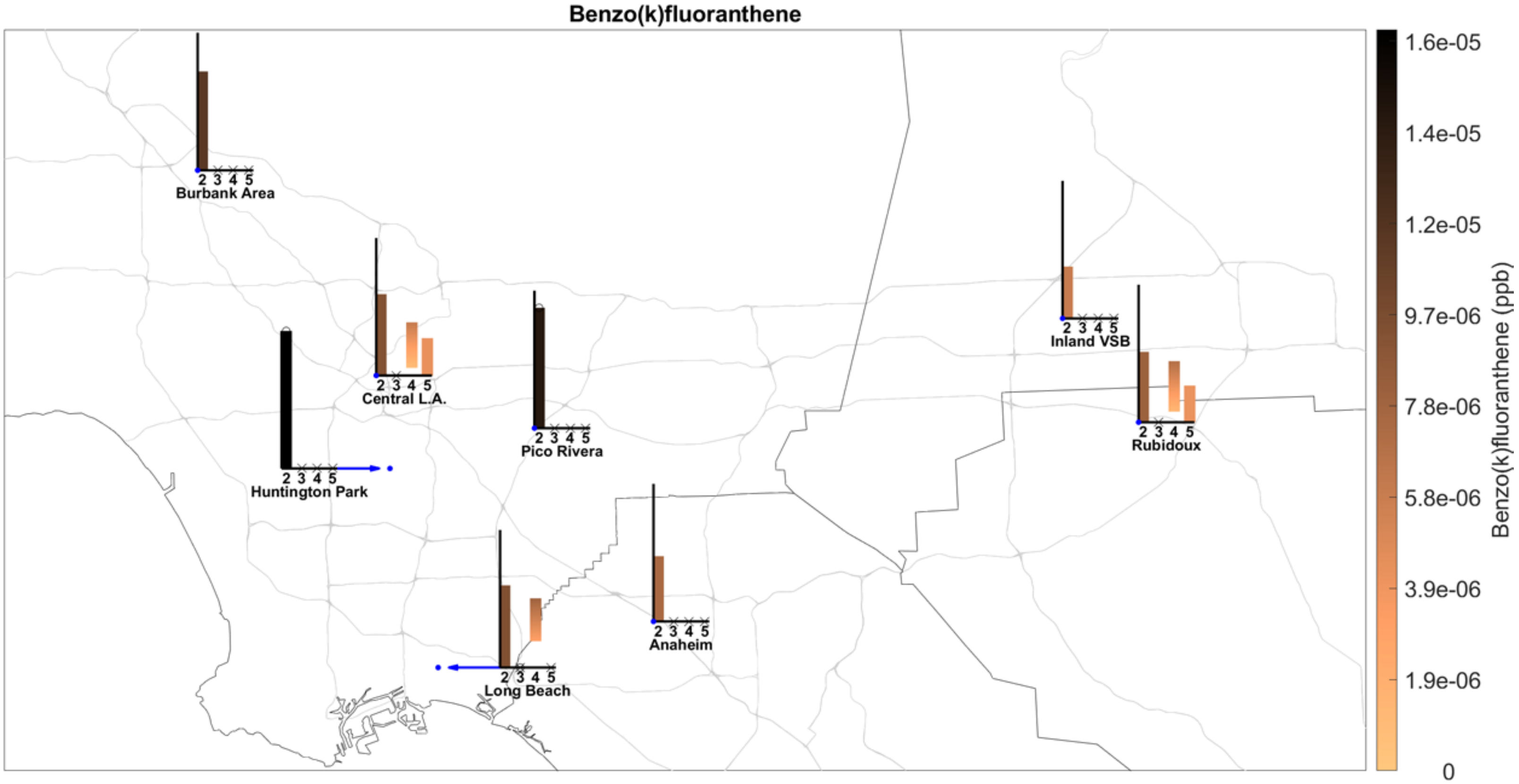


Figure IV-171. Geographic distribution of Benzo(k)fluoranthene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Chrysene

Table IV-88. Ambient Concentrations (ng/m^3) of Chrysene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							0.323		0.341	0.427
95% CI LB							0.29		0.293	0.372
95% CI UB							0.358		0.392	0.482
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							1.04		1.4	1.53
MATES IV										
Average						0.172	0.119		0.125	
95% CI LB						0.107	0.0998		0.1	
95% CI UB						0.264	0.14		0.158	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						9.8	5.2		6.9	
Max						2	0.434		0.781	
MATES V										
Average							0.156		0.121	
95% CI LB							0.111		0.0922	
95% CI UB							0.221		0.153	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		0	
Max							1.61		0.727	

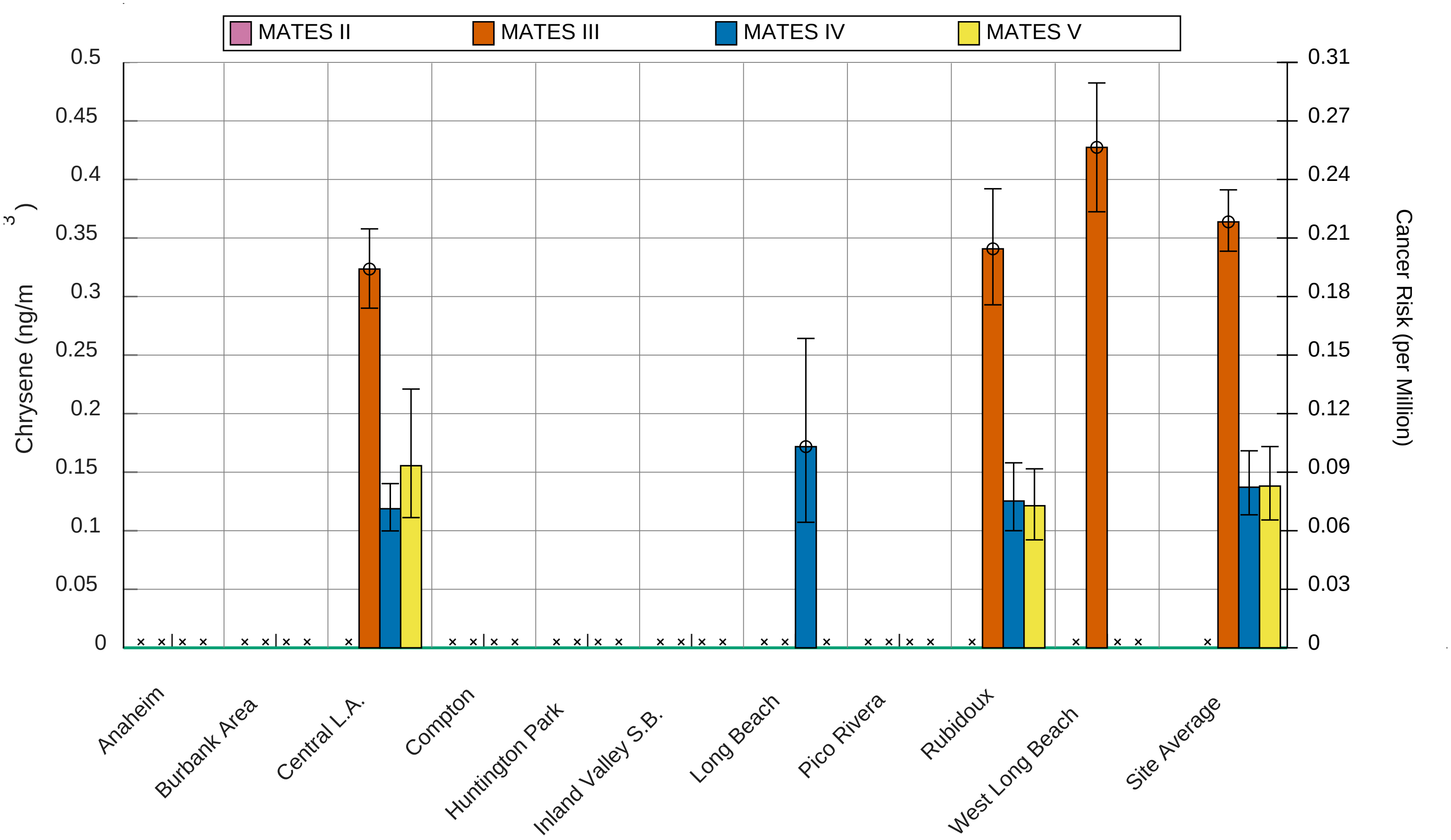


Figure IV-172. Annual Average Concentrations of Chrysene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

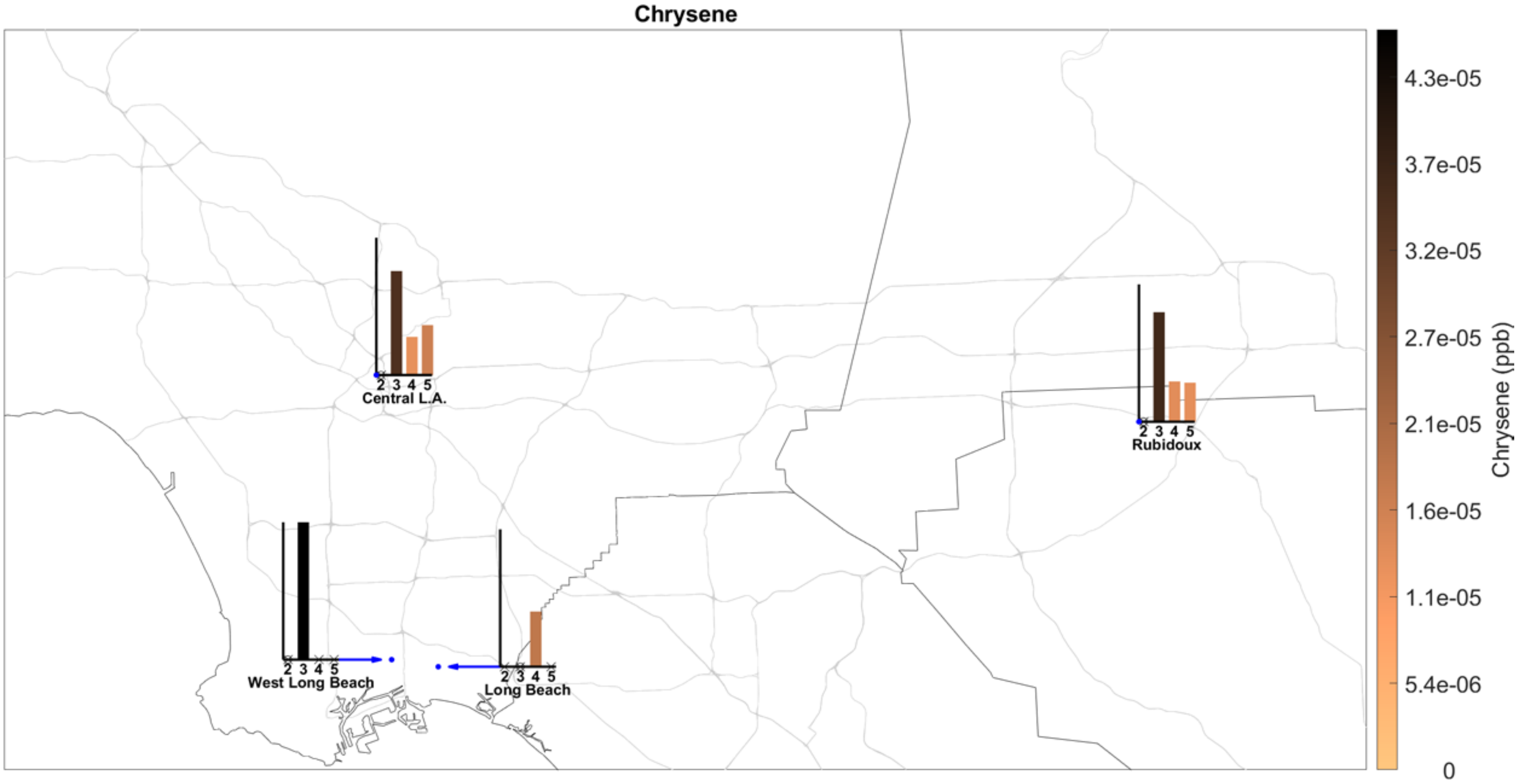


Figure IV-173. Geographic distribution of Chrysene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Coronene

Table IV-89. Ambient Concentrations (ng/m^3) of Coronene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average						0.0684	0.0533		0.0136, 0.0685[a]	
95% CI LB						0.0614	0.0485		0.00605[a]	
95% CI UB						0.0833	0.0709		0.0727[a]	
N	0	0	0	0	0	51	58	0	58[a]	0
% < MDL						76.5	72.4		82.8[a]	
Max						0.253	0.177		0.125[a]	
MATES V										
Average							0.0941		0.0745	
95% CI LB							0.0718		0.0563	
95% CI UB							0.118		0.0955	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		0	
Max							0.445		0.419	

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

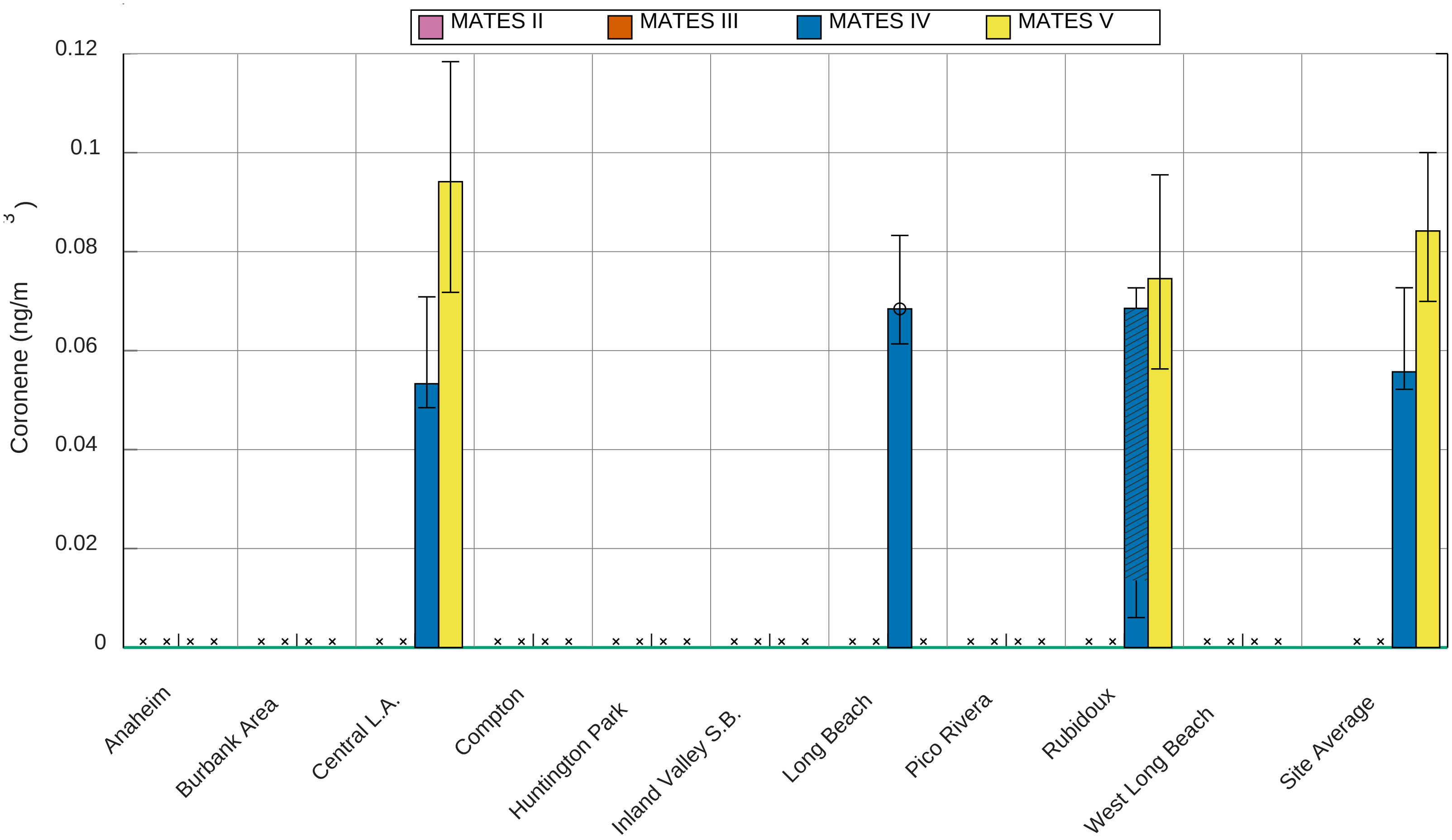


Figure IV-174. Annual Average Concentrations of Coronene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

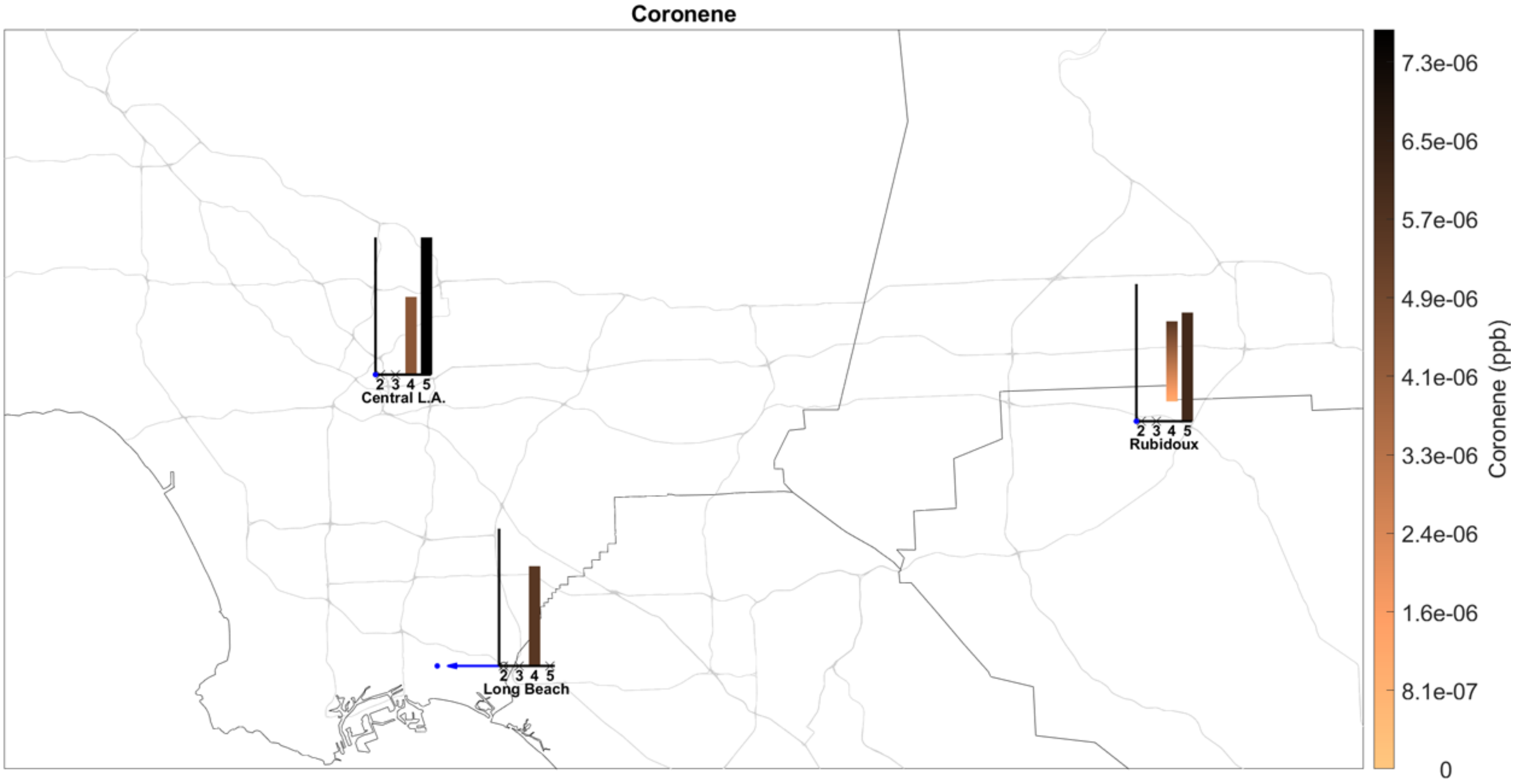


Figure IV-175. Geographic distribution of Coronene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Cyclopenta(c,d)pyrene

Table IV-90. Ambient Concentrations (ng/m^3) of Cyclopenta(c,d)pyrene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average						0.0207, 0.078[a]	0.00988, 0.0673[a]		0.00632, 0.0731[a]	
95% CI LB						0.00247[a]	0.00297[a]		0[a]	
95% CI UB						0.103[a]	0.089[a]		0.0807[a]	
N	0	0	0	0	0	51[a]	58[a]	0	58[a]	0
% < MDL						90.2[a]	87.9[a]		94.8[a]	
Max						0.586[a]	0.166[a]		0.17[a]	
MATES V										
Average							0.0432		0.0456	
95% CI LB							0.0243		0.023	
95% CI UB							0.0669		0.0767	
N	0	0	0	0	0	0	57	0	59	0
% < MDL							24.6		28.8	
Max							0.411		0.701	

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

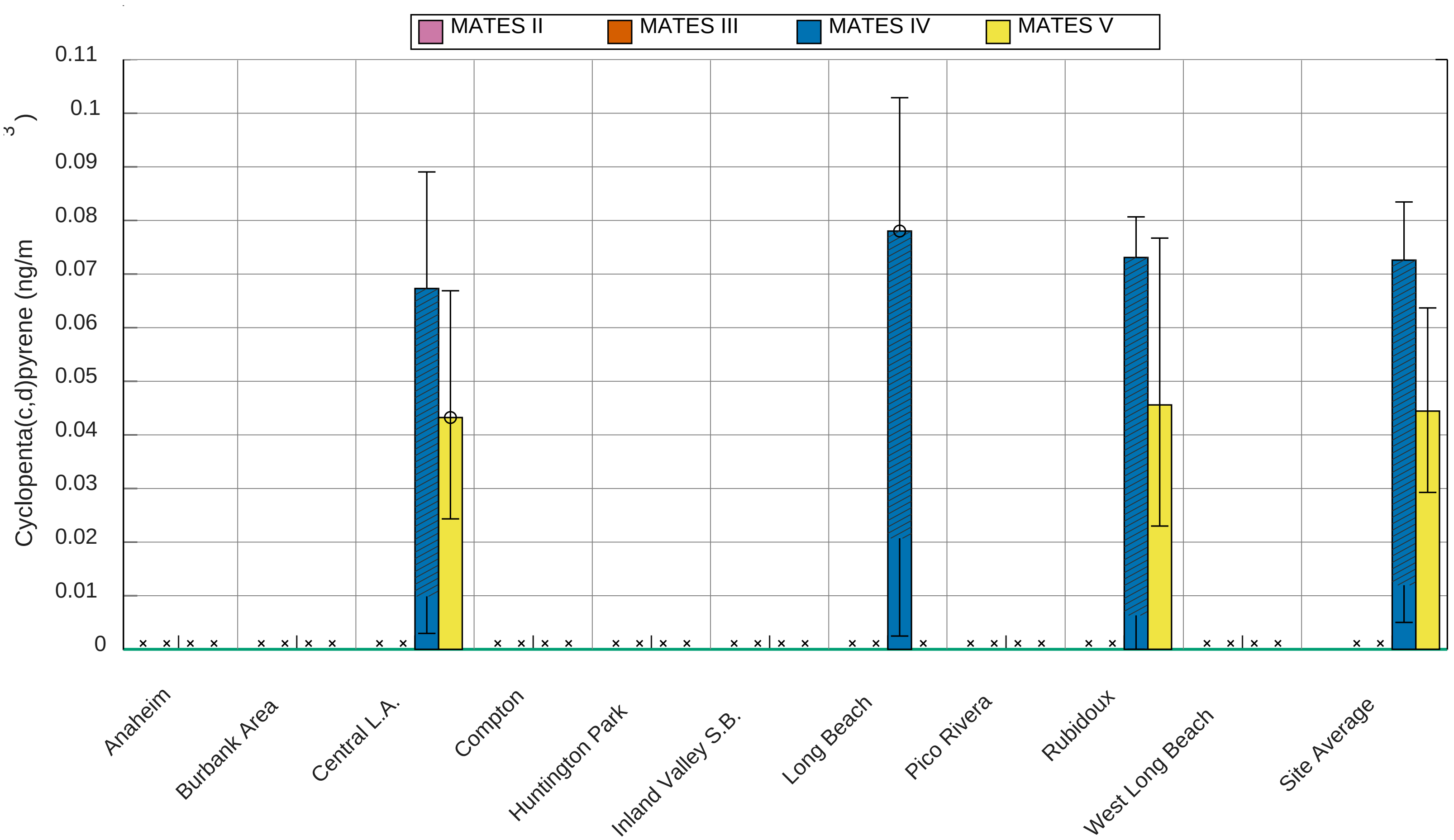


Figure IV-176. Annual Average Concentrations of Cyclopenta(c,d)pyrene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

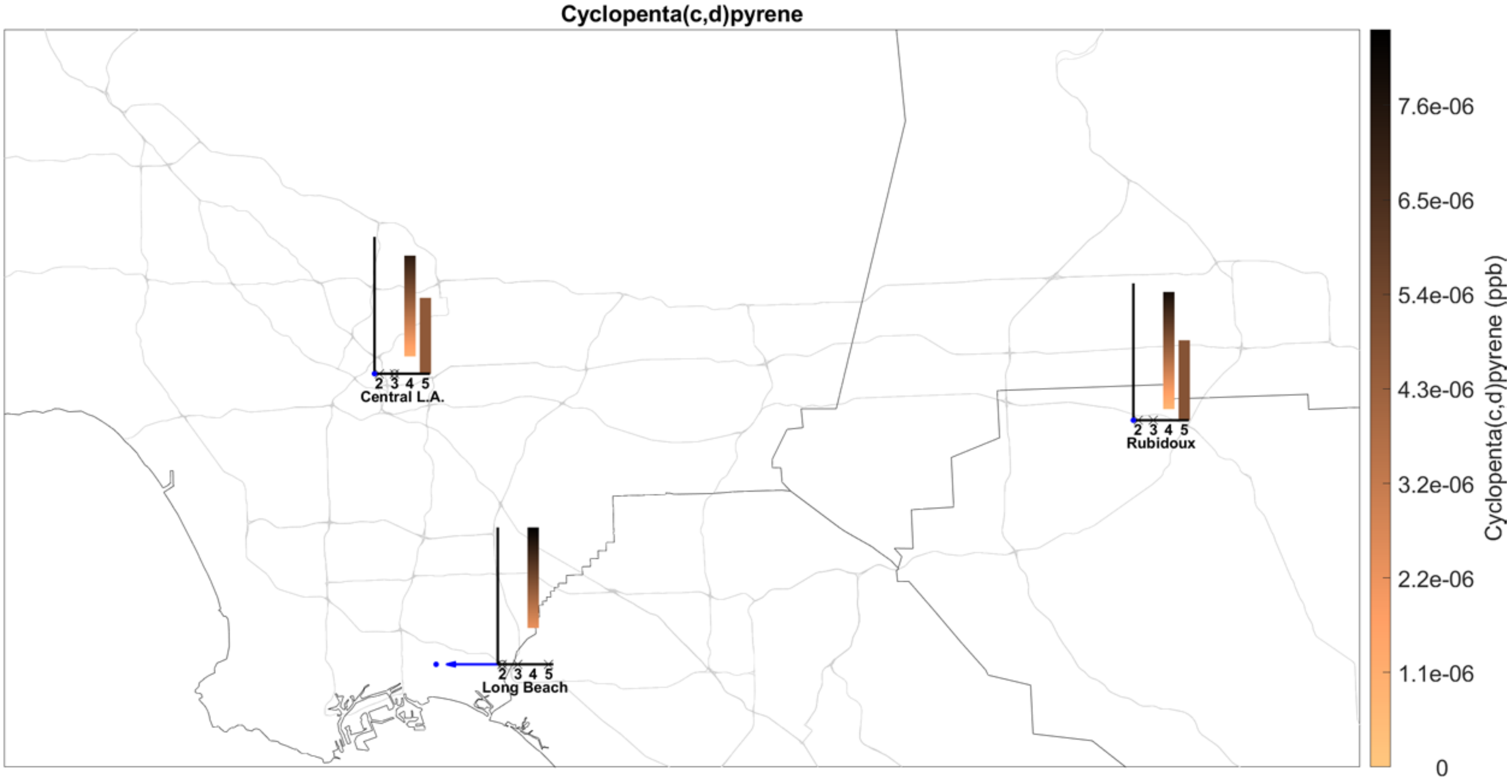


Figure IV-177. Geographic distribution of Cyclopenta(c,d)pyrene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Dibenz(a,h)anthracene

Table IV-91. Ambient Concentrations (ng/m^3) of Dibenz(a,h)anthracene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	0.00323, 0.0516[a]	0.0242, 0.0661[a]		0.00226, 0.0506[a]	0.0754	0.0123, 0.0558[a]	0.00161, 0.05[a]	0.0177, 0.0586[a]	0.0113, 0.058[a]	
95% CI LB	0[a]	0.00581[a]		0[a]	0.0521	0.00161[a]	0[a]	0.00364[a]	0[a]	
95% CI UB	0.0548[a]	0.0823[a]		0.0519[a]	0.119	0.0632[a]	0.05[a]	0.0677[a]	0.073[a]	
N	31[a]	31[a]	0	31[a]	24	31[a]	31[a]	22[a]	30[a]	0
% < MDL	96.8[a]	83.9[a]		96.8[a]	75	87.1[a]	96.8[a]	81.8[a]	93.3[a]	
Max	0.1[a]	0.2[a]		0.07[a]	0.49	0.14[a]	0.05[a]	0.12[a]	0.26[a]	
MATES III										
Average							0.0271		0.0345	0.0532
95% CI LB							0.0232		0.027	0.0441
95% CI UB							0.0315		0.0437	0.0646
N	0	0	0	0	0	0	129	0	128	128
% < MDL							1.6		2.3	0
Max							0.13		0.396	0.529
MATES IV										
Average						0.00629, 0.0514[a]	0.000664, 0.0477[a]		0.000903, 0.0533[a]	
95% CI LB						0[a]	0[a]		0[a]	
95% CI UB						0.0595[a]	0.0607[a]		0.0566[a]	
N	0	0	0	0	0	51[a]	58[a]	0	58[a]	0
% < MDL						94.1[a]	98.3[a]		98.3[a]	
Max						0.217[a]	0.0385[a]		0.0524[a]	
MATES V										
Average							0.0187		0.0193	
95% CI LB							0.0148		0.0157	
95% CI UB							0.024		0.0235	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							63.8		61.7	
Max							0.121		0.101	

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

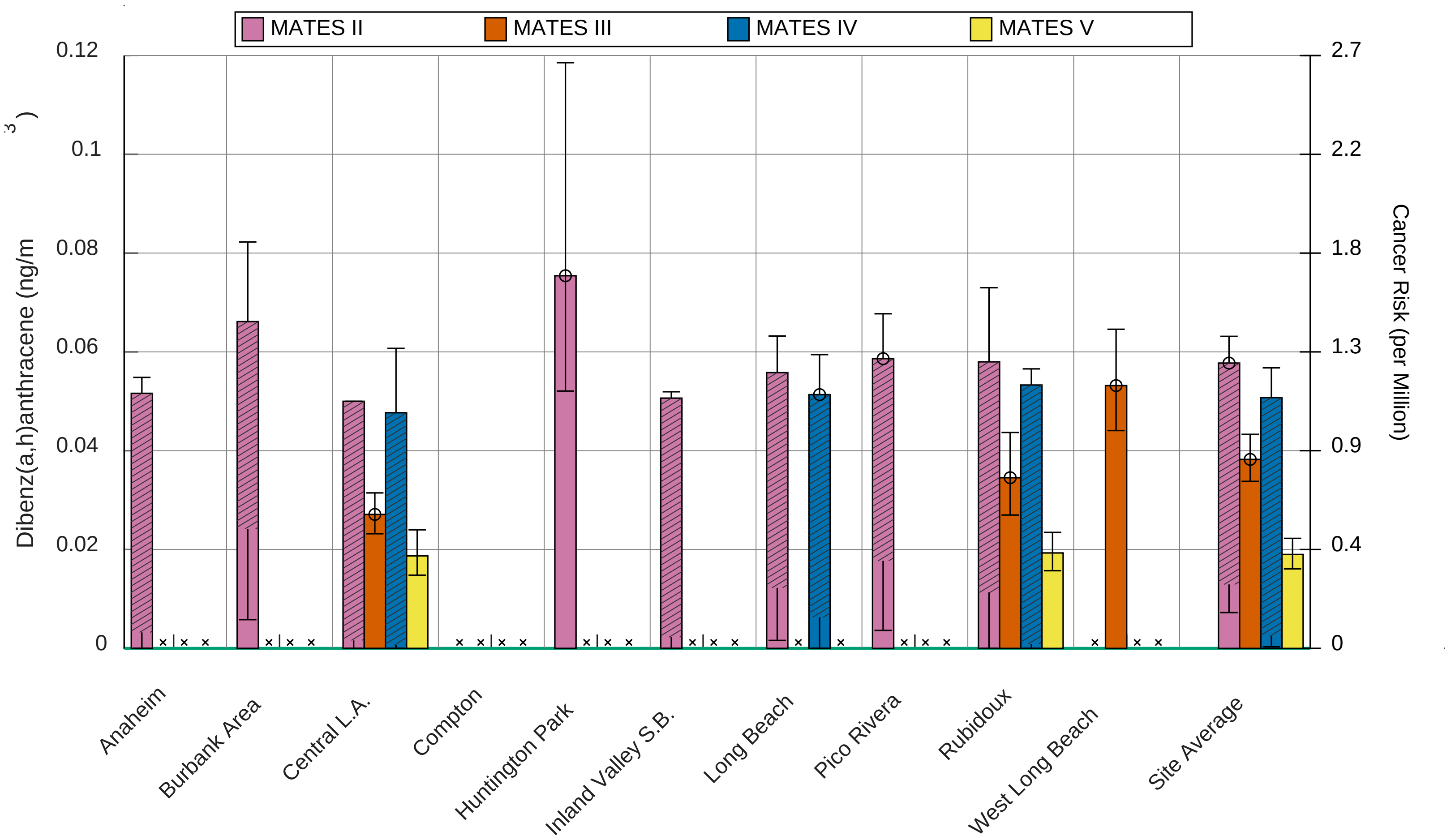


Figure IV-178. Annual Average Concentrations of Dibenz(a,h)anthracene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

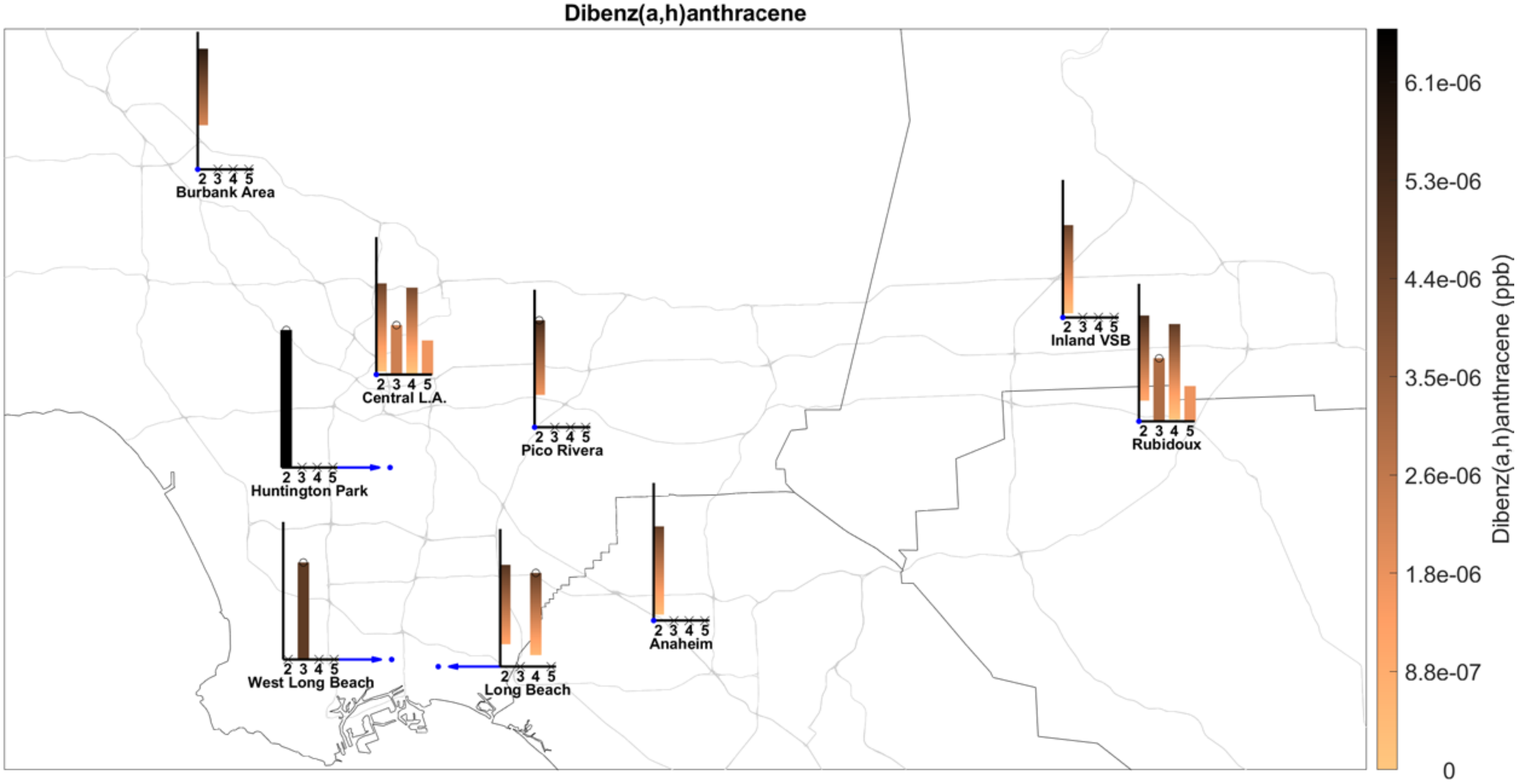


Figure IV-179. Geographic distribution of Dibenz(a,h)anthracene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Fluoranthene

Table IV-92. Ambient Concentrations (ng/m^3) of Fluoranthene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							2.15		1.41	1.88
95% CI LB							2		1.28	1.69
95% CI UB							2.29		1.52	2.08
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							4.64		3.09	4.92
MATES IV										
Average						1.14	1.92		1.21	
95% CI LB						0.948	1.7		1.07	
95% CI UB						1.39	2.16		1.36	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						0	0		0	
Max						5.71	4.56		3.31	
MATES V										
Average							2.05		0.882	
95% CI LB							1.69		0.767	
95% CI UB							2.51		1.01	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		0	
Max							11.1		2.88	

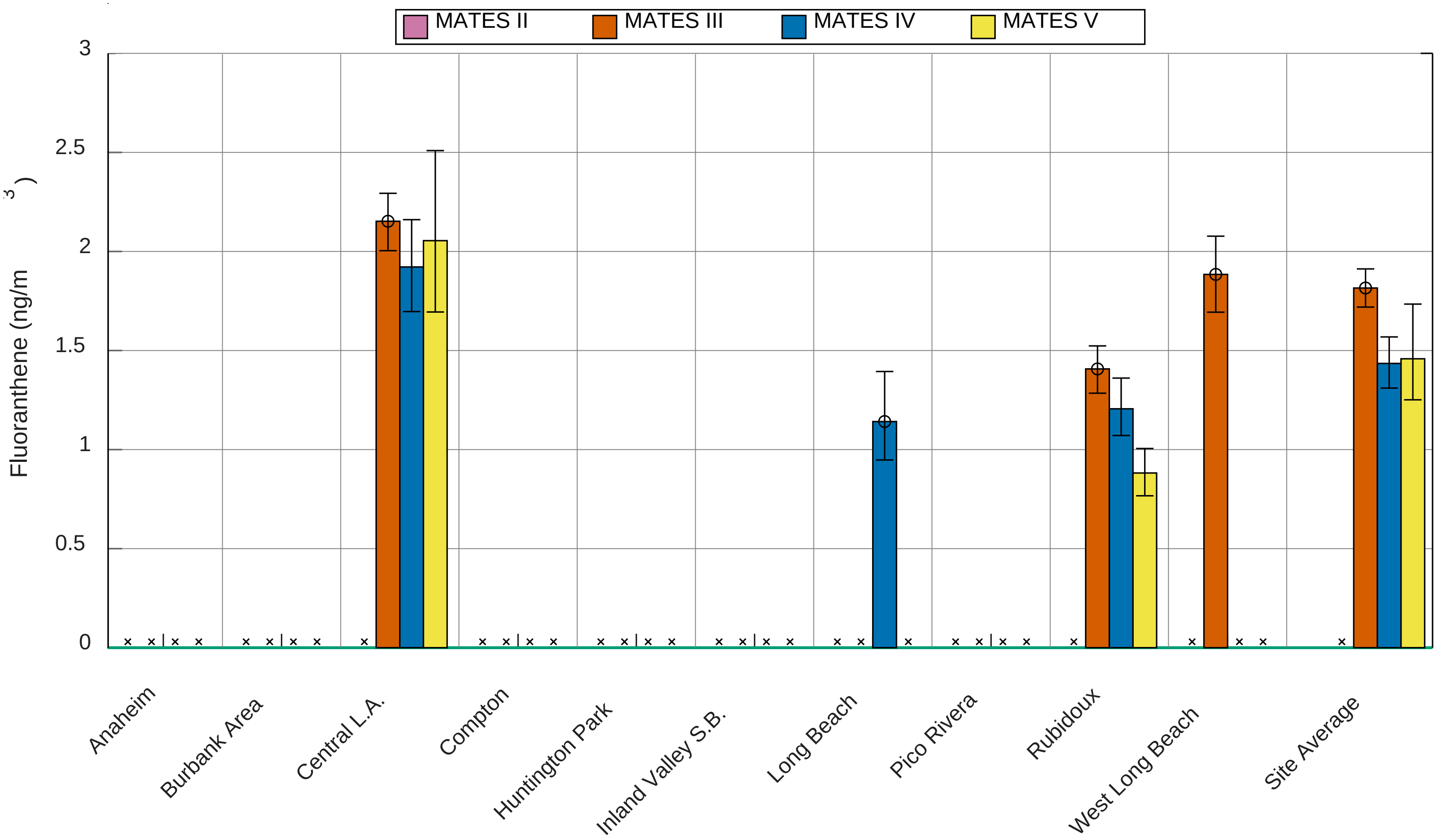


Figure IV-180. Annual Average Concentrations of Fluoranthene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

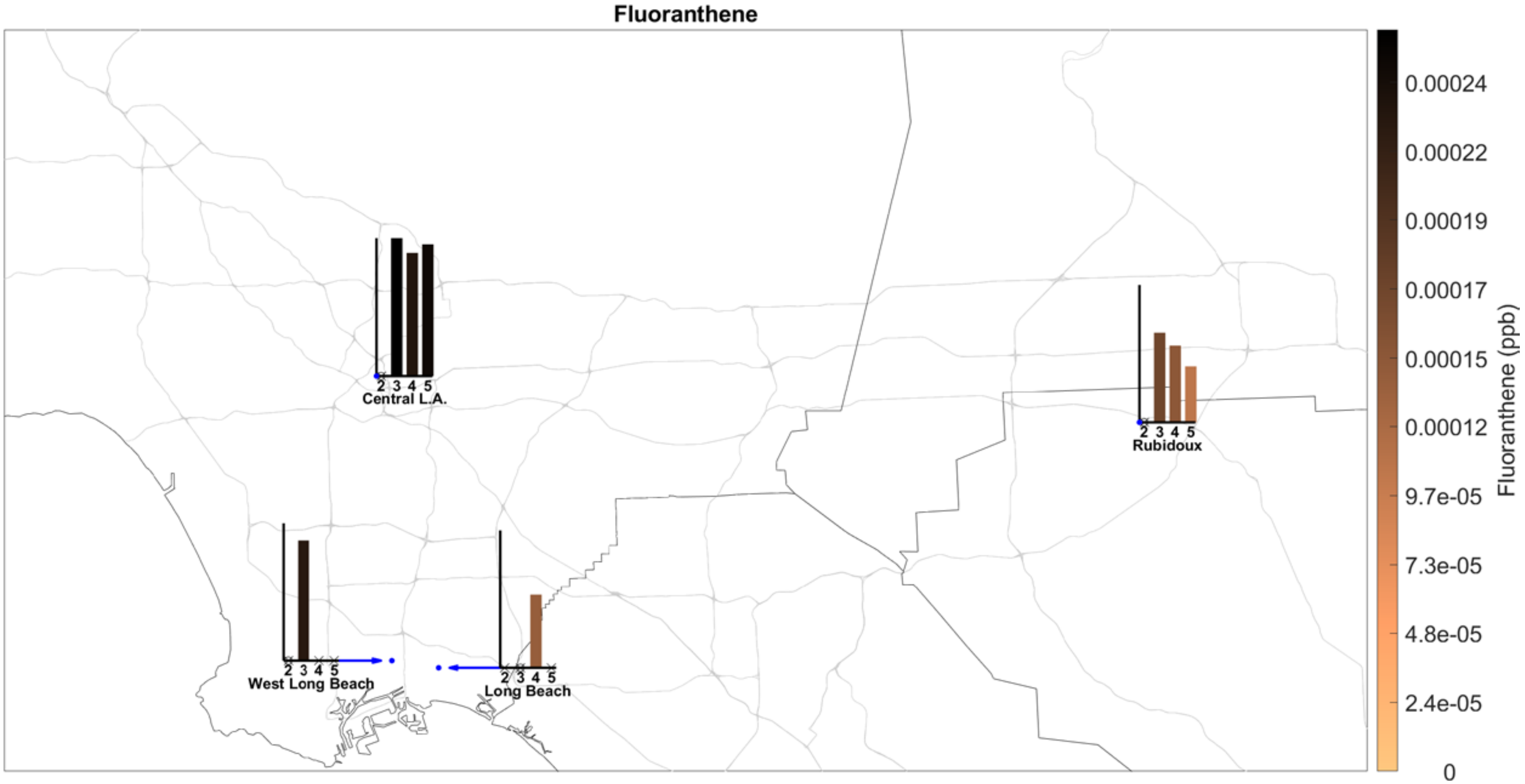


Figure IV-181. Geographic distribution of Fluoranthene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Fluorene

Table IV-93. Ambient Concentrations (ng/m^3) of Fluorene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							7.89		5.5	8.4
95% CI LB							7.18		4.93	7.4
95% CI UB							8.65		6.05	9.46
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							25.8		15.1	27.9
MATES IV										
Average						2.87	7.26		3.42	
95% CI LB						2.47	6.19		2.88	
95% CI UB						3.25	8.41		3.98	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						5.9	1.7		13.8	
Max						5.4	19.3		8.67	
MATES V										
Average							6.4		2.44	
95% CI LB							5.35		2.11	
95% CI UB							7.66		2.83	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		0	
Max							29.5		9.79	

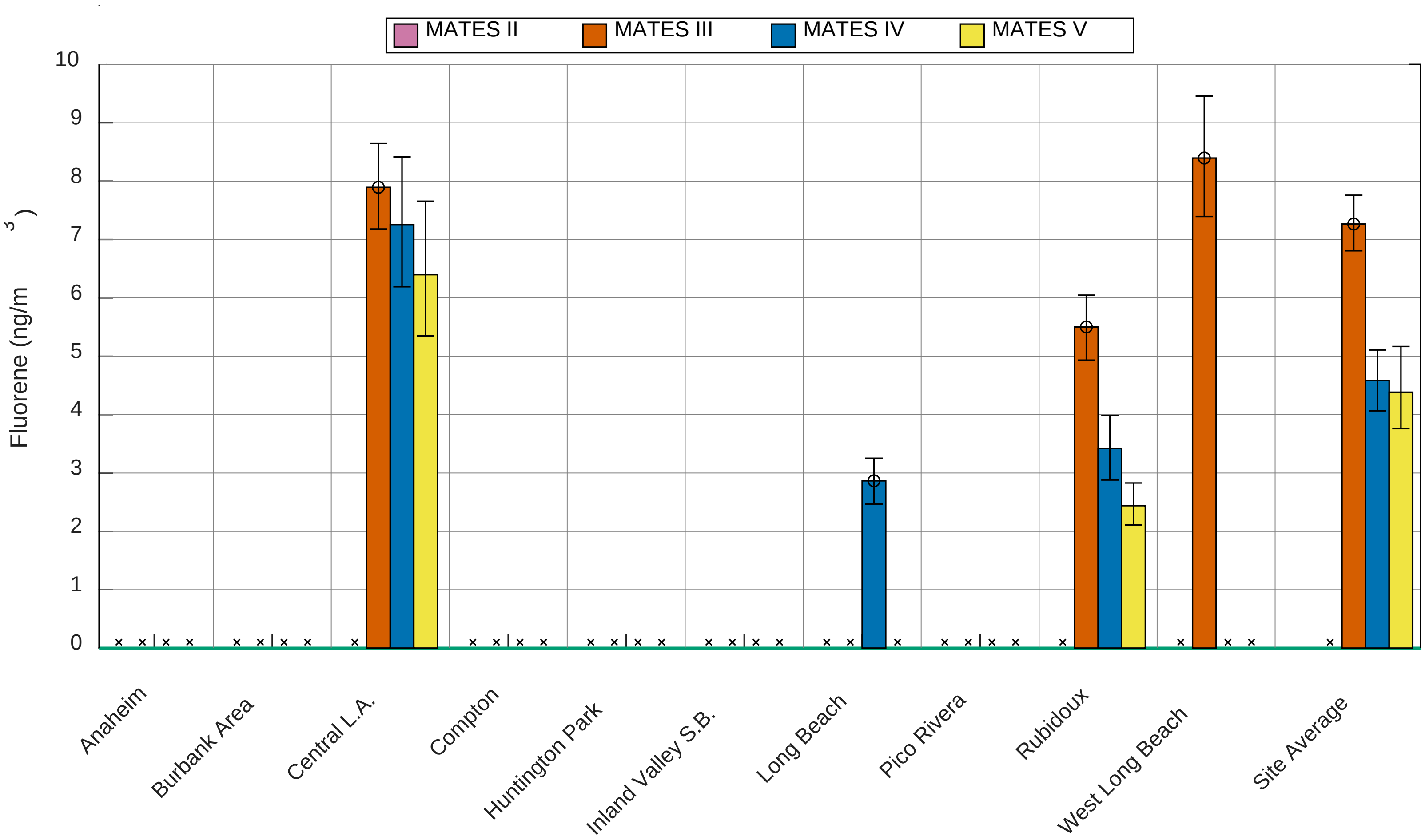


Figure IV-182. Annual Average Concentrations of Fluorene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

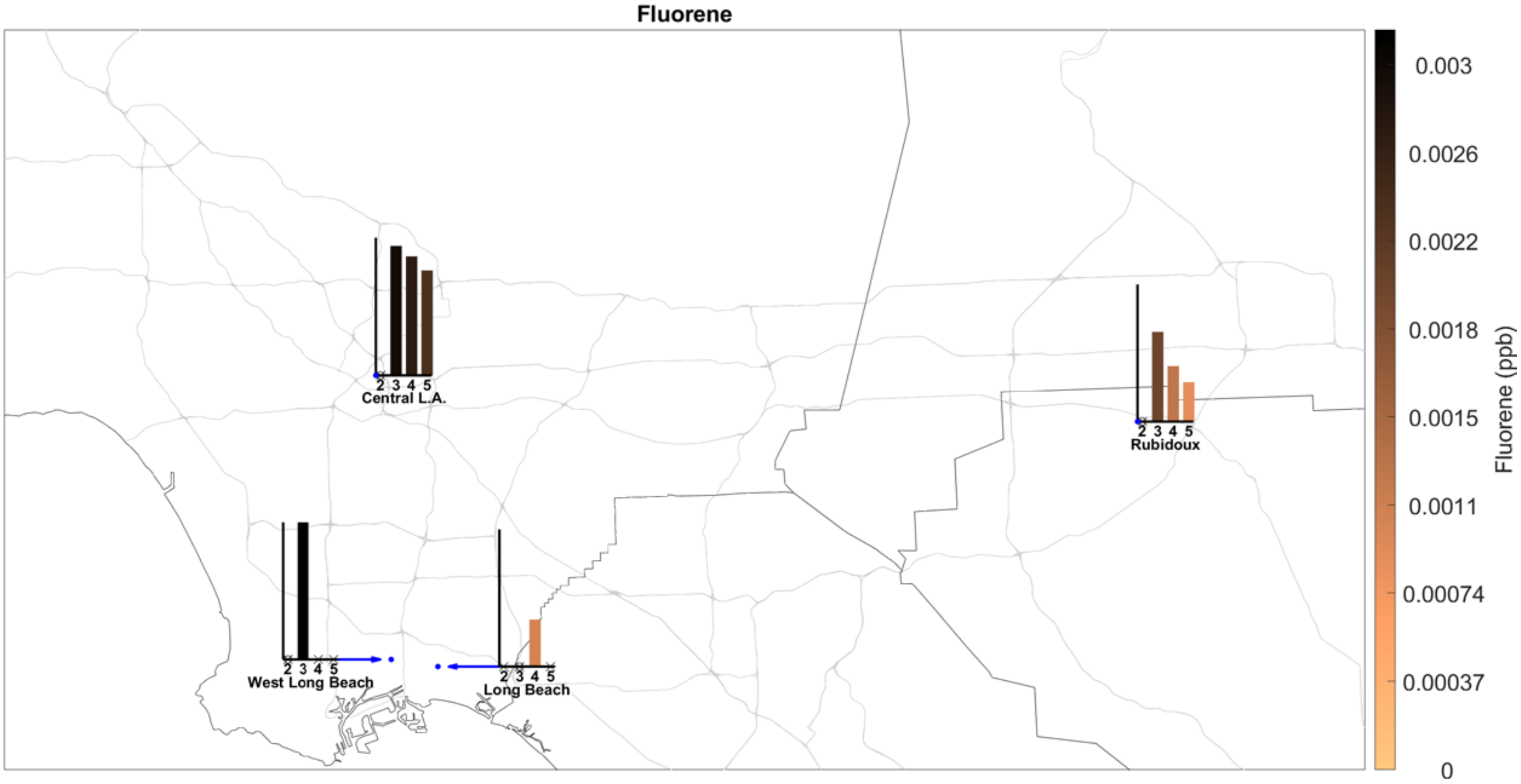


Figure IV-183. Geographic distribution of Fluorene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

9-Fluorenone

Table IV-94. Ambient Concentrations (ng/m^3) of 9-Fluorenone from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average						1.36	2.64		1.81	
95% CI LB						1.17	2.24		1.58	
95% CI UB						1.57	3.08		2.07	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						0	0		0	
Max						3.31	8.14		4.61	
MATES V										
Average							2.43		1.47	
95% CI LB							1.96		1.2	
95% CI UB							2.94		1.73	
N	0	0	0	0	0	0	57	0	59	0
% < MDL							10.5		13.6	
Max							10.3		5.33	

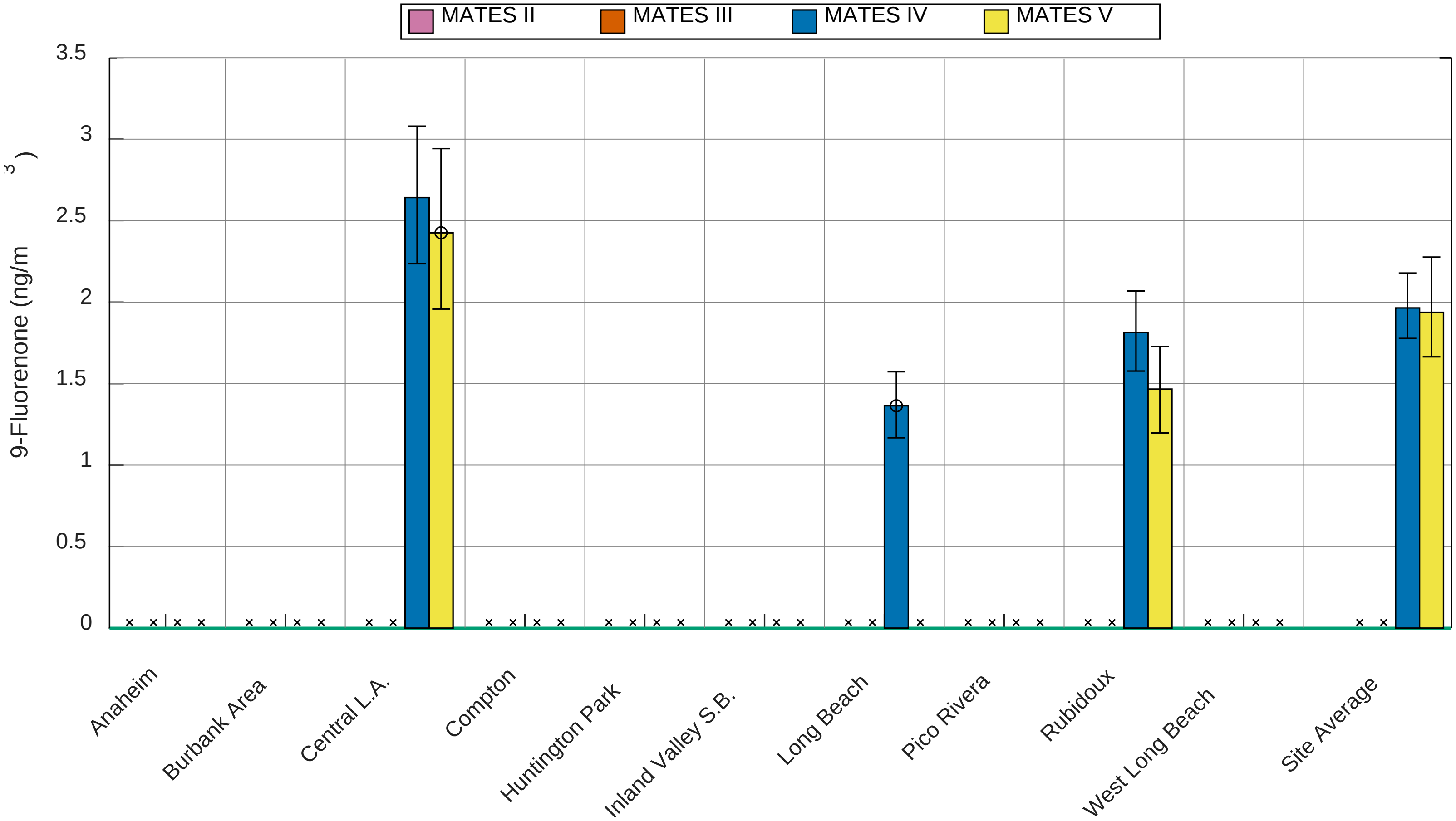


Figure IV-184. Annual Average Concentrations of 9-Fluorenone in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

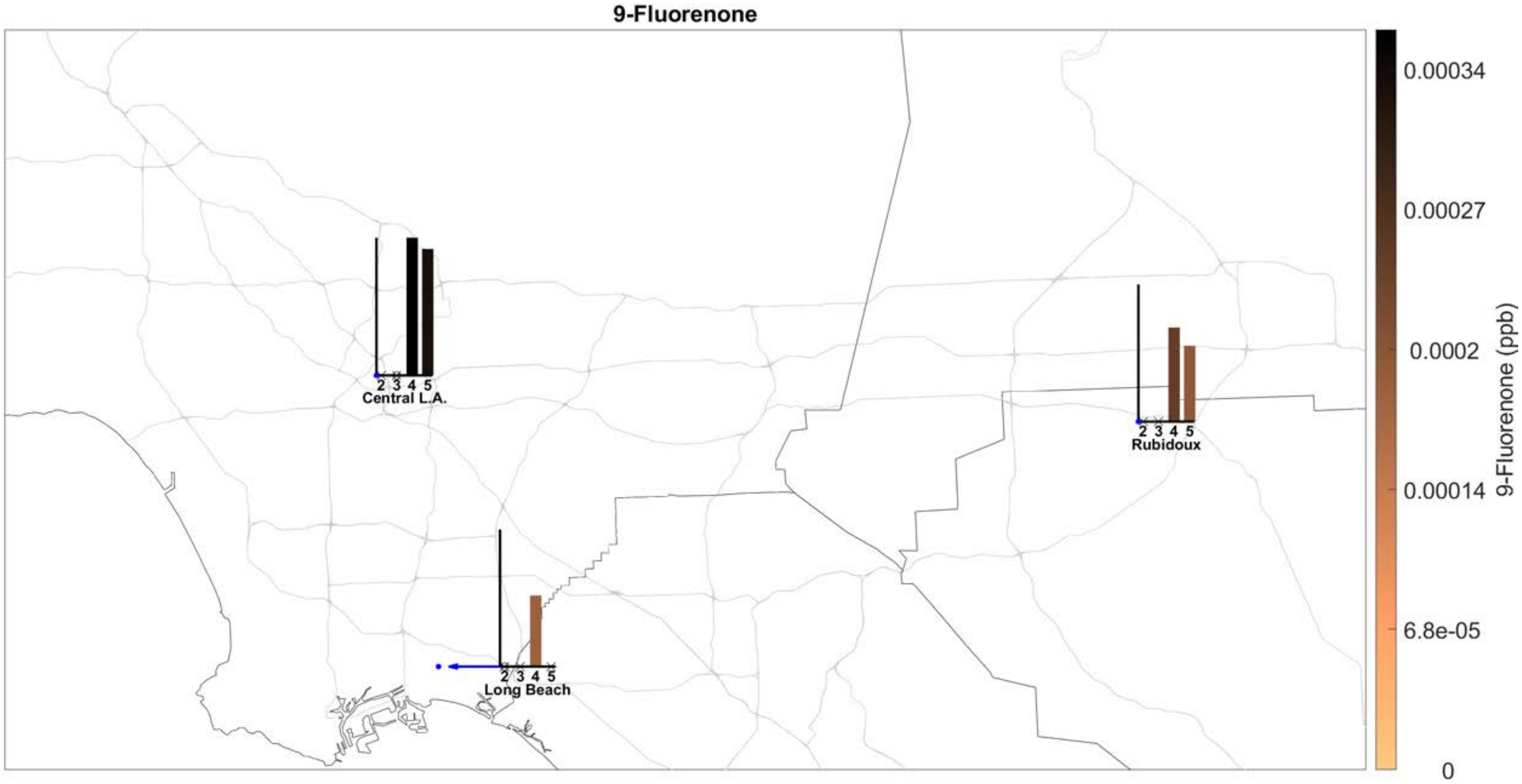


Figure IV-185. Geographic distribution of 9-Fluorenone from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Indeno(1,2,3-c,d)pyrene

Table IV-95. Ambient Concentrations (ng/m^3) of Indeno(1,2,3-c,d)pyrene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	AN	BU	CP	SB	HP	LB	LA	PR	RU	WLB
MATES II										
Average	0.228	0.445		0.171	0.575	0.309	0.31	0.446	0.232	
95% CI LB	0.13	0.283		0.132	0.333	0.18	0.214	0.258	0.137	
95% CI UB	0.351	0.64		0.218	0.87	0.477	0.426	0.682	0.351	
N	31	31	0	31	24	31	31	22	30	0
% < MDL	29	6.5		9.7	0	19.4	12.9	4.5	23.3	
Max	1.7	2.5		0.52	2.9	2.2	1.5	2.3	1.65	
MATES III										
Average							0.191		0.191	0.214
95% CI LB							0.166		0.161	0.177
95% CI UB							0.217		0.224	0.253
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							0.884		1.11	1.25
MATES IV										
Average						0.0892	0.0538		0.0642	
95% CI LB						0.0575	0.0414		0.0518	
95% CI UB						0.139	0.0691		0.0796	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						66.7	65.5		63.8	
Max						0.966	0.302		0.316	
MATES V										
Average							0.0941		0.0891	
95% CI LB							0.0625		0.0608	
95% CI UB							0.135		0.123	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							5.2		8.3	
Max							0.89		0.687	

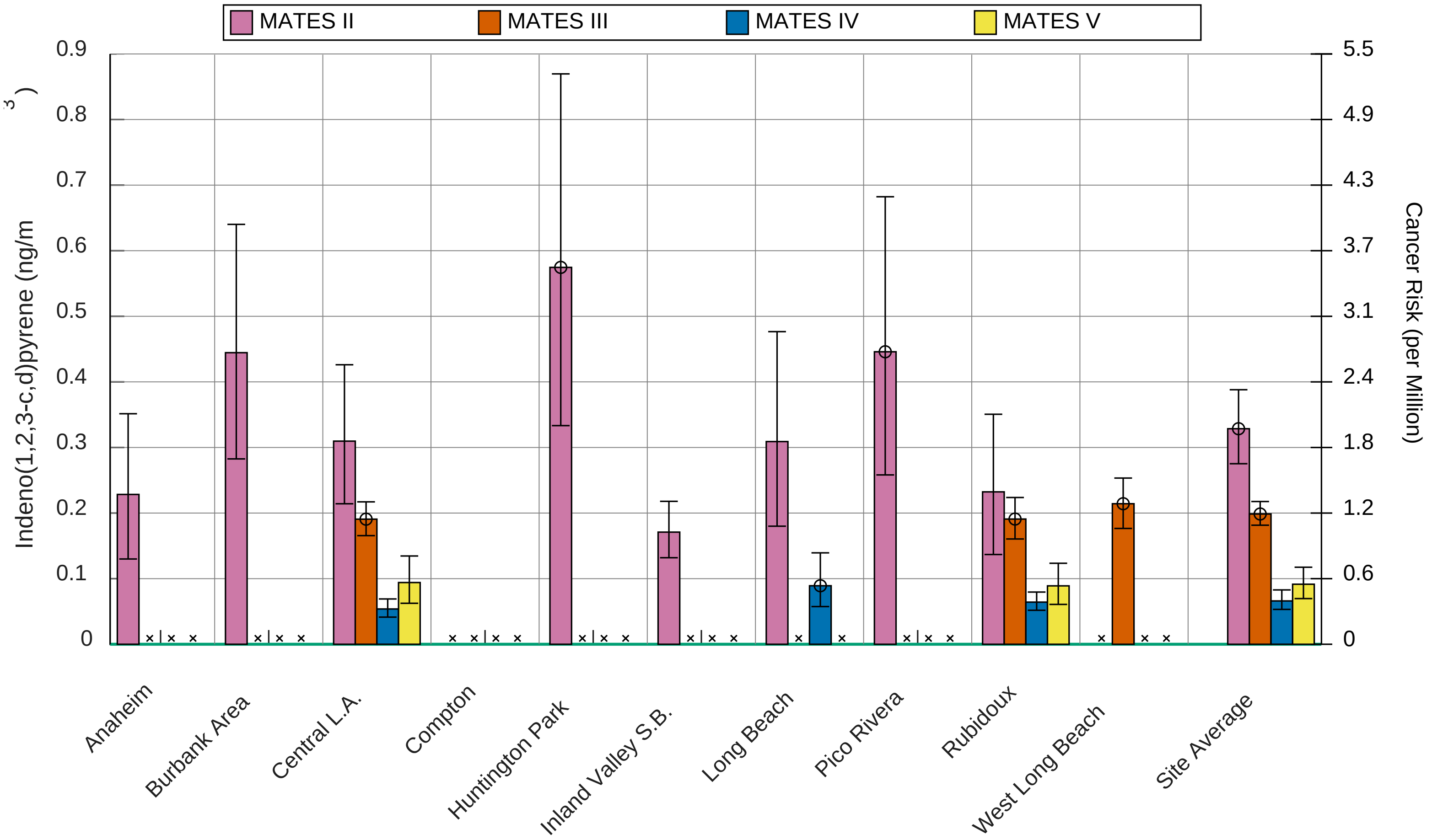


Figure IV-186. Annual Average Concentrations of Indeno(1,2,3-c,d)pyrene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

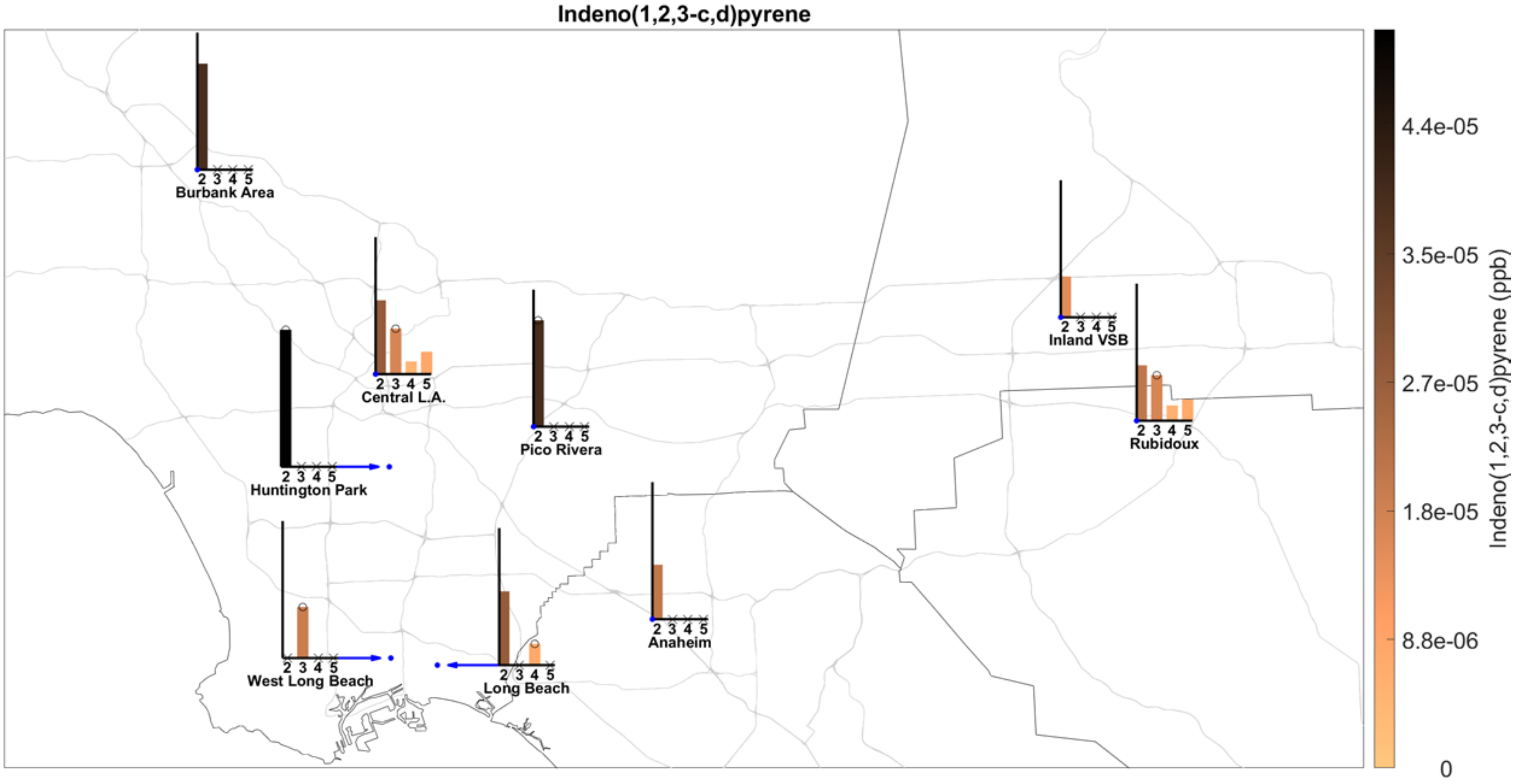


Figure IV-187. Geographic distribution of Indeno(1,2,3-c,d)pyrene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Naphthalene

Table IV-96. Ambient Concentrations (ng/m^3) of Naphthalene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							221		162	204
95% CI LB							199		142	174
95% CI UB							244		184	233
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							701		534	817
MATES IV										
Average						76.6	152		83.1	
95% CI LB						60.6	130		70.5	
95% CI UB						94.5	176		96.9	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						0	0		0	
Max						270	338		245	
MATES V										
Average							77		45.8	
95% CI LB							64.2		37.7	
95% CI UB							90.6		54.7	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		0	
Max							195		181	

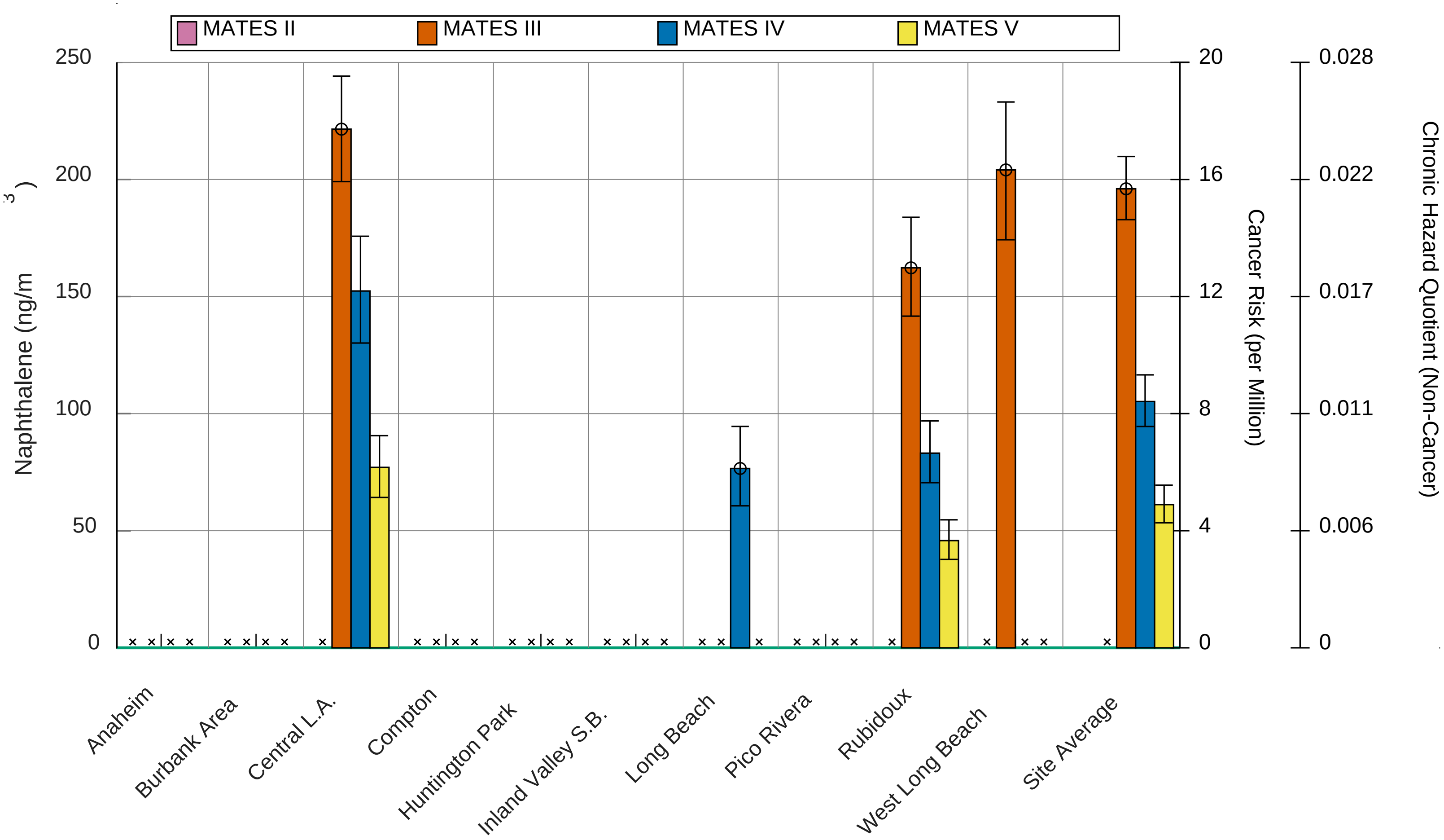


Figure IV-188. Annual Average Concentrations of Naphthalene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

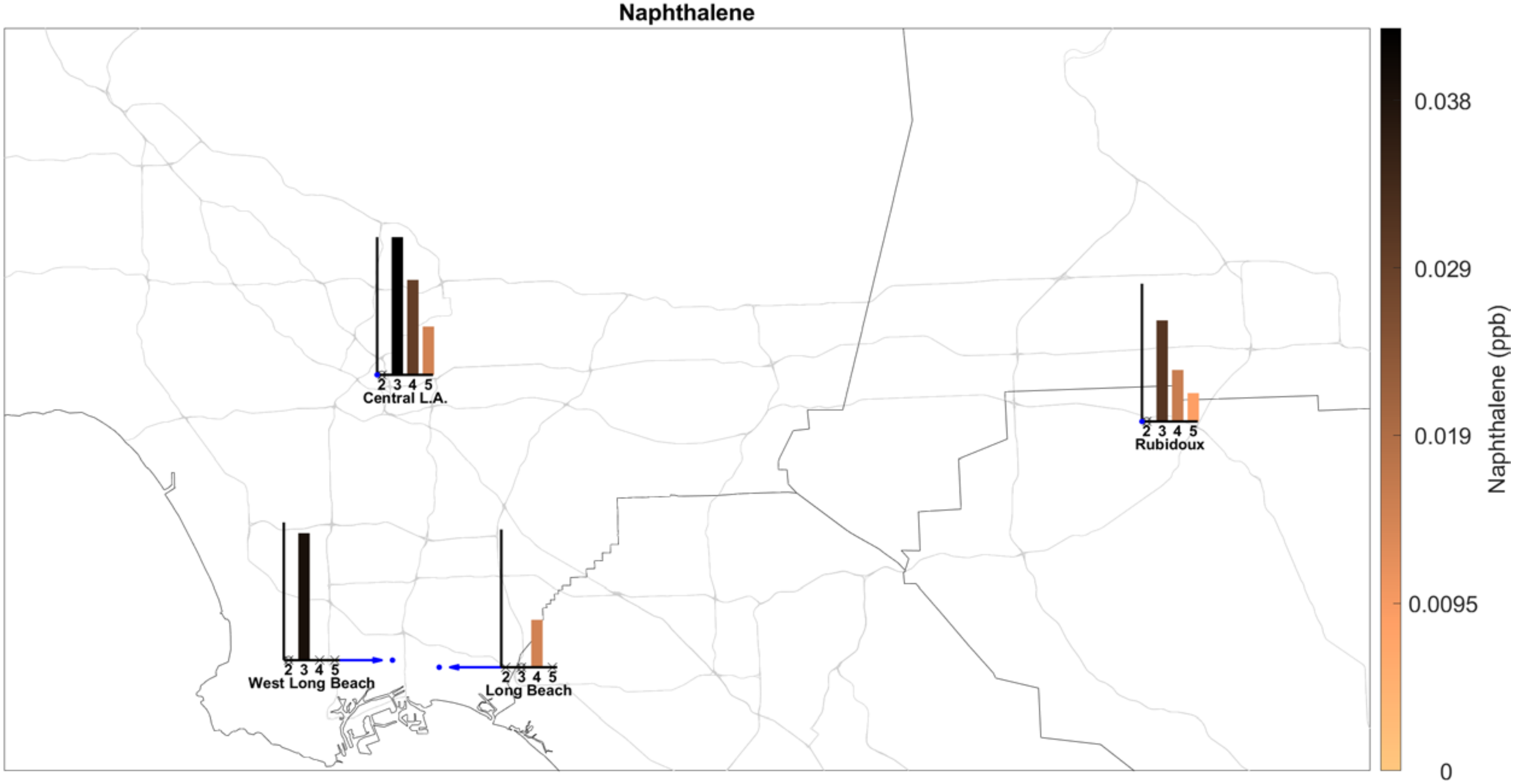


Figure IV-189. Geographic distribution of Naphthalene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Perylene

Table IV-97. Ambient Concentrations (ng/m^3) of Perylene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average						0.0109, 0.0603[a]	0.000631, 0.0533[a]		0.00188, 0.0602[a]	
95% CI LB						0.000945[a]	0[a]		0[a]	
95% CI UB						0.076[a]	0.0693[a]		0.0651[a]	
N	0	0	0	0	0	51[a]	58[a]	0	58[a]	0
% < MDL						92.2[a]	98.3[a]		98.3[a]	
Max						0.388[a]	0.0366[a]		0.109[a]	
MATES V										
Average							0.0131		0.0132	
95% CI LB							0.0102		0.0105	
95% CI UB							0.017		0.0174	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							75.9		75	
Max							0.0789		0.103	

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

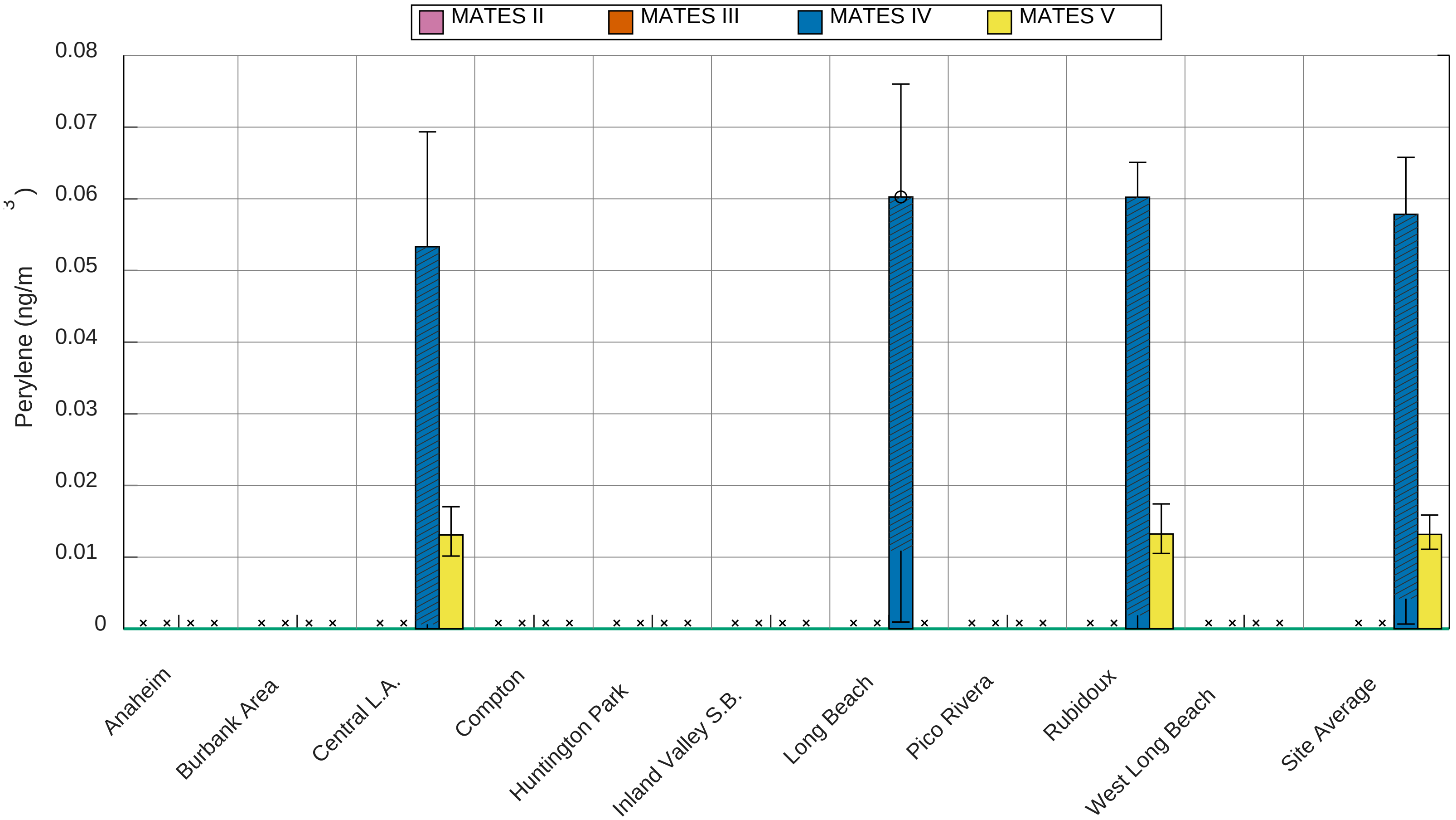


Figure IV-190. Annual Average Concentrations of Perylene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

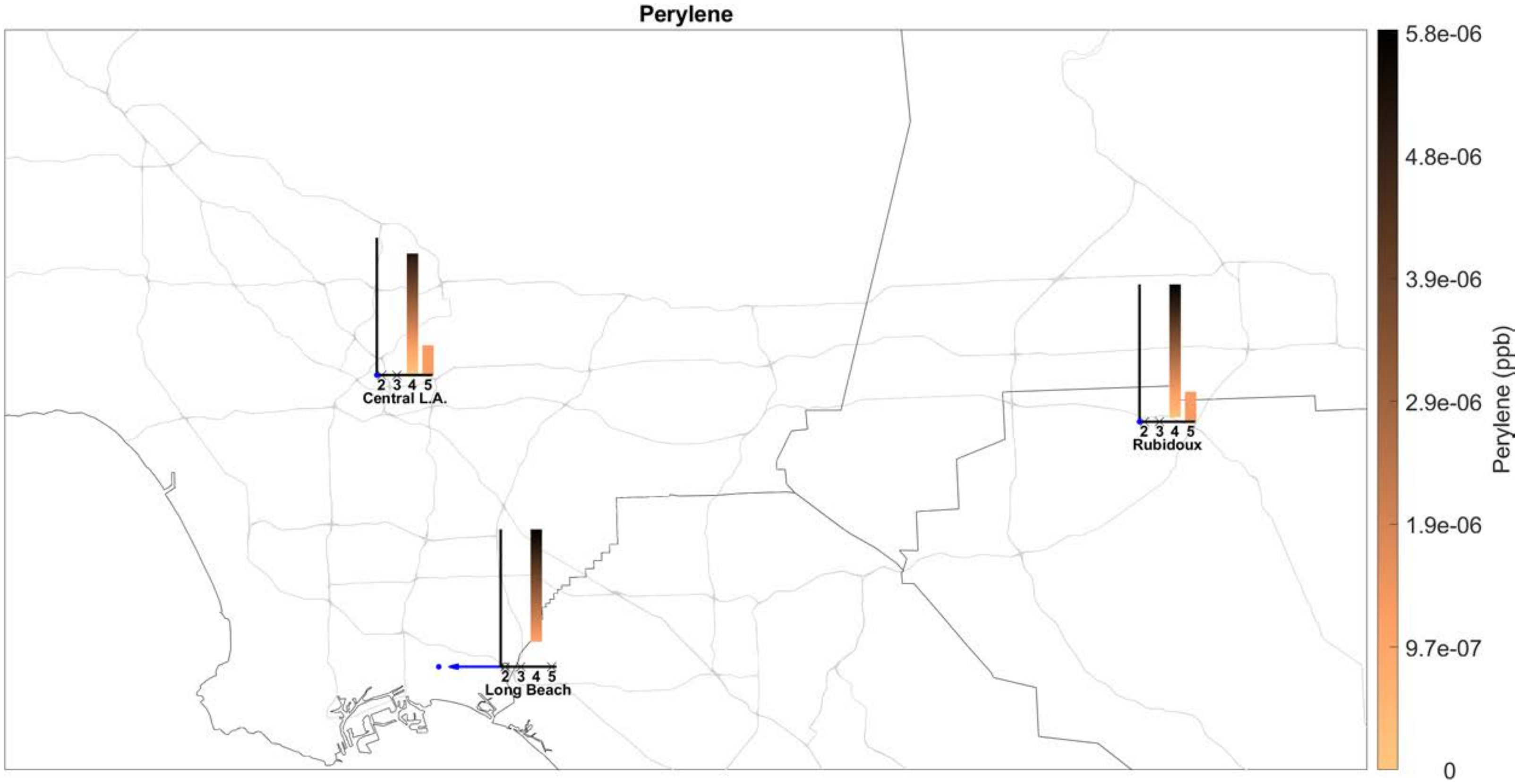


Figure IV-191. Geographic distribution of Perylene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Phenanthrene

Table IV-98. Ambient Concentrations (ng/m^3) of Phenanthrene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							14.7		9.15	13.6
95% CI LB							13.5		8.33	12
95% CI UB							16.1		10	15.4
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							43.4		27.6	58.8
MATES IV										
Average						5.76	13.9		6.06	
95% CI LB						5.02	11.9		5.31	
95% CI UB						6.52	16		6.87	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						0	0		0	
Max						13.9	35.6		15.3	
MATES V										
Average							10.5		3.94	
95% CI LB							8.86		3.4	
95% CI UB							12.4		4.55	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		0	
Max							44.9		14.9	

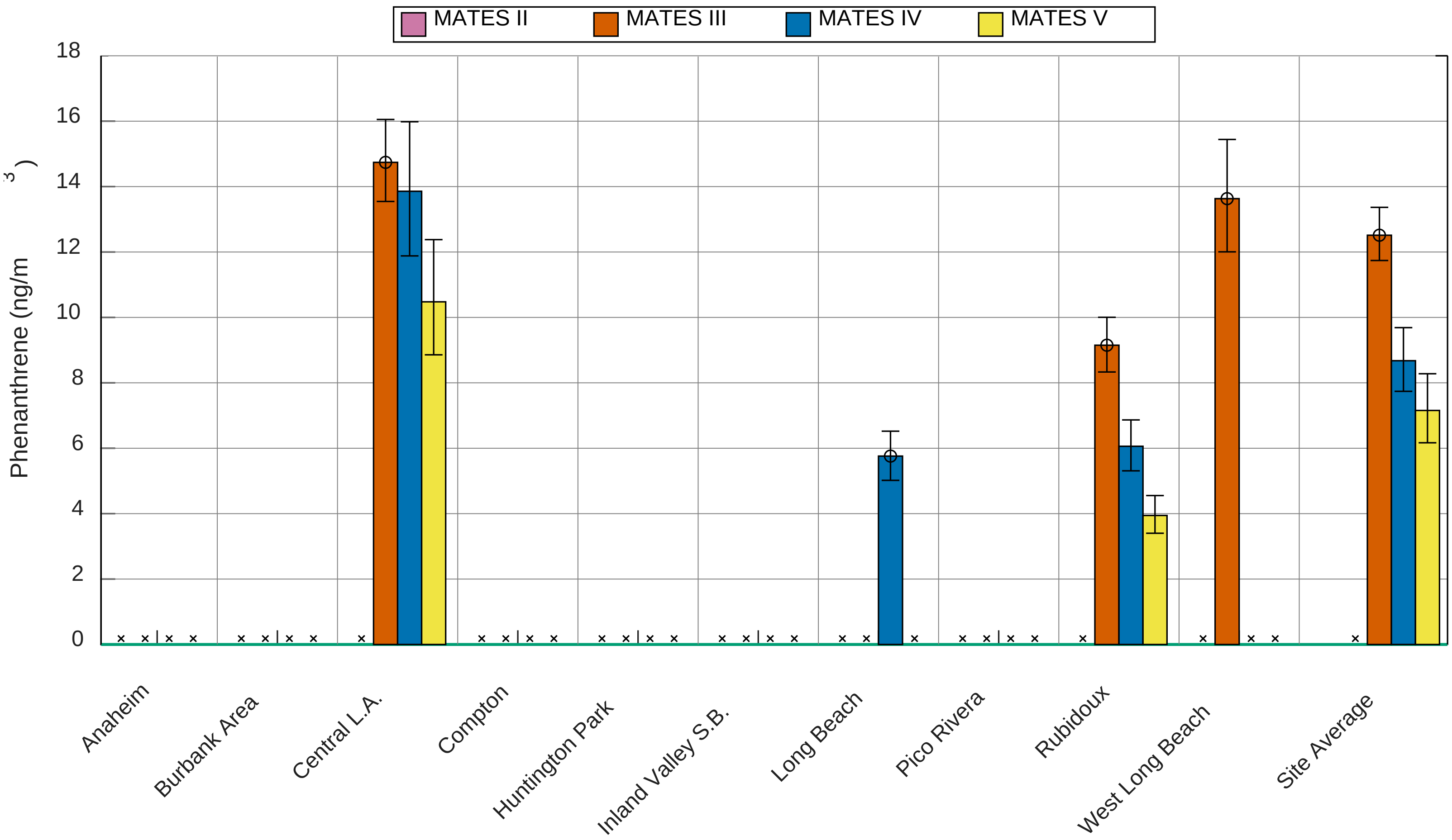


Figure IV-192. Annual Average Concentrations of Phenanthrene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

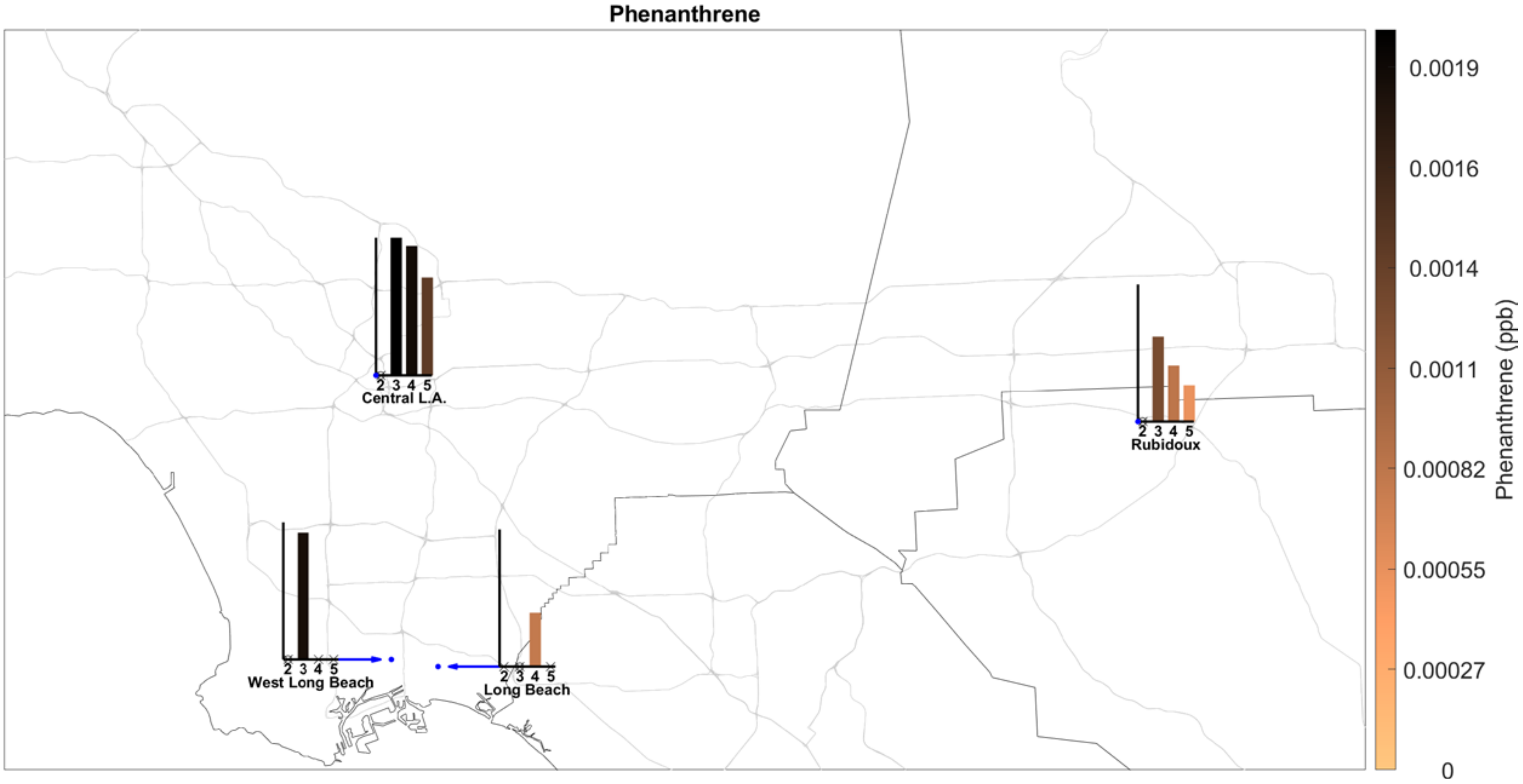


Figure IV-193. Geographic distribution of Phenanthrene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Pyrene

Table IV-99. Ambient Concentrations (ng/m^3) of Pyrene from the PAH analysis at the Fixed Sites.

Statistic	Measurement Site AN	BU	CP	SB	HP	LB	LA	PR	RU	WLB
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average							1.71		1.22	1.7
95% CI LB							1.58		1.1	1.52
95% CI UB							1.83		1.34	1.87
N	0	0	0	0	0	0	129	0	128	128
% < MDL							0		0	0
Max							3.82		3.56	5.09
MATES IV										
Average						0.857	1.12		0.732	
95% CI LB						0.692	0.999		0.644	
95% CI UB						1.05	1.25		0.829	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						0	0		0	
Max						3.73	2.34		2.11	
MATES V										
Average							1.16		0.564	
95% CI LB							0.981		0.478	
95% CI UB							1.37		0.657	
N	0	0	0	0	0	0	58	0	60	0
% < MDL							0		0	
Max							4.73		2.09	

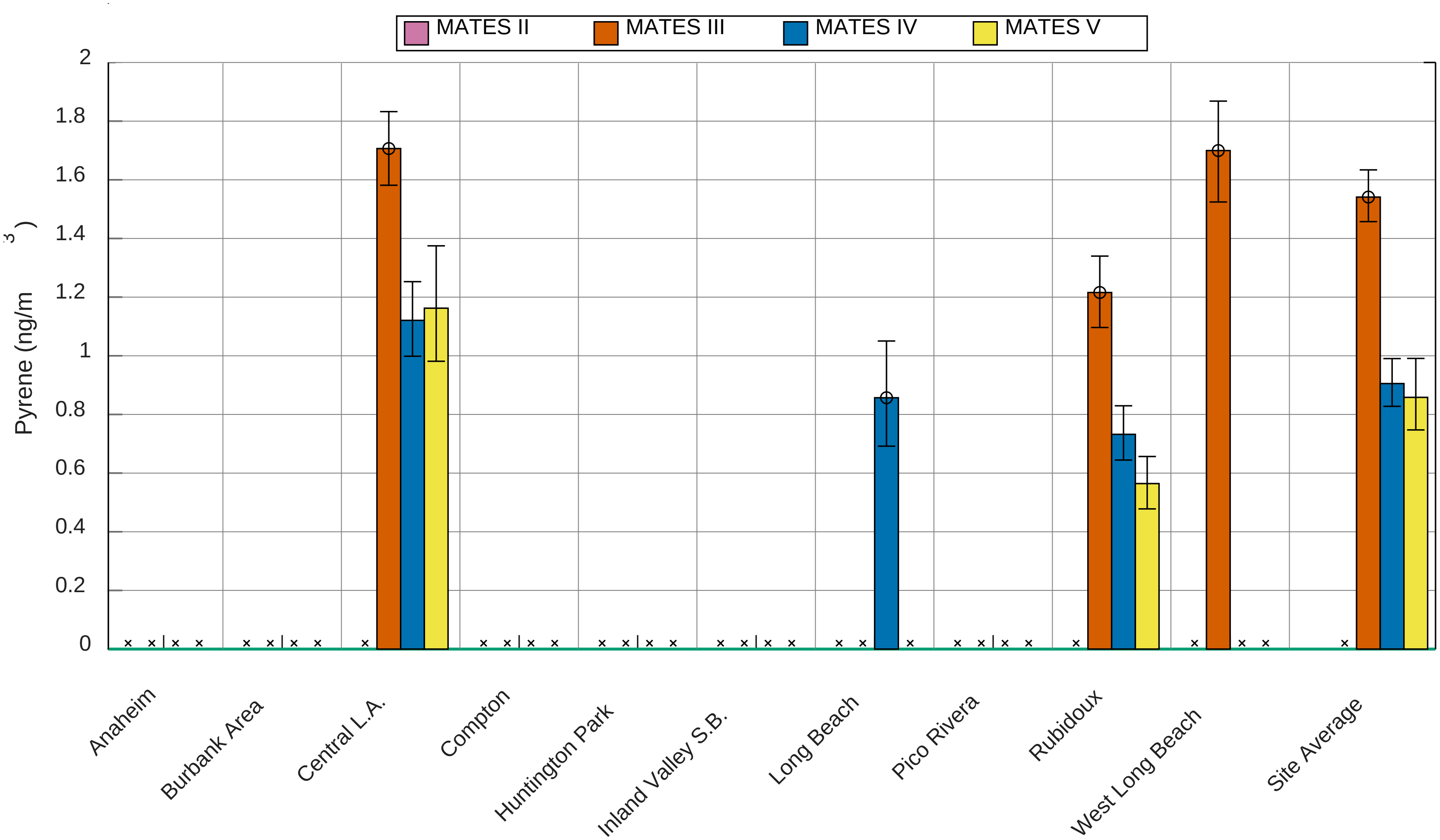


Figure IV-194. Annual Average Concentrations of Pyrene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

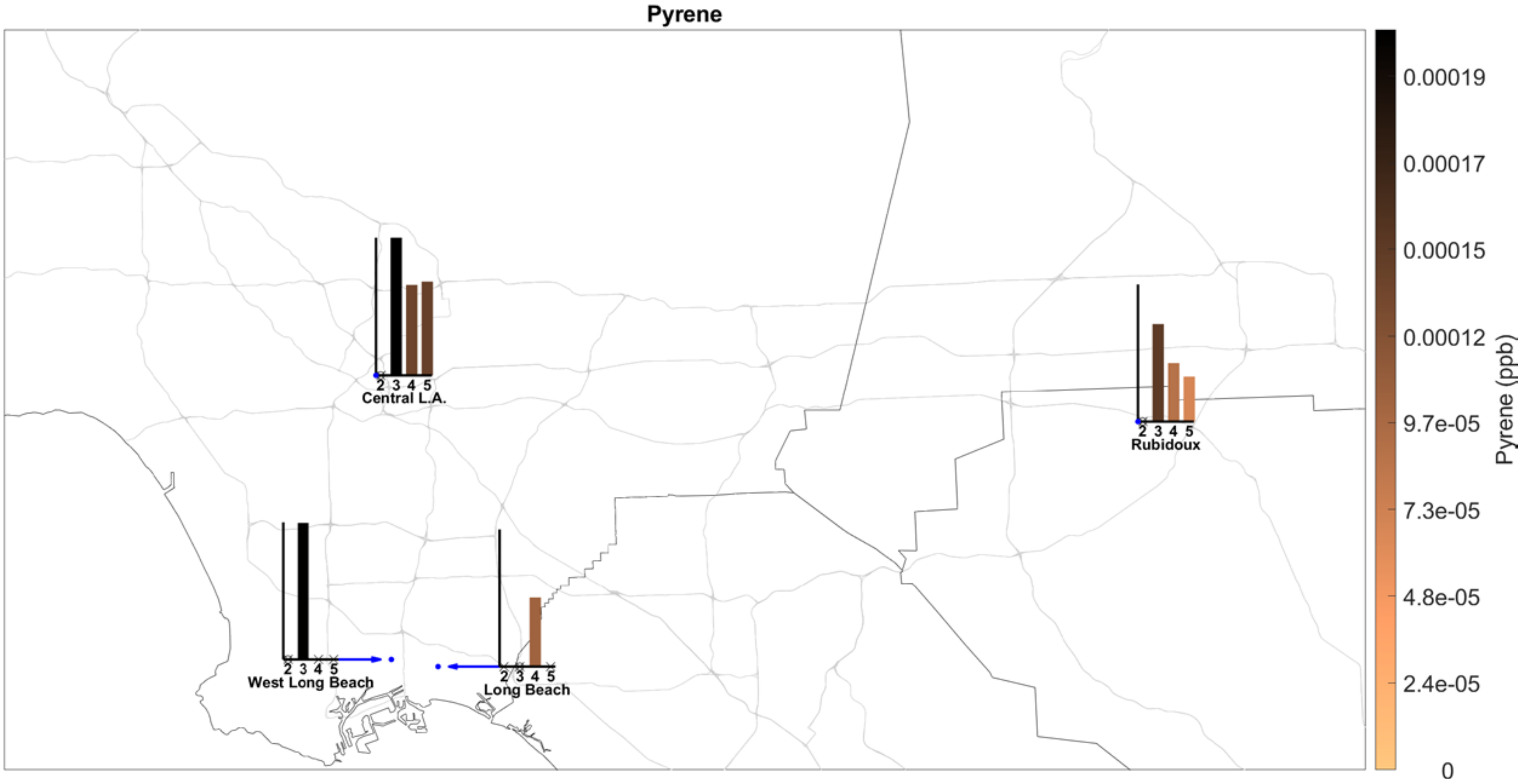


Figure IV-195. Geographic distribution of Pyrene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Retene

Table IV-100. Ambient Concentrations (ng/m^3) of Retene from the PAH analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average						0.65	0.269		0.273	
95% CI LB						0.402	0.191		0.215	
95% CI UB						0.957	0.364		0.334	
N	0	0	0	0	0	51	58	0	58	0
% < MDL						31.4	43.1		36.2	
Max						5.17	1.7		1.19	
MATES V										
Average							0.411		0.491	
95% CI LB							0.286		0.362	
95% CI UB							0.548		0.642	
N	0	0	0	0	0	0	57	0	59	0
% < MDL							14		16.9	
Max							2.67		2.84	

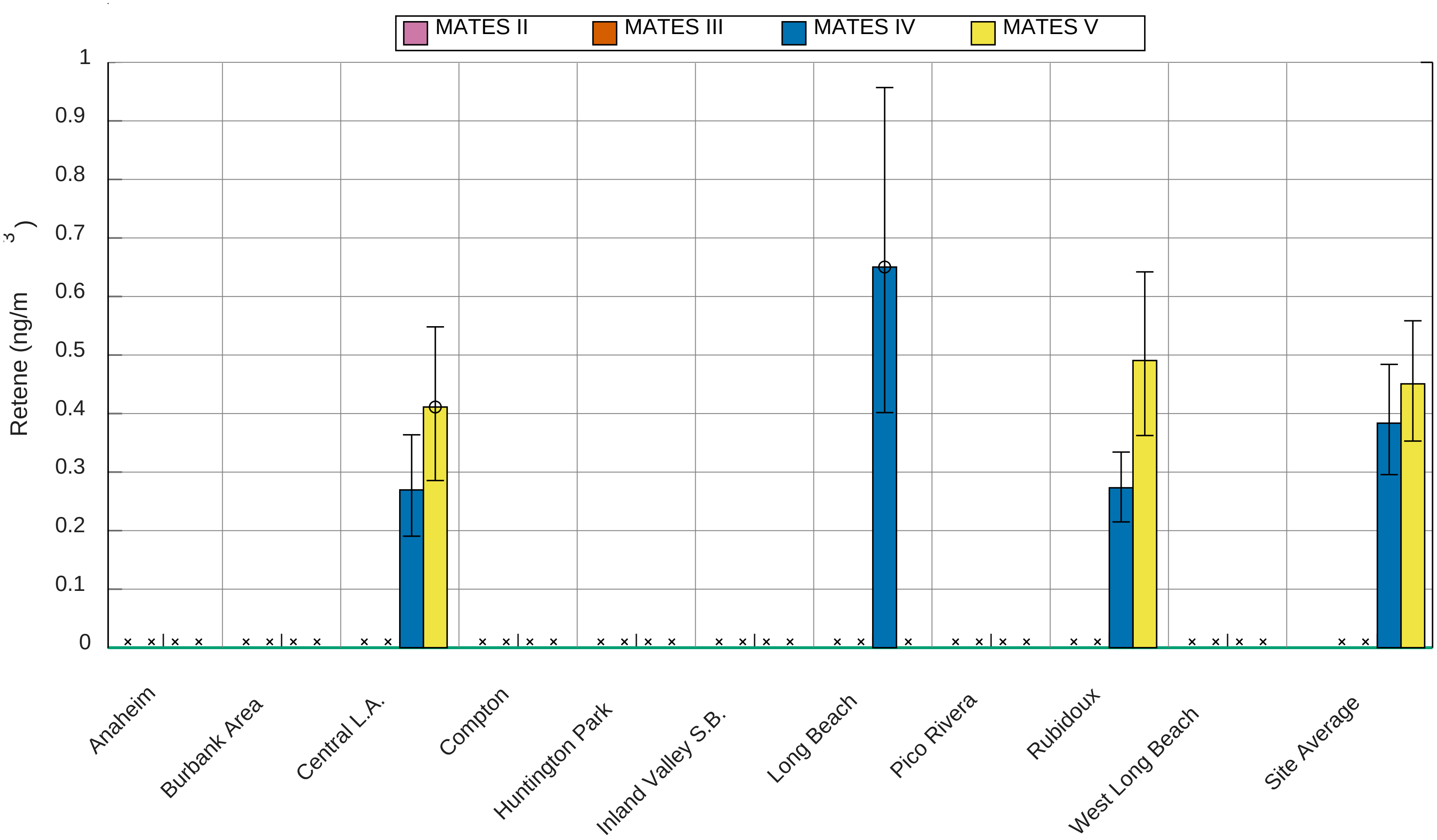


Figure IV-196. Annual Average Concentrations of Retene in the PAH Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted for 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.

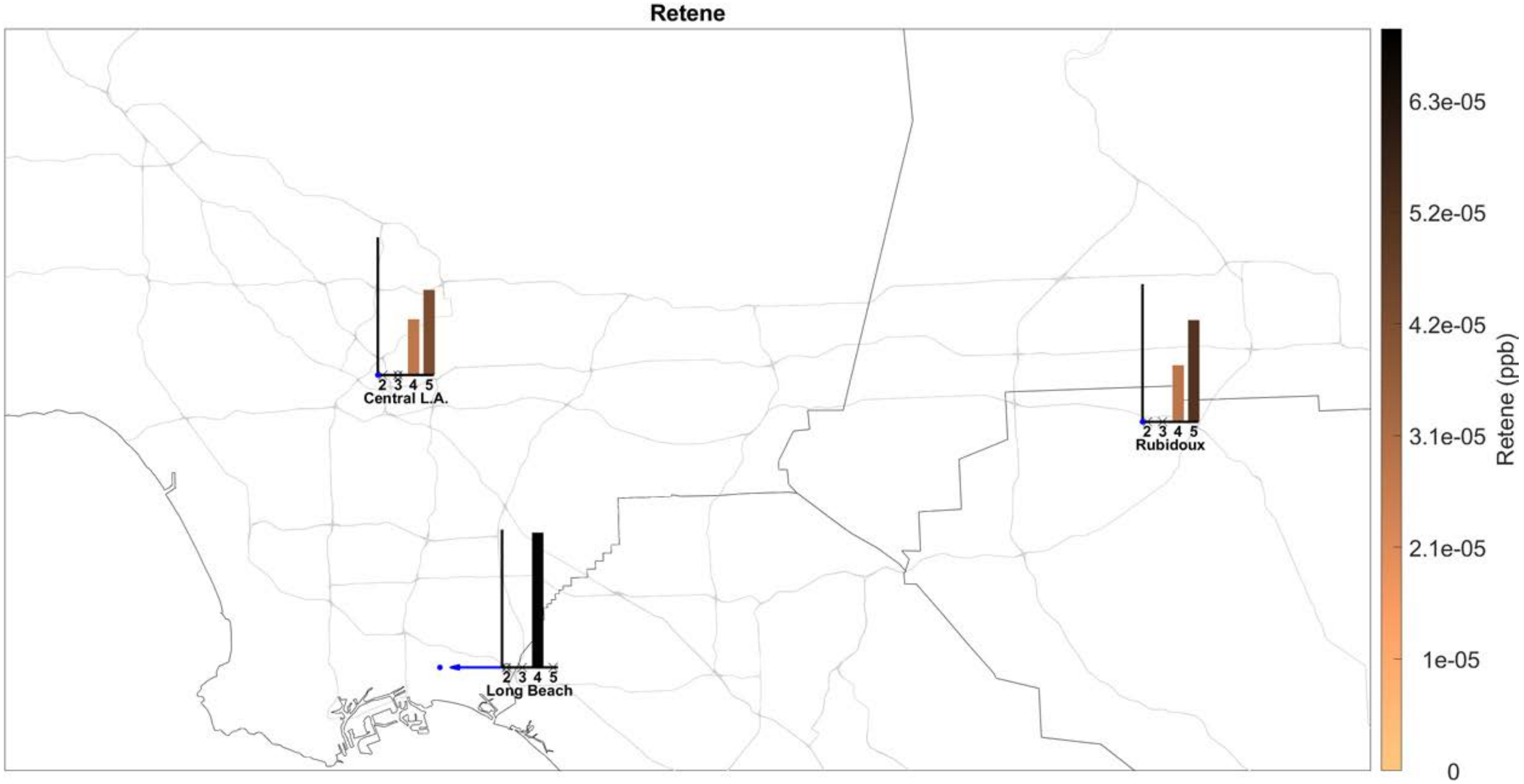


Figure IV-197. Geographic distribution of Retene from the PAH Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

PM2.5 Mass (SASS) Analysis

PM2.5 Mass

Table IV-101. Ambient Concentrations (µg/m) of PM2.5 Mass from the PM2.5 Mass (SASS) analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	17.6	20.9	18.9	21.5	22.4	17.8	19.6	20.7	22.9	18.3
95% CI LB	16.3	19.3	17.5	20	20.2	16.6	18.3	18.7	21	17.1
95% CI UB	18.8	22.6	20.3	23.3	24.7	19.2	21.1	22.9	24.8	19.6
N	235	233	230	229	113	219	236	109	235	227
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	64	80.8	57.5	112	77.9	61.1	73.2	64.9	110	60.3
MATES IV										
Average	12.4	14.4	12.9	14.3	14.4	12.9	14.1	14.2	13.8	13.2
95% CI LB	11.3	13.1	11.7	12.8	13.1	11.9	13	13	12.4	12.1
95% CI UB	13.5	15.6	14.2	15.8	15.8	14.1	15.4	15.4	15.2	14.5
N	59	59	61	60	57	61	59	58	61	60
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	31.6	27.9	29.6	34.1	35.4	27.1	27.4	29.5	30.3	28.1
MATES V										
Average	10.6	10.8	12.9	12.6	12.7	10.9	12.5	12.8	12.8	11.9
95% CI LB	9.31	9.25	11.2	11.2	11.1	9.67	10.8	11.3	11.4	10.5
95% CI UB	12.1	12.6	14.7	14	14.6	12.2	14.5	14.4	14.3	13.3
N	56	58	61	61	59	61	61	59	60	57
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	28.6	28.1	32.2	27.9	36.9	27.8	45.2	38.6	34.1	29.1

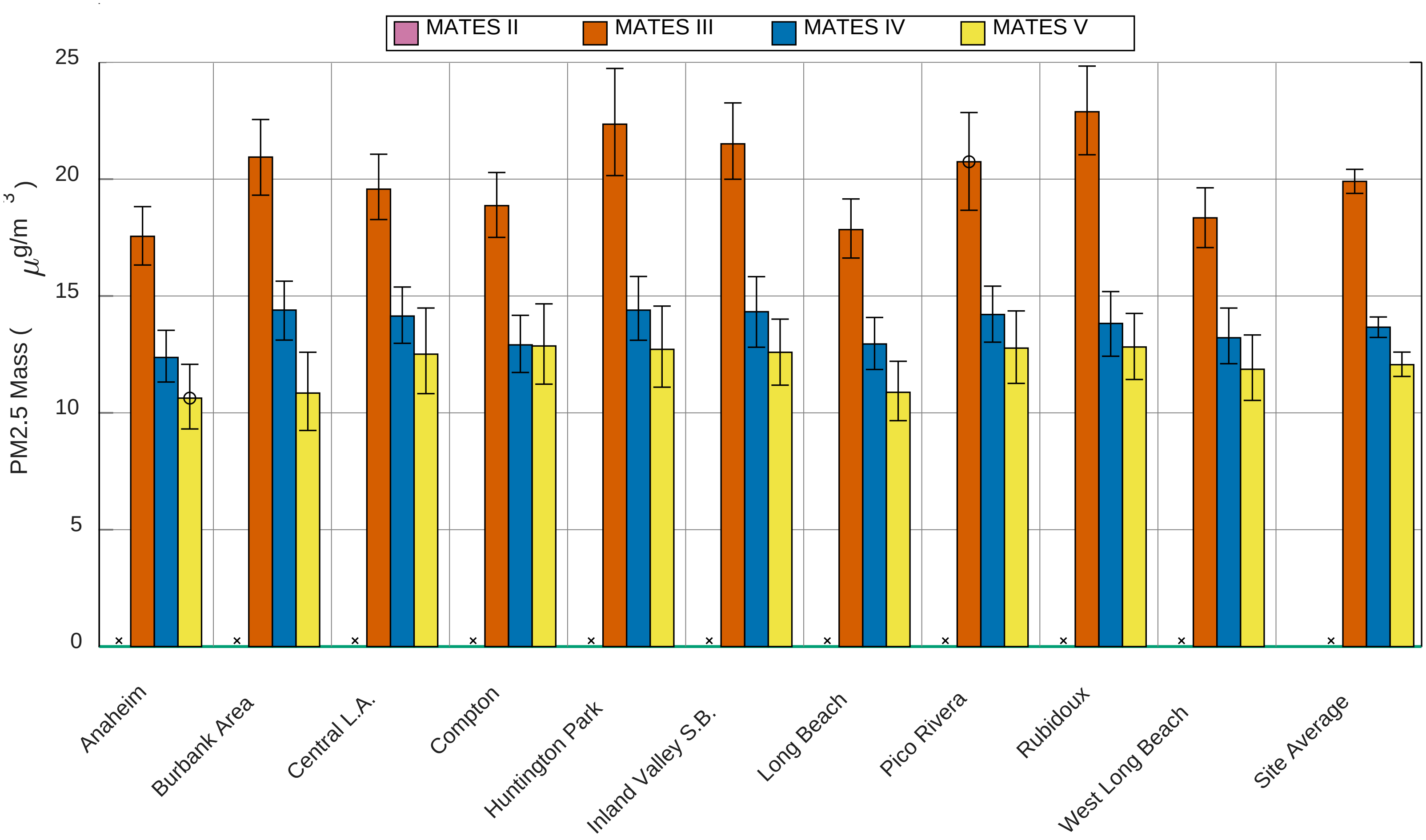


Figure IV-198. Annual Average Concentrations of PM2.5 Mass in the PM2.5 Mass (SASS) Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

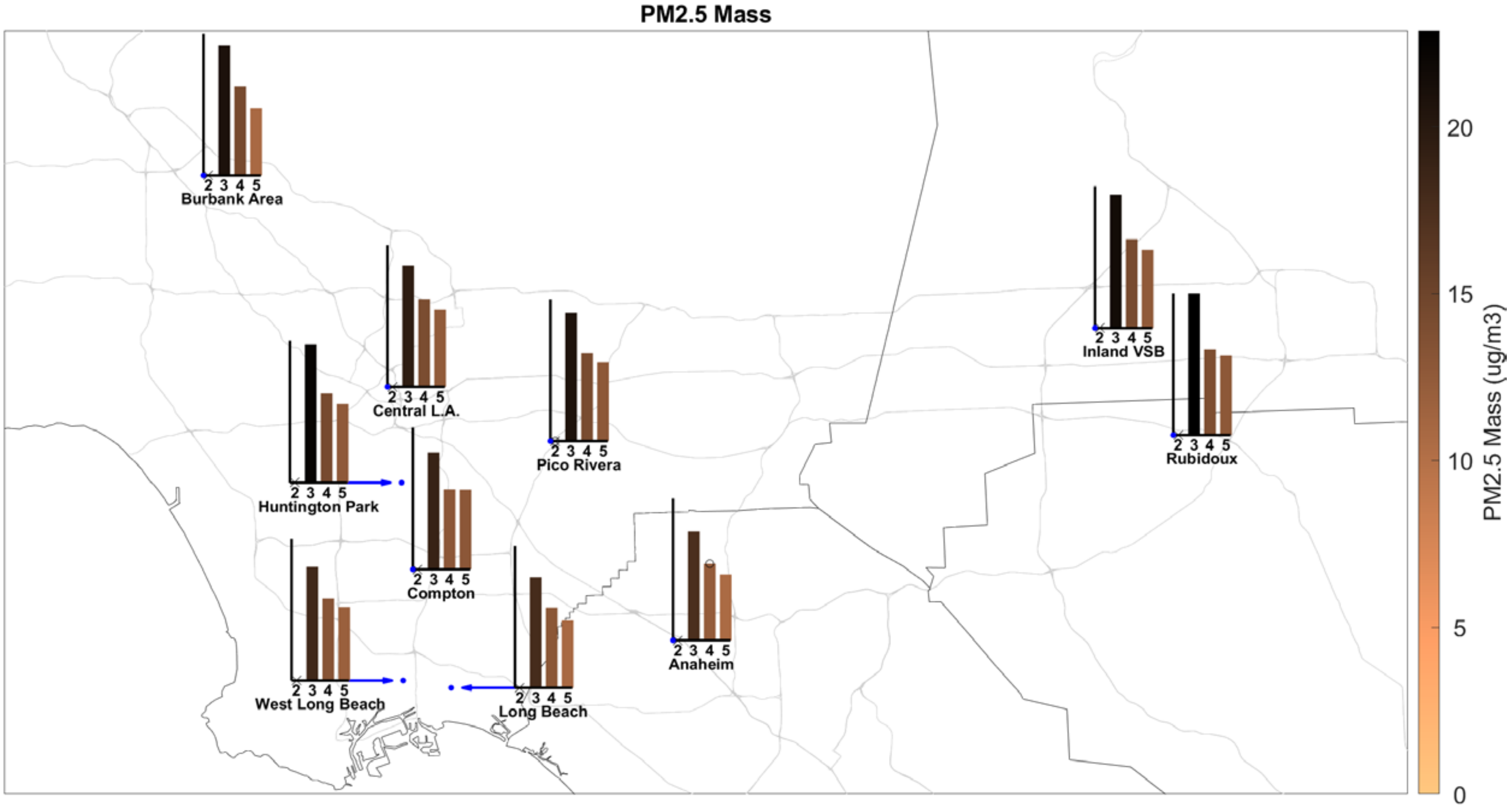


Figure IV-199. Geographic distribution of PM2.5 Mass from the PM2.5 Mass (SASS) Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

PM2.5 Carbon Analysis

EC1

Table IV-102. Ambient Concentrations (ng/m^3) of EC1 from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	342	462	593	614	544	383	563	569	555	482
95% CI LB	240	337	384	484	394	253	404	408	414	312
95% CI UB	457	606	823	752	710	541	758	763	712	686
N	56	59	61	60	60	61	61	59	59	55
% < MDL	12.5	16.9	9.8	8.3	8.3	19.7	9.8	6.8	8.5	14.5
Max	1800	3000	4800	2300	2500	2500	4300	3800	2700	3400

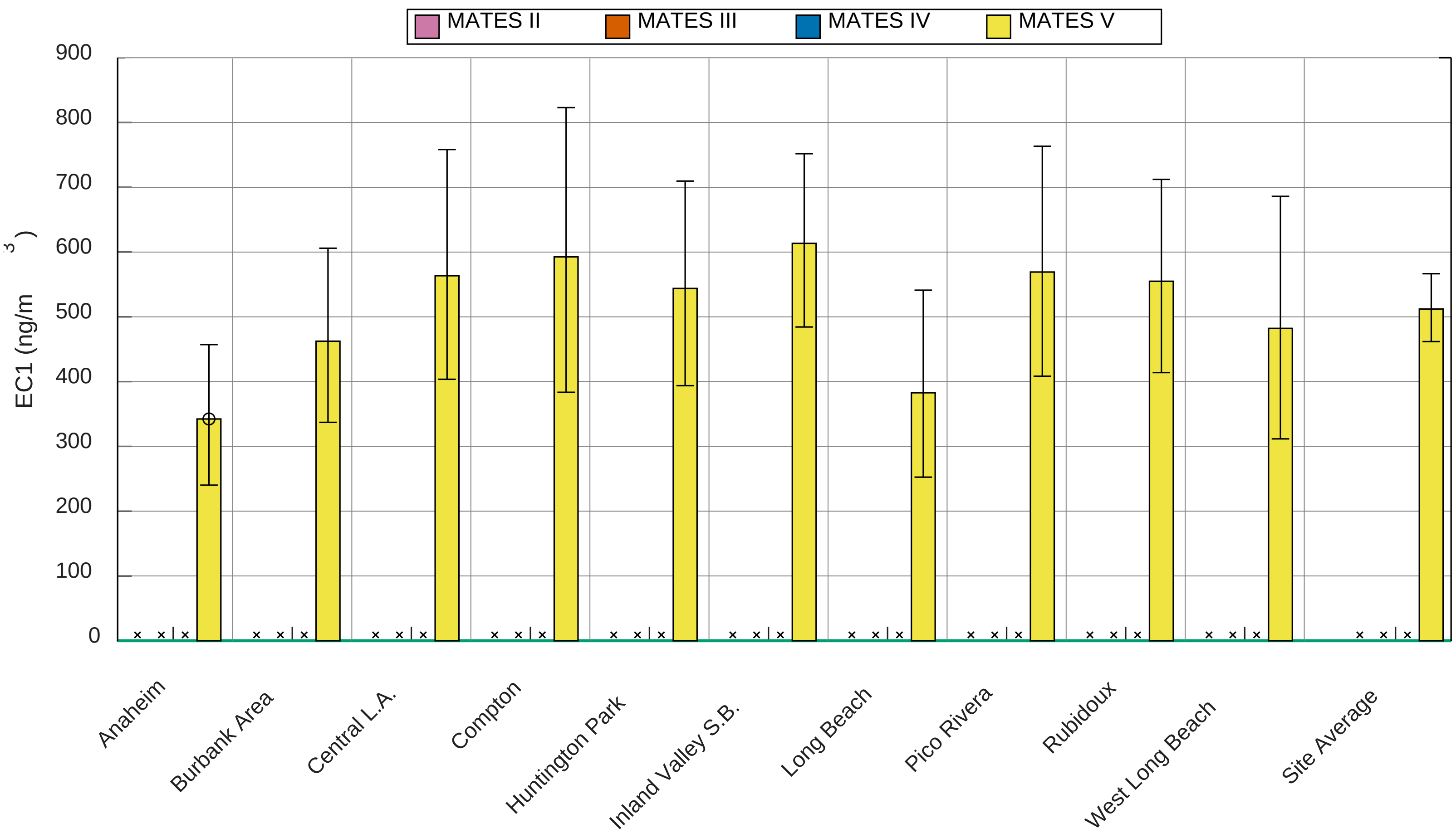


Figure IV-200. Annual Average Concentrations of EC1 in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

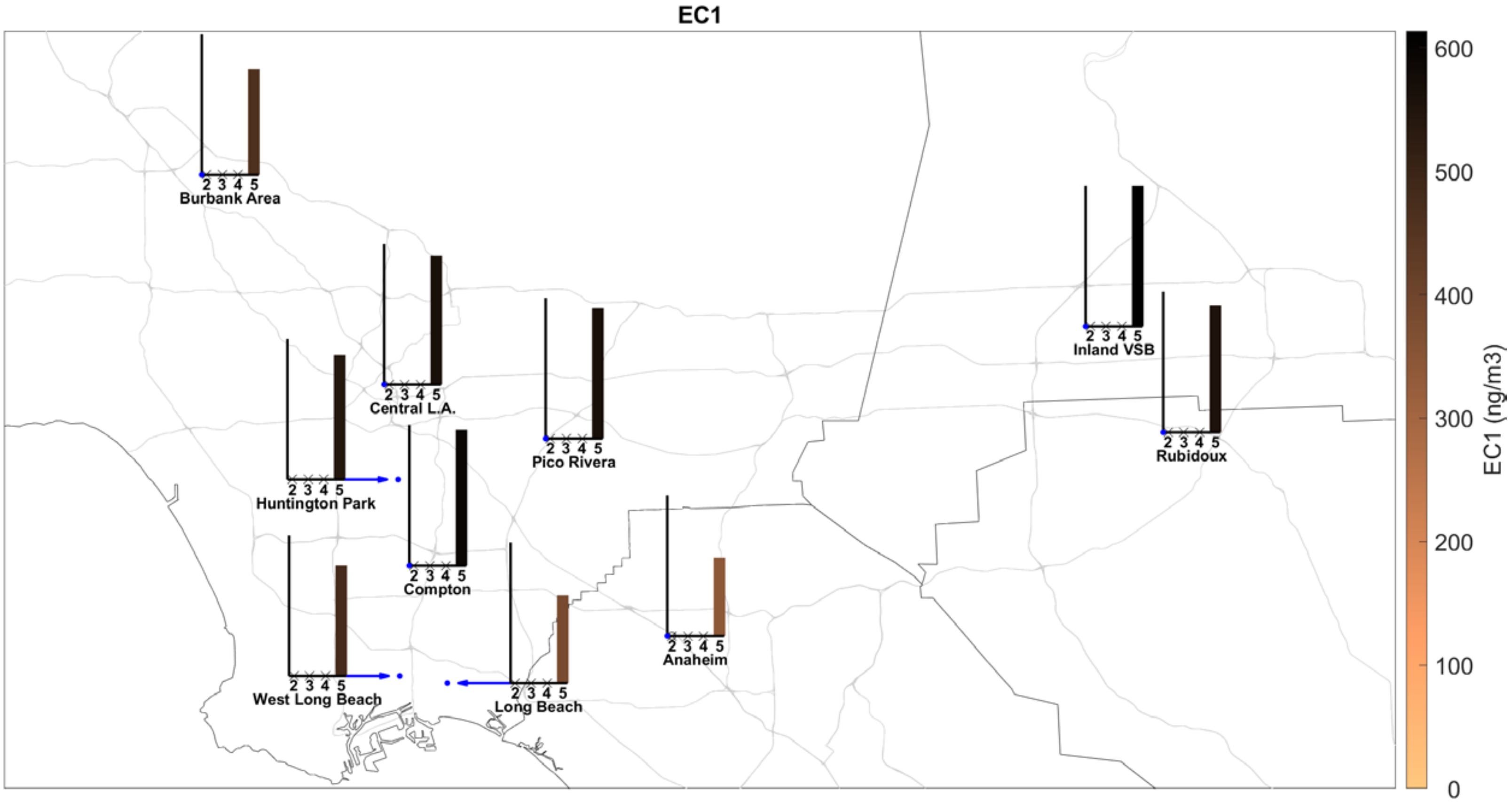


Figure IV-201. Geographic distribution of EC1 from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

EC2

Table IV-103. Ambient Concentrations (ng/m^3) of EC2 from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	325	338	434	500	450	330	451	494	460	475
95% CI LB	244	279	337	420	364	246	375	406	365	371
95% CI UB	417	402	540	586	540	418	534	590	567	588
N	56	59	61	60	60	61	61	59	59	55
% < MDL	5.4	3.4	6.6	5	1.7	8.2	1.6	1.7	3.4	1.8
Max	1700	1200	1500	1500	1400	1600	1350	1500	2100	1600

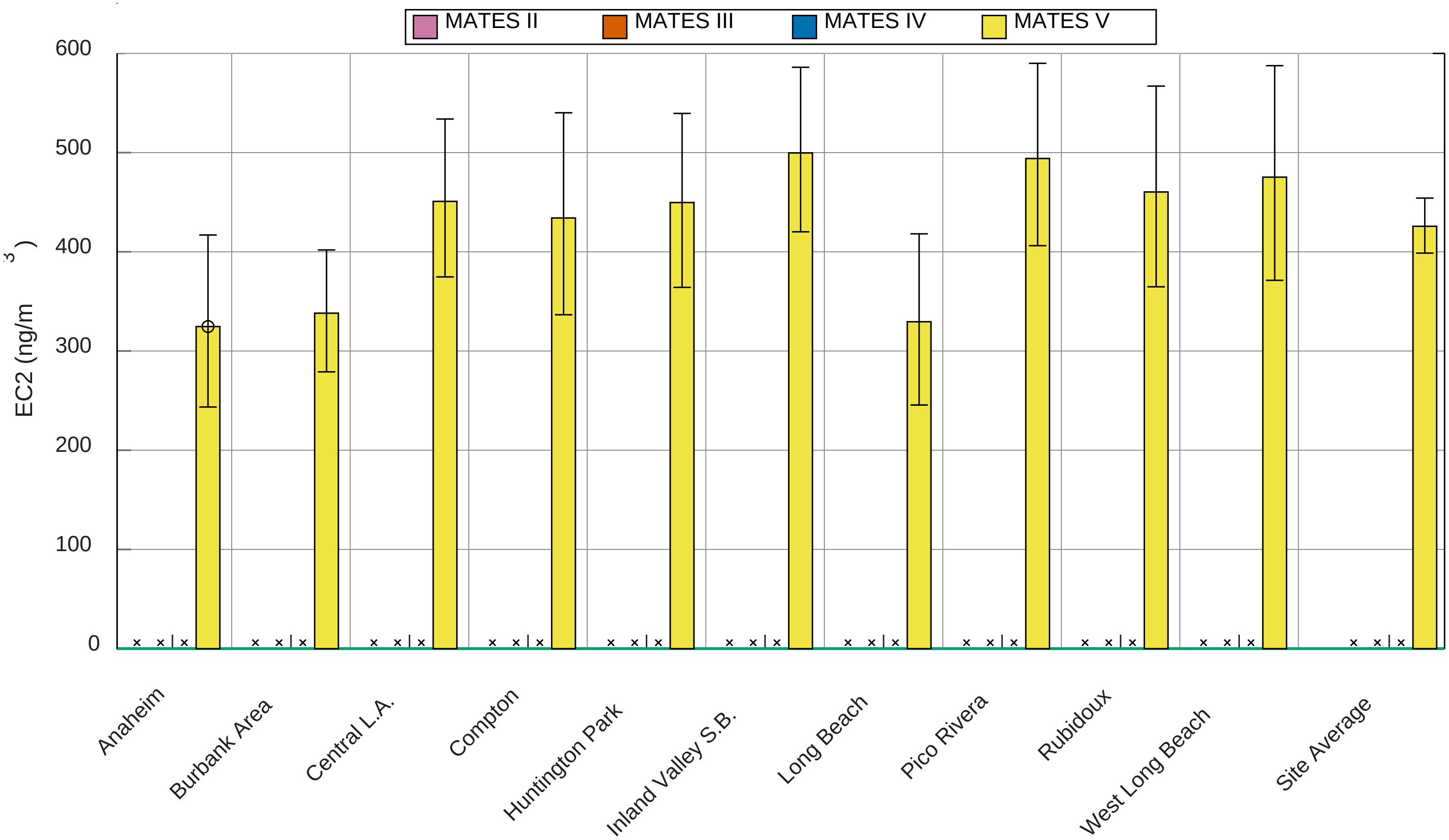


Figure IV-202. Annual Average Concentrations of EC2 in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

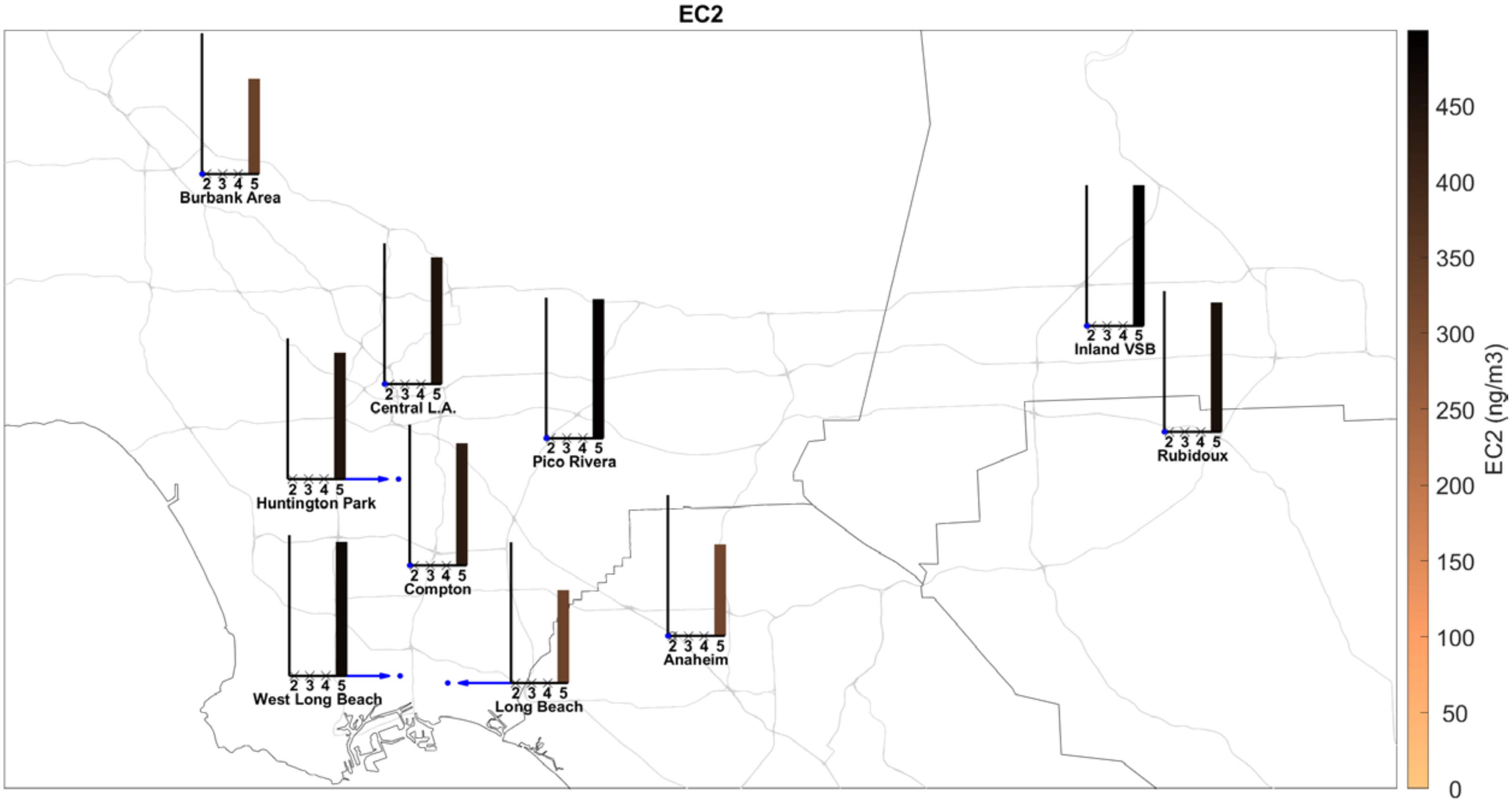


Figure IV-203. Geographic distribution of EC2 from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

EC3

Table IV-104. Ambient Concentrations (ng/m^3) of EC3 from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	0.893, 40.2[a]	5.08, 41.7[a]	6.89, 42.3[a]	7.67, 43[a]	4, 41.3[a]	4.59, 41.3[a]	10.3, 44.4[a]	11.7, 44.2[a]	10.5, 44.4[a]	7.09, 42.7[a]
95% CI LB	0[a]	1.19[a]	2.46[a]	2.33[a]	0.667[a]	0.82[a]	4.18[a]	5.59[a]	4.07[a]	2[a]
95% CI UB	40.5[a]	43.6[a]	44.6[a]	47.3[a]	43.2[a]	42.8[a]	48[a]	47.3[a]	49.5[a]	45.6[a]
N	56[a]	59[a]	61[a]	60[a]	60[a]	61[a]	61[a]	59[a]	59[a]	55[a]
% < MDL	98.2[a]	91.5[a]	88.5[a]	88.3[a]	93.3[a]	91.8[a]	85.2[a]	81.4[a]	84.7[a]	89.1[a]
Max	50[a]	80[a]	90[a]	150[a]	70[a]	70[a]	95[a]	110[a]	140[a]	90[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

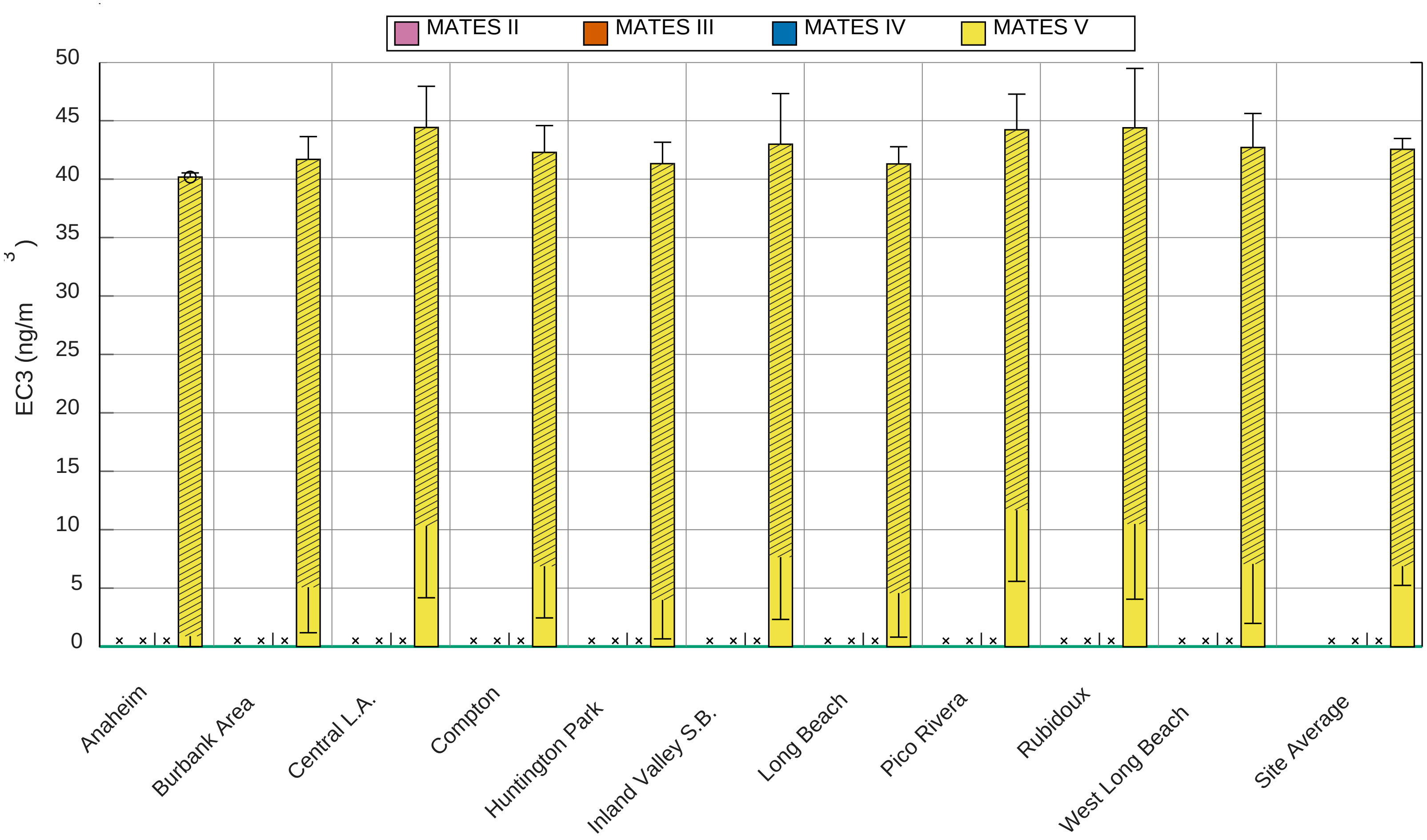


Figure IV-204. Annual Average Concentrations of EC3 in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

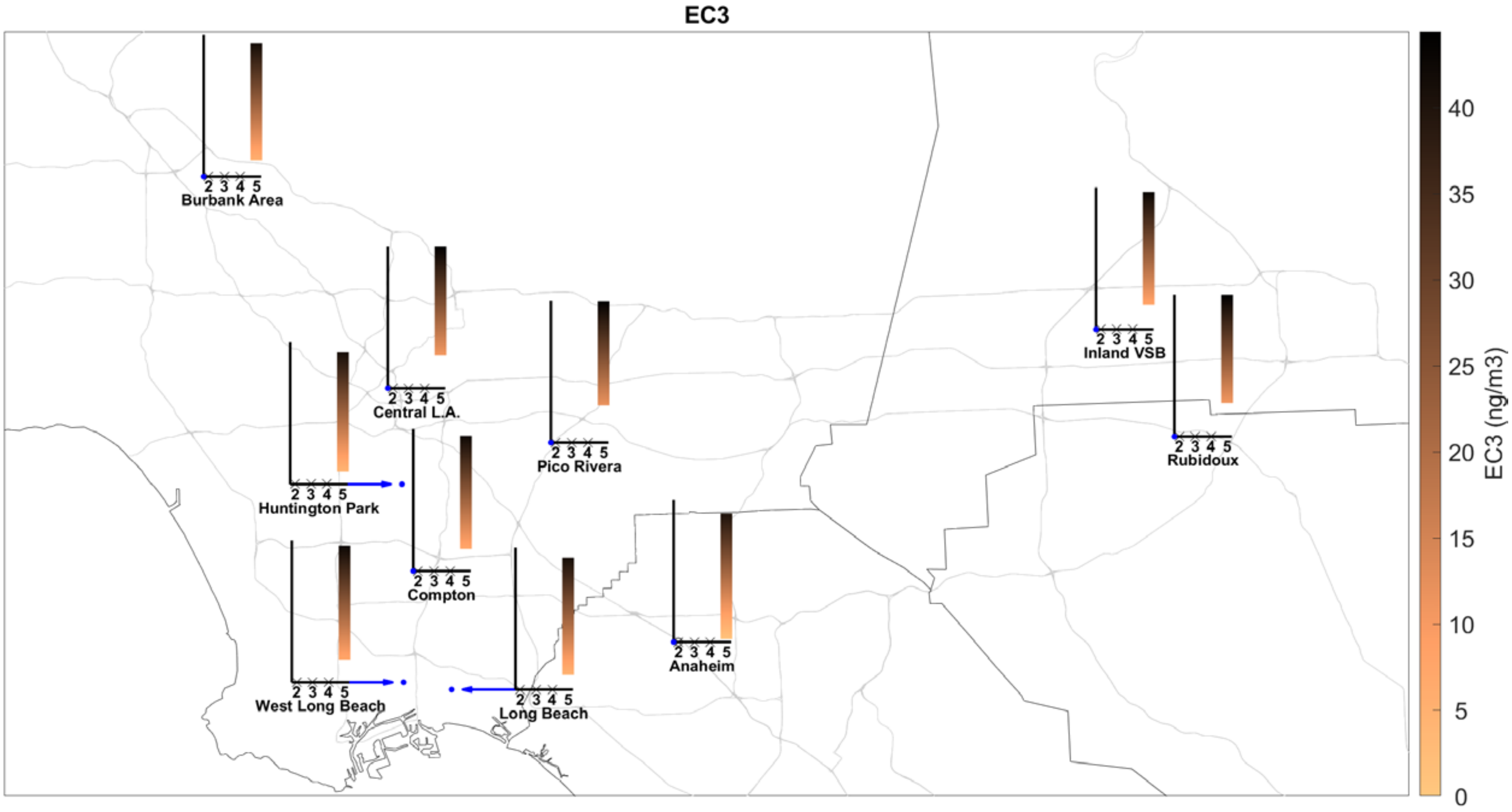


Figure IV-205. Geographic distribution of EC3 from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Elemental Carbon

Table IV-105. Ambient Concentrations (ng/m^3) of Elemental Carbon from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	1360	1960	1700	2040	2200	1470	1850	1970	1650	2080
95% CI LB	1220	1820	1530	1890	1910	1340	1720	1770	1510	1870
95% CI UB	1490	2110	1890	2210	2510	1610	1990	2180	1800	2320
N	242	241	235	236	118	228	240	116	235	228
% < MDL	0.4	0	0.4	0.8	0.8	0.4	0	0	0.4	0.4
Max	6440	6280	7180	7100	9080	5990	5300	5180	5700	8780
MATES IV										
Average	901	1290	1060	1360	1280	898	1230	1400	1110	1130
95% CI LB	688	1040	783	1150	1030	668	1030	1160	946	845
95% CI UB	1140	1580	1360	1590	1560	1150	1470	1670	1290	1460
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	1.7	0	1.7	0	1.6	0	0	0	0
Max	3900	4600	4700	5000	5400	3500	3800	4700	3400	4900
MATES V										
Average	458	467	734	746	679	481	686	732	669	708
95% CI LB	333	371	520	614	521	342	534	568	497	519
95% CI UB	605	570	977	881	850	636	861	916	870	926
N	56	59	61	60	60	61	61	59	59	55
% < MDL	3.6	6.8	6.6	5	0	8.2	1.6	1.7	3.4	1.8
Max	2600	1900	4700	2300	2600	2400	2850	3200	4200	2900

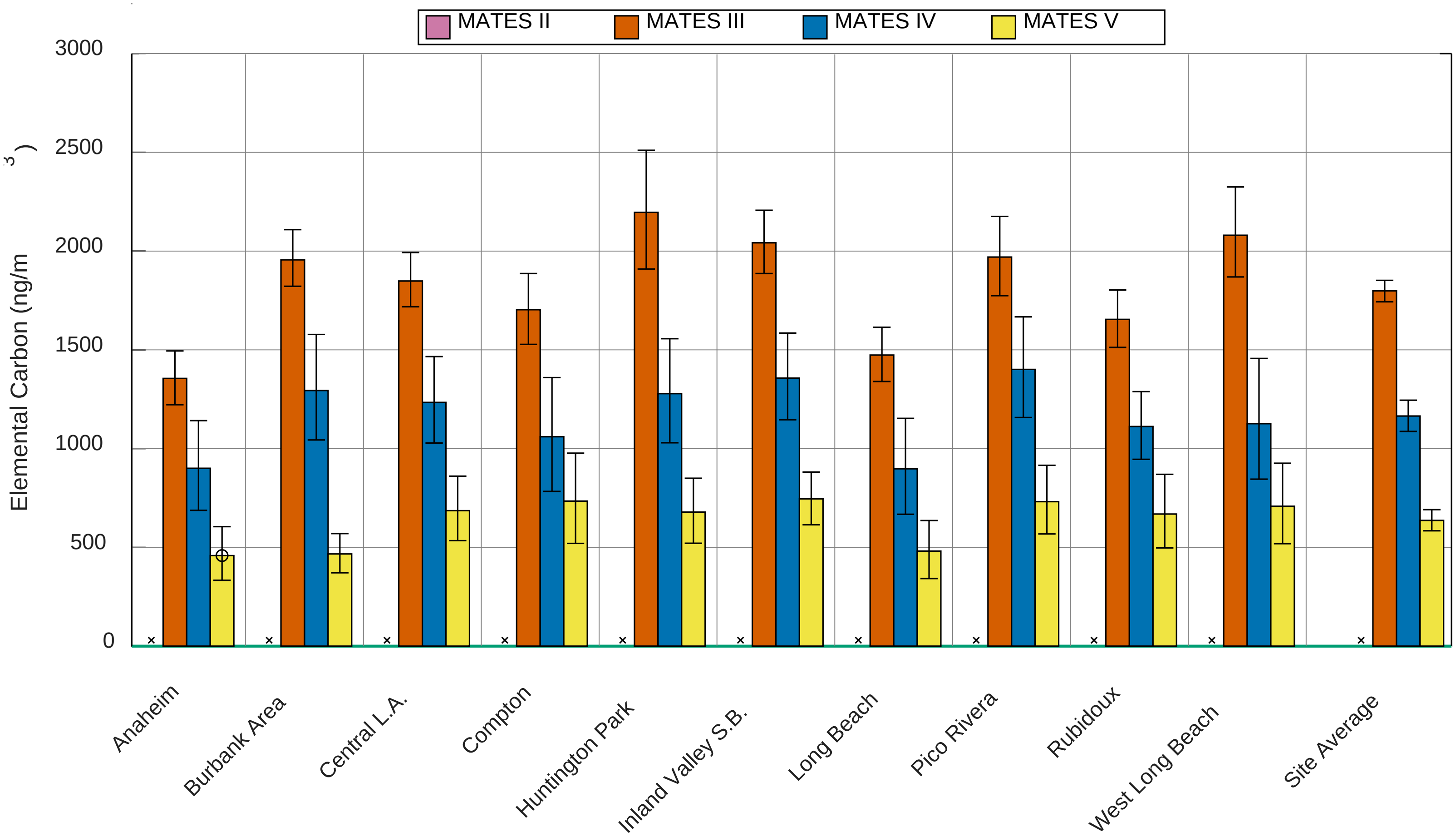


Figure IV-206. Annual Average Concentrations of Elemental Carbon in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

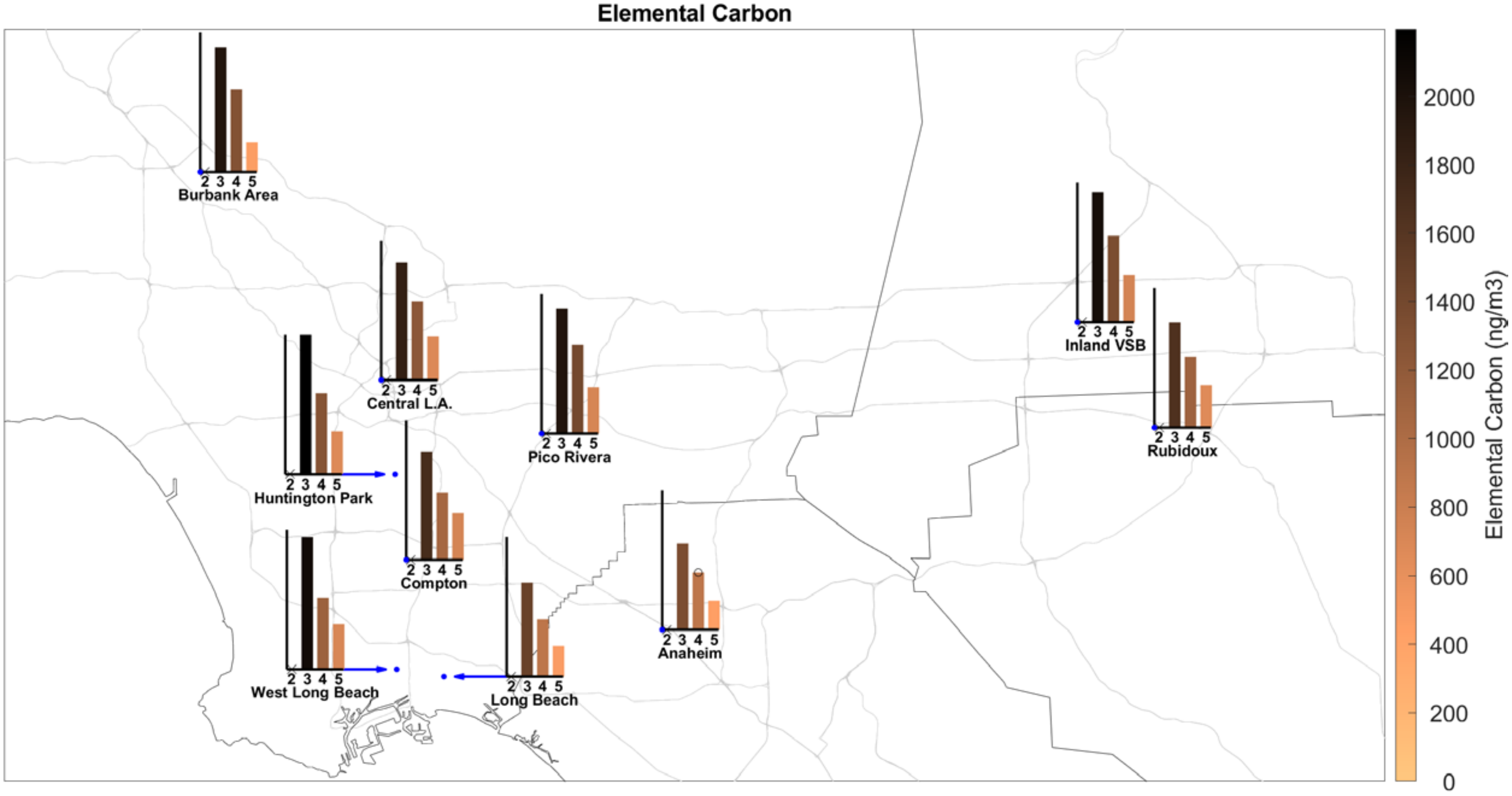


Figure IV-207. Geographic distribution of Elemental Carbon from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

OC1

Table IV-106. Ambient Concentrations (ng/m^3) of OC1 from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	45.5, 509[a]	74.9, 523[a]	92, 523[a]	536	64.2, 514[a]	8.69, 497[a]	93.7, 523[a]	103, 531[a]	103, 526[a]	24.7, 504[a]
95% CI LB	10.4[a]	21.9[a]	35.4[a]	515	19.3[a]	0[a]	36.3[a]	38.2[a]	43.1[a]	0[a]
95% CI UB	522[a]	549[a]	554[a]	563	529[a]	499[a]	549[a]	562[a]	548[a]	517[a]
N	56[a]	59[a]	61[a]	60	60[a]	61[a]	61[a]	59[a]	59[a]	55[a]
% < MDL	92.9[a]	89.8[a]	86.9[a]	75	90[a]	98.4[a]	86.9[a]	86.4[a]	84.7[a]	96.4[a]
Max	760[a]	1000[a]	1200[a]	1000	830[a]	530[a]	1000[a]	1100[a]	850[a]	800[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

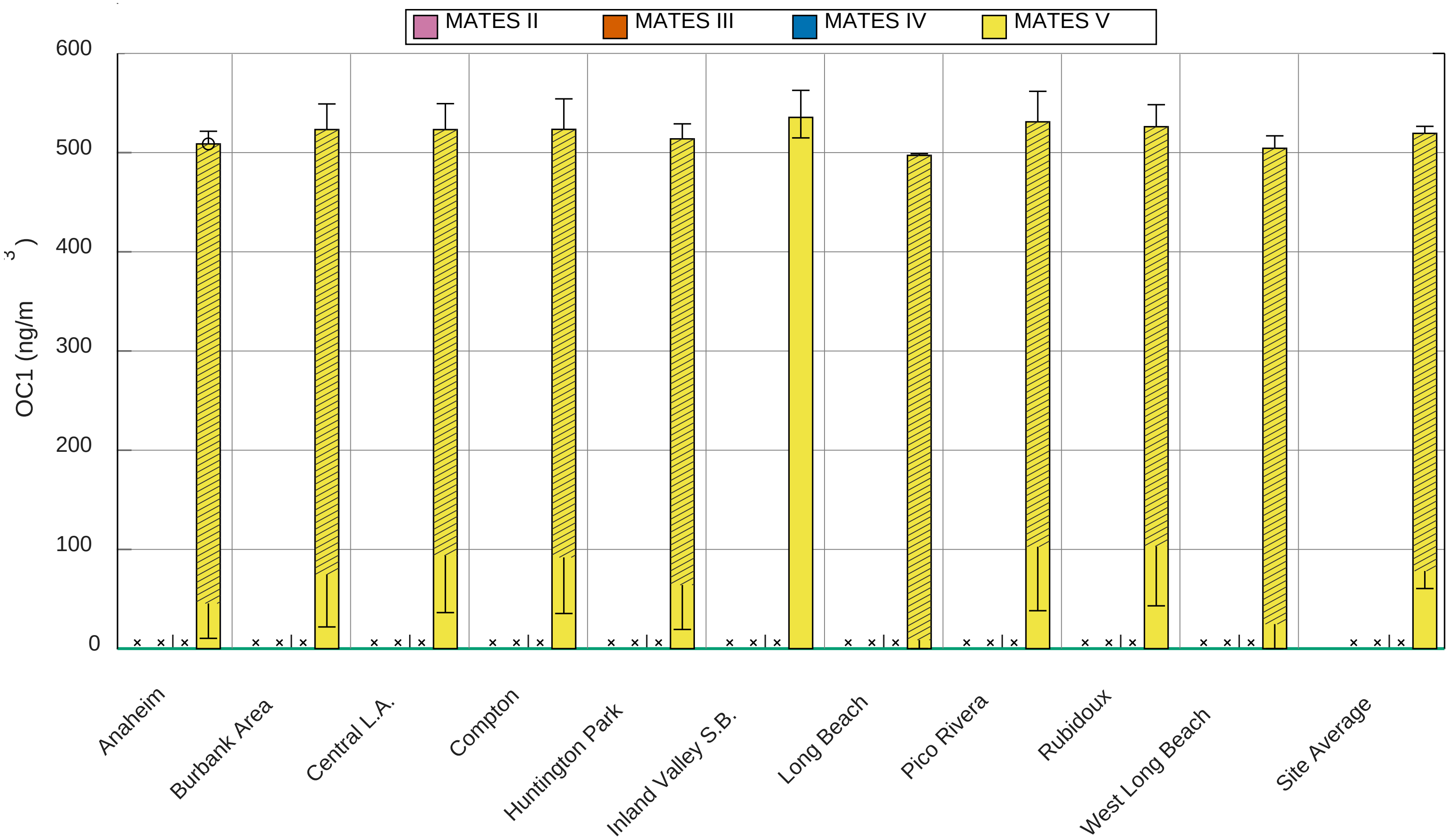


Figure IV-208. Annual Average Concentrations of OC1 in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

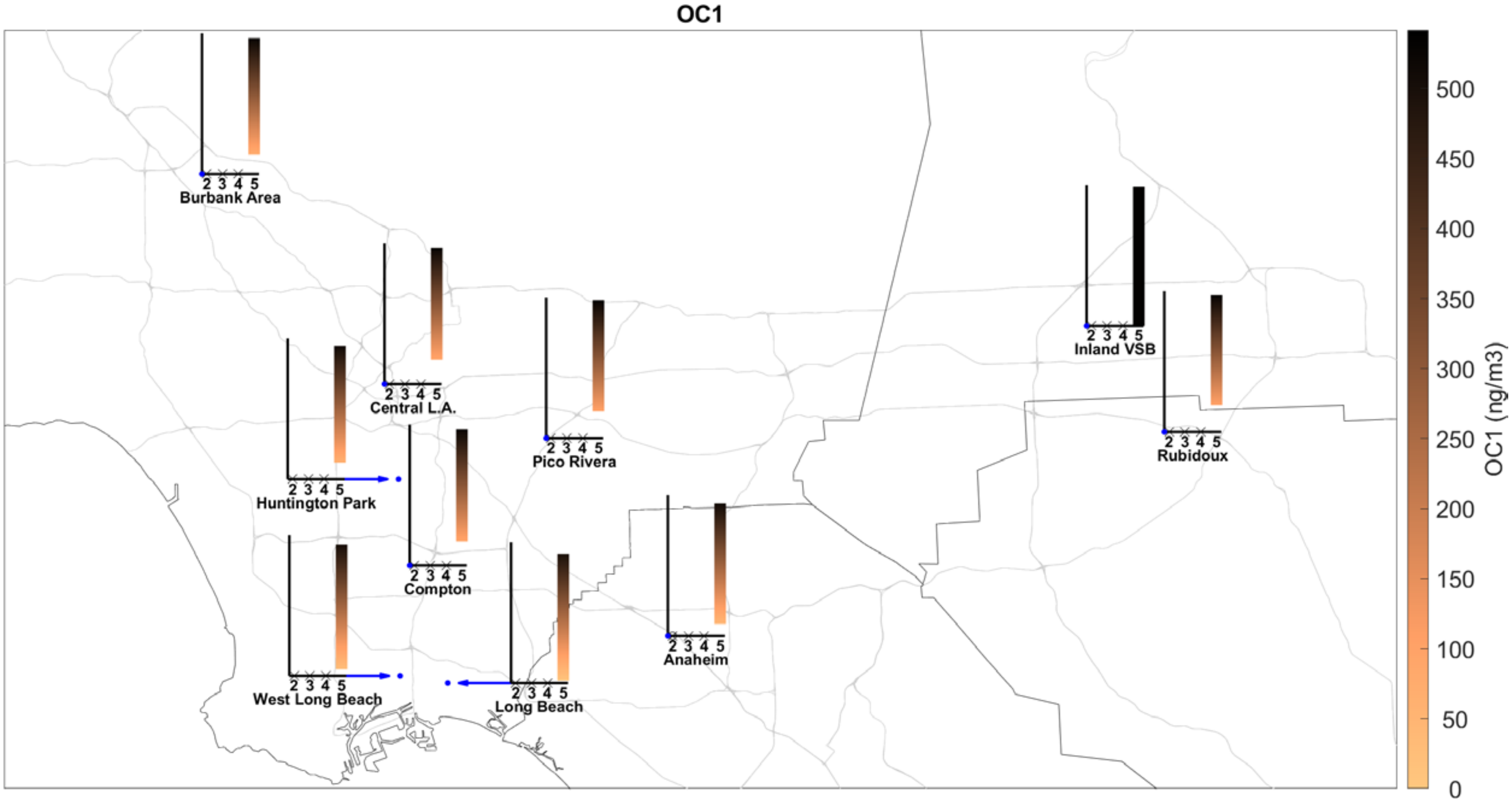


Figure IV-209. Geographic distribution of OC1 from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

OC2

Table IV-107. Ambient Concentrations (ng/m^3) of OC2 from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	915	1100	1100	1340	1150	864	1190	1210	1180	971
95% CI LB	818	984	965	1210	1040	769	1080	1100	1060	852
95% CI UB	1020	1230	1230	1470	1270	970	1320	1330	1300	1100
N	56	59	61	60	60	61	61	59	59	55
% < MDL	5.4	10.2	3.3	8.3	3.3	16.4	1.6	0	5.1	9.1
Max	2100	2300	2600	2500	2300	2400	3000	2700	2300	2500

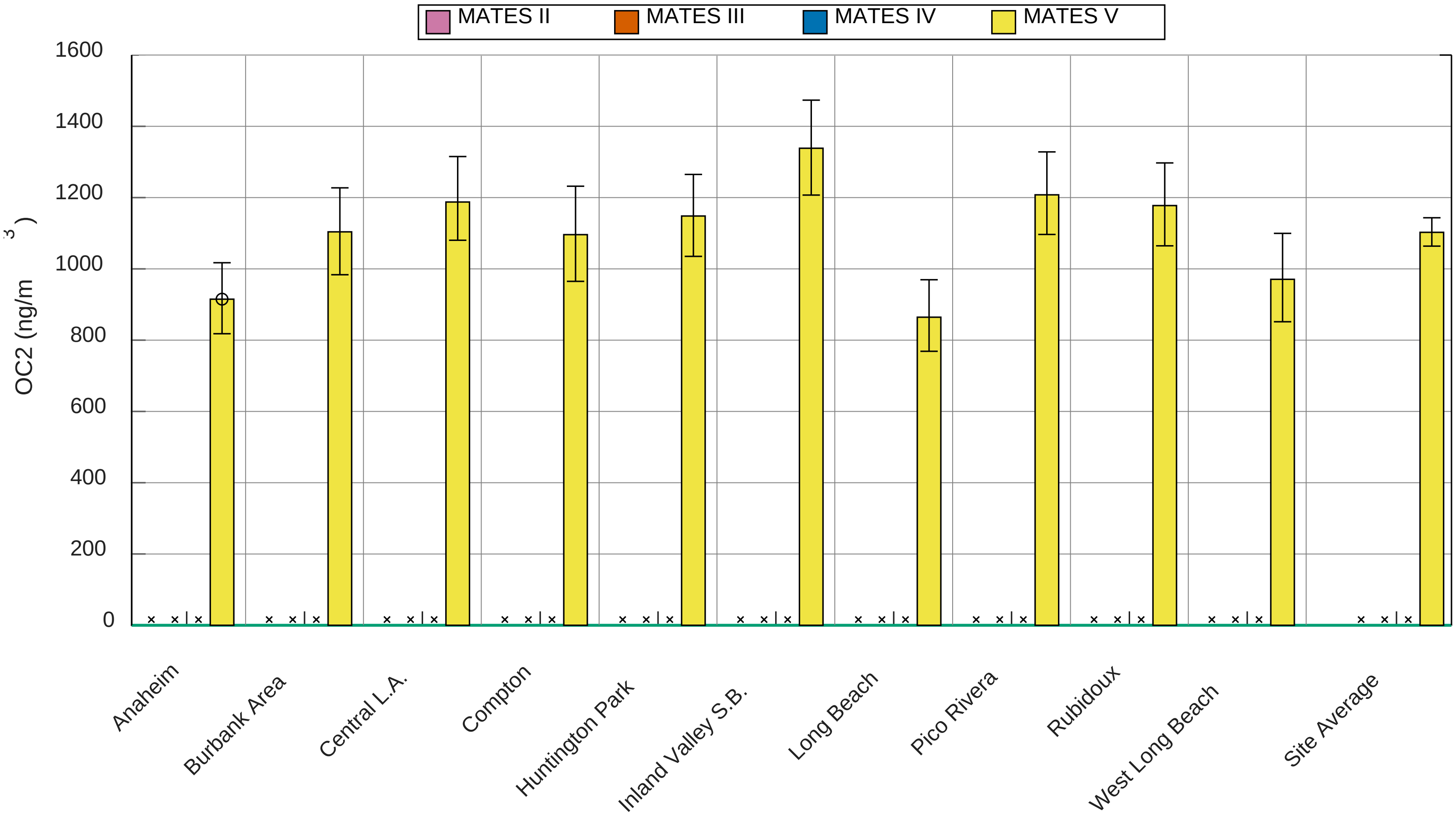


Figure IV-210. Annual Average Concentrations of OC2 in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

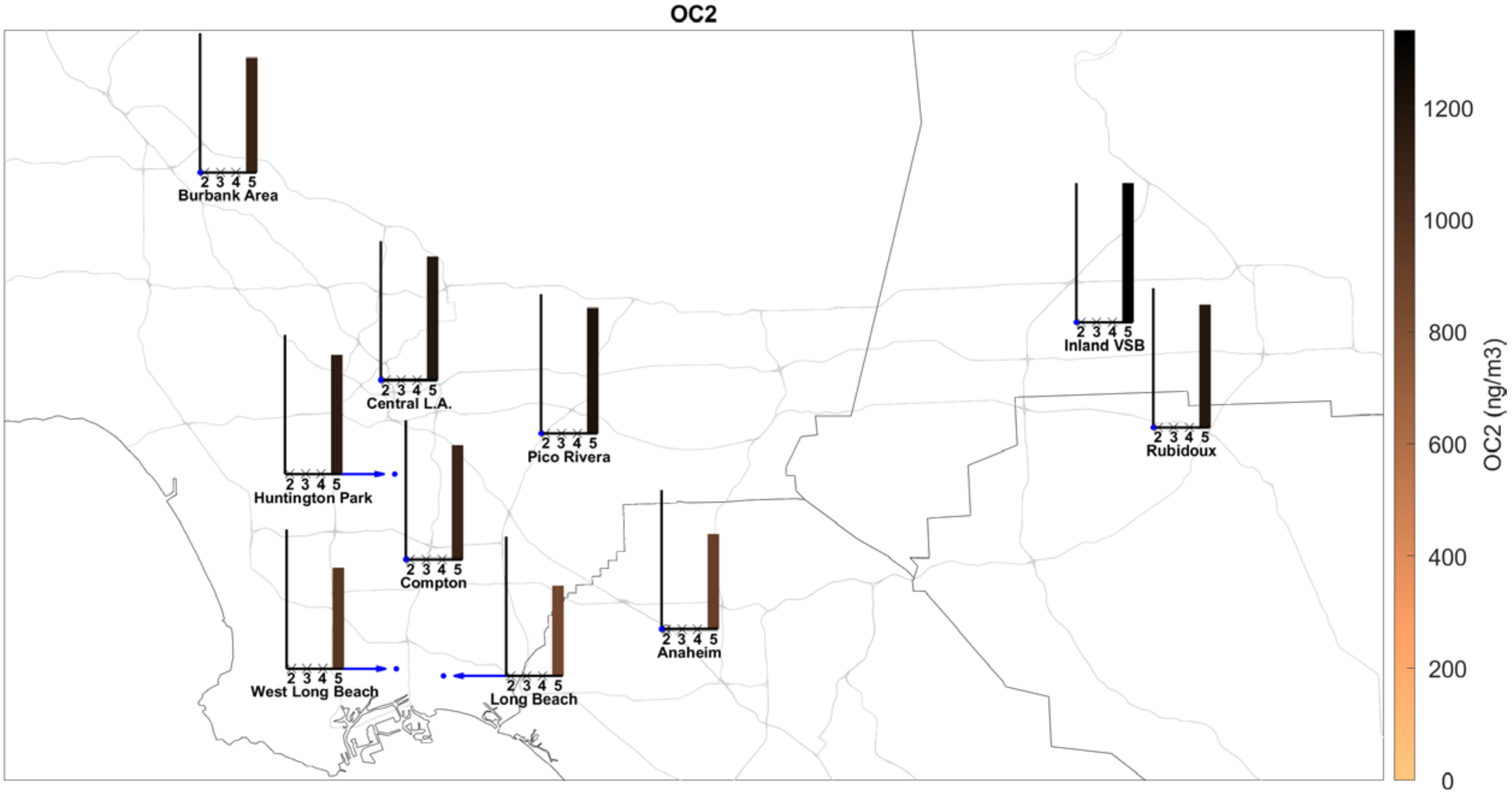


Figure IV-211. Geographic distribution of OC2 from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

OC3

Table IV-108. Ambient Concentrations (ng/m^3) of OC3 from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	1550	1790	1840	2030	1830	1450	1880	1890	1870	1630
95% CI LB	1380	1580	1590	1820	1630	1260	1680	1690	1660	1400
95% CI UB	1720	2000	2130	2260	2060	1670	2120	2100	2100	1890
N	56	59	61	60	60	61	61	59	59	55
% < MDL	0	0	0	0	0	0	0	0	1.7	0
Max	3600	4900	5300	4900	5200	4900	5150	4700	4200	5500

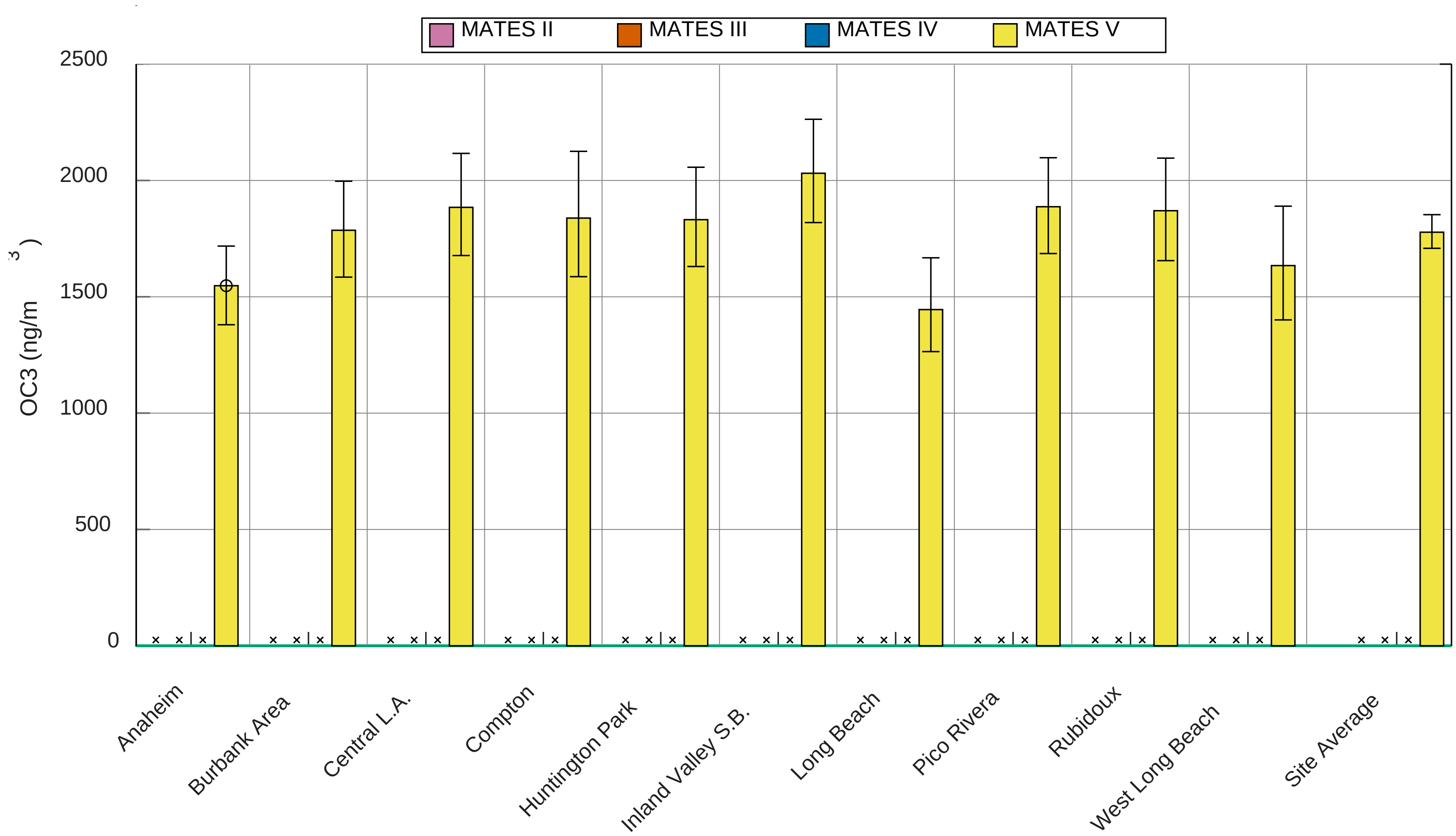


Figure IV-212. Annual Average Concentrations of OC3 in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

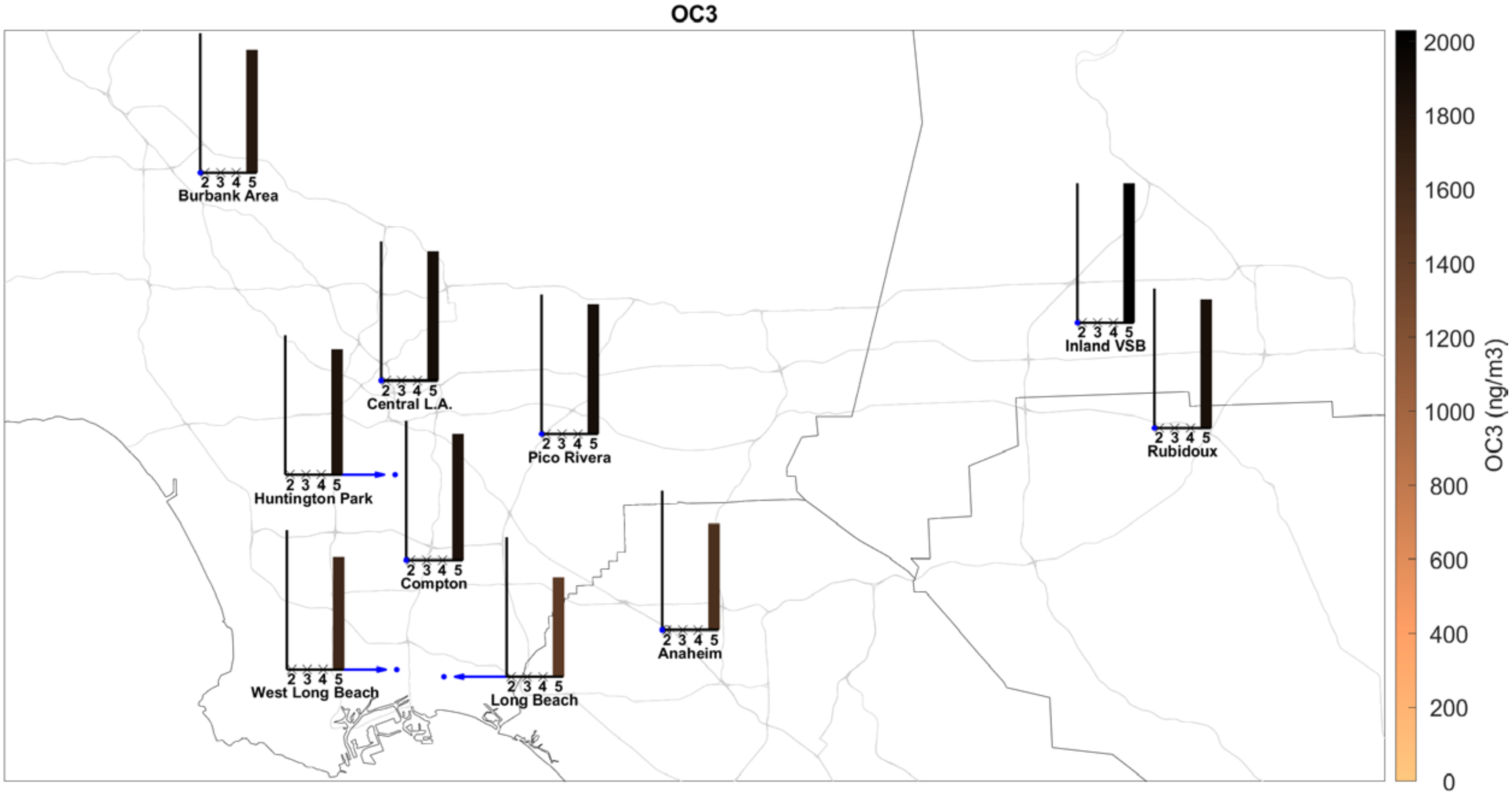


Figure IV-213. Geographic distribution of OC3 from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

OC4

Table IV-109. Ambient Concentrations (ng/m^3) of OC4 from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	598	678	702	743	675	604	690	691	682	642
95% CI LB	542	609	600	666	605	540	611	611	611	556
95% CI UB	669	759	813	828	761	690	782	776	765	737
N	56	59	61	60	60	61	61	59	59	55
% < MDL	69.6	50.8	63.9	36.7	56.7	75.4	52.5	50.8	42.4	69.1
Max	1900	2000	2600	2000	1800	1900	2000	1900	1800	2000

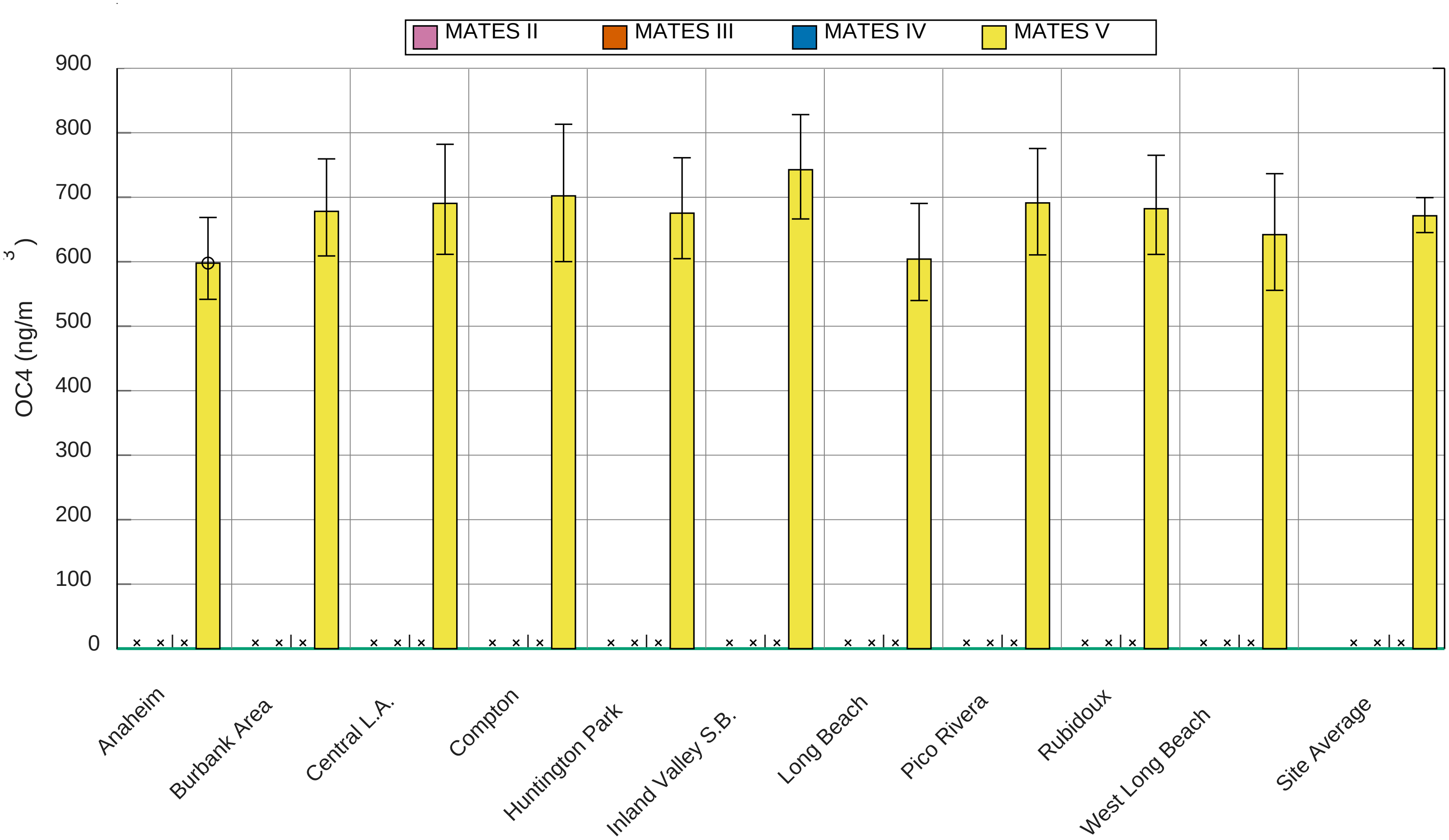


Figure IV-214. Annual Average Concentrations of OC4 in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

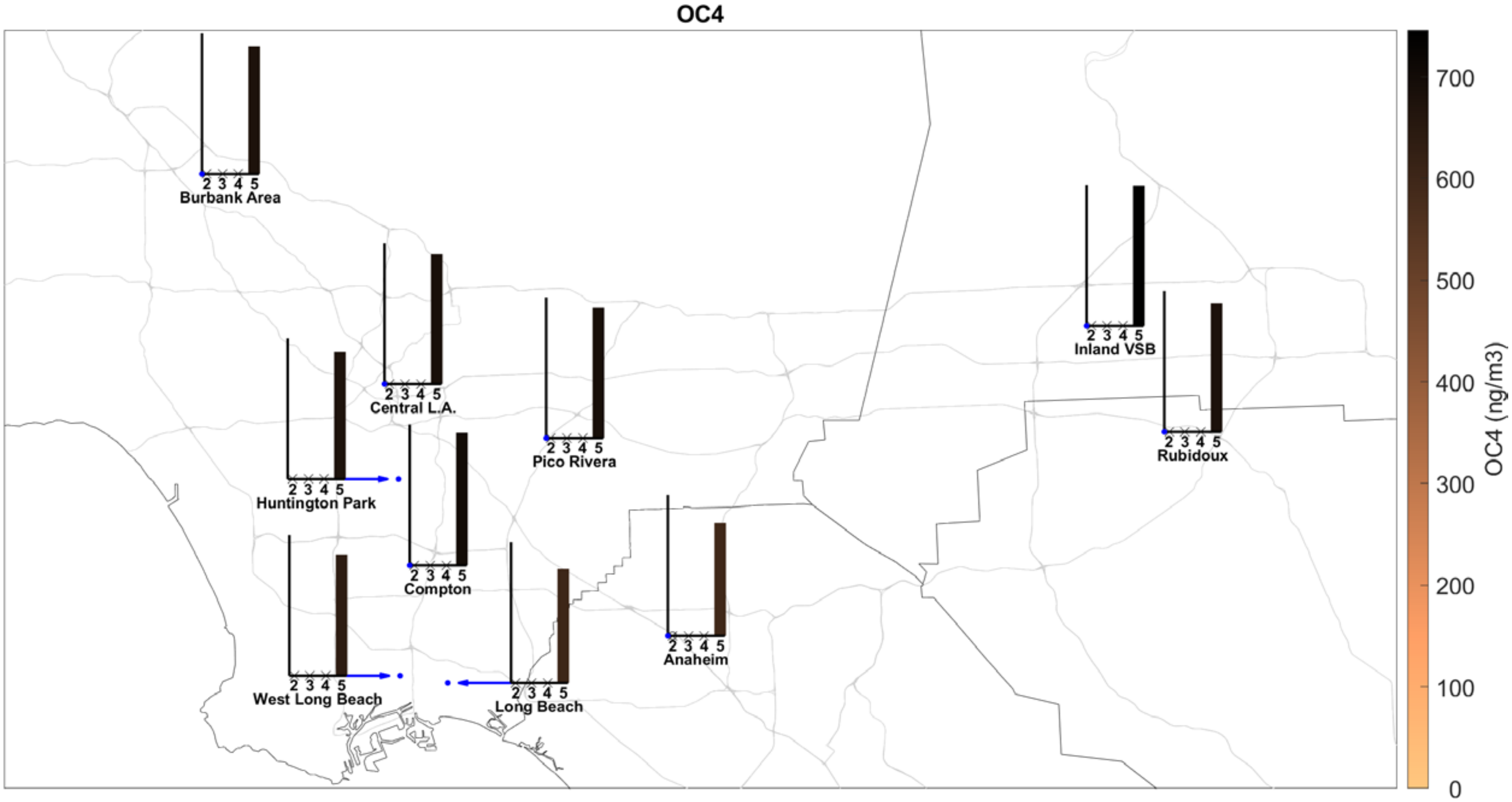


Figure IV-215. Geographic distribution of OC4 from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Organic Carbon

Table IV-110. Ambient Concentrations (ng/m^3) of Organic Carbon from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	6190	8140	7010	7990	8330	6500	7480	7060	6920	6600
95% CI LB	5830	7740	6590	7580	7590	6070	7130	6640	6490	6140
95% CI UB	6560	8540	7460	8380	9120	6960	7860	7540	7350	7140
N	242	241	235	236	118	228	240	116	235	228
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	17700	22300	23700	18000	25500	19800	22300	13800	22400	20000
MATES IV										
Average	3740	4740	4000	4840	4680	3590	4470	4680	4620	3670
95% CI LB	3360	4310	3530	4390	4240	3140	4100	4260	4250	3210
95% CI UB	4110	5180	4510	5310	5160	4060	4850	5090	4970	4180
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	1.7	0	0	0	0	0	0	0	0
Max	8000	9500	10000	11000	10000	11000	8100	10000	9800	9900
MATES V										
Average	3230	4000	4000	4720	4050	3020	4230	4240	4240	3430
95% CI LB	2810	3450	3390	4170	3540	2570	3700	3740	3710	2880
95% CI UB	3680	4560	4660	5290	4590	3550	4840	4810	4780	4050
N	56	59	61	60	60	61	61	59	59	55
% < MDL	0	0	0	0	0	0	0	0	1.7	0
Max	8800	11000	12000	11000	11000	11000	13500	12000	9900	11000

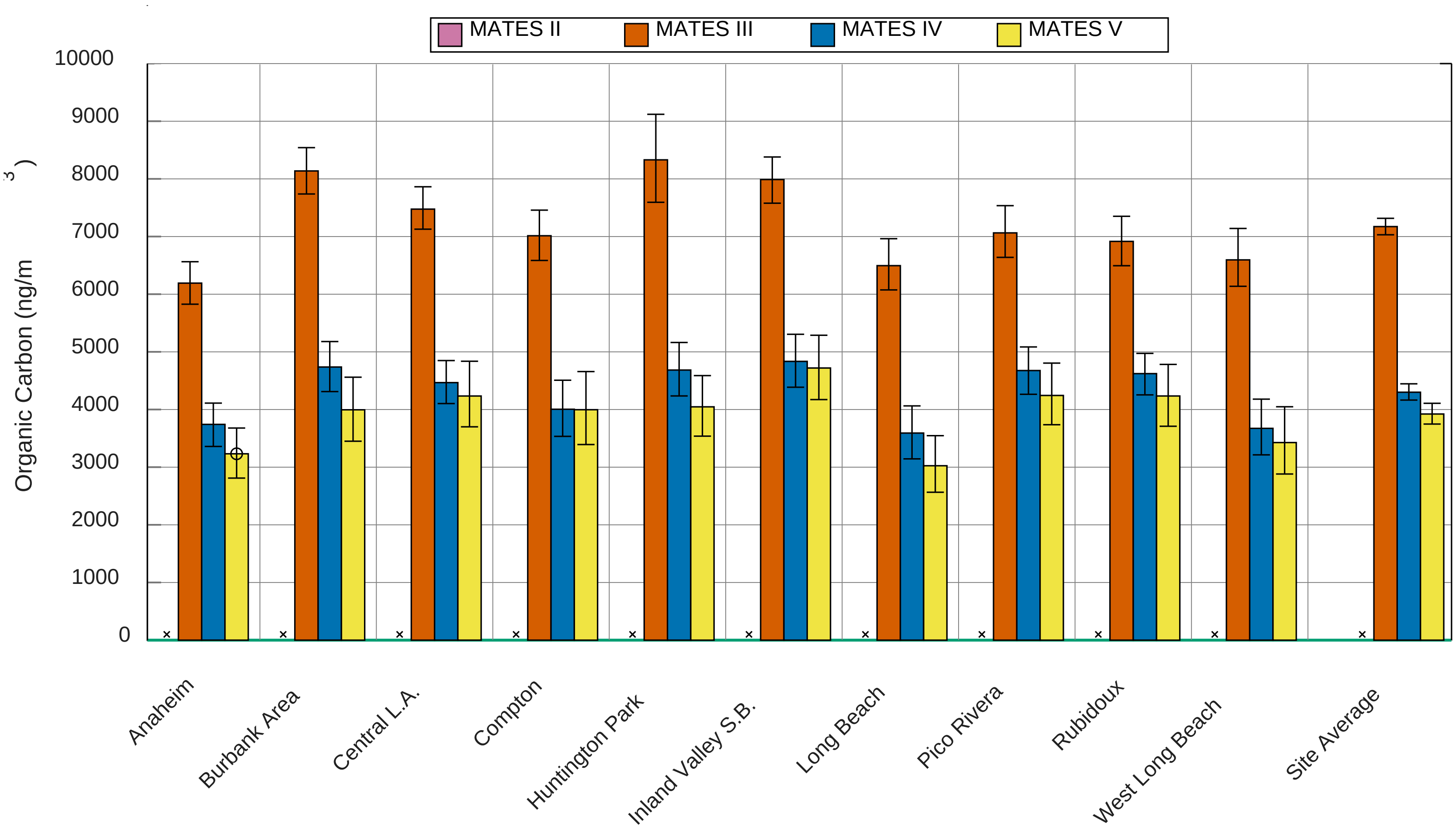


Figure IV-216. Annual Average Concentrations of Organic Carbon in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

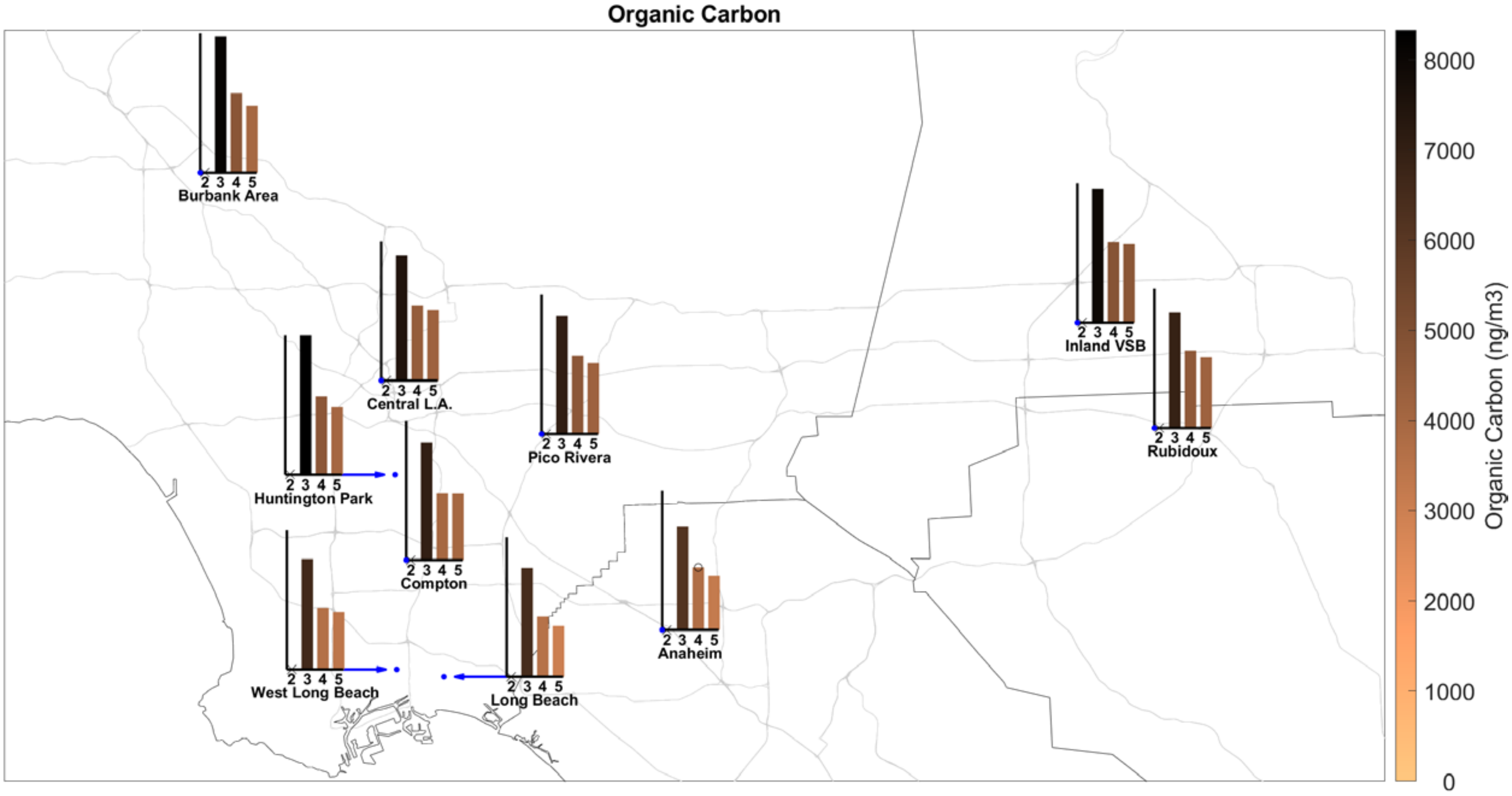


Figure IV-217. Geographic distribution of Organic Carbon from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Total Carbon

Table IV-111. Ambient Concentrations (ng/m^3) of Total Carbon from the PM2.5 Carbon analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	7550	10100	8720	10000	10500	7970	9320	9030	8570	8680
95% CI LB	7080	9570	8160	9500	9490	7430	8870	8430	8060	8040
95% CI UB	8030	10600	9310	10500	11500	8510	9790	9660	9100	9380
N	242	241	235	236	118	228	240	116	235	228
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	22600	28600	30800	21400	34000	24800	24500	18200	24600	26900
MATES IV										
Average	4640	6020	5060	6200	5970	4470	5700	6060	5750	4820
95% CI LB	4070	5330	4340	5580	5300	3810	5150	5470	5270	4070
95% CI UB	5240	6720	5860	6870	6710	5170	6270	6690	6230	5670
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	1.7	0	0	0	0	0	0	0	0
Max	12000	14000	15000	17000	15000	14000	12000	14000	12000	15000
MATES V										
Average	3680	4460	4720	5460	4730	3510	4920	4990	4890	4130
95% CI LB	3150	3840	3930	4790	4090	2930	4250	4330	4230	3420
95% CI UB	4230	5100	5630	6150	5400	4210	5690	5720	5610	4930
N	56	59	61	60	60	61	61	59	59	55
% < MDL	0	0	0	0	0	0	0	0	1.7	0
Max	11000	13000	17000	13000	12000	12000	16500	15000	14000	14000

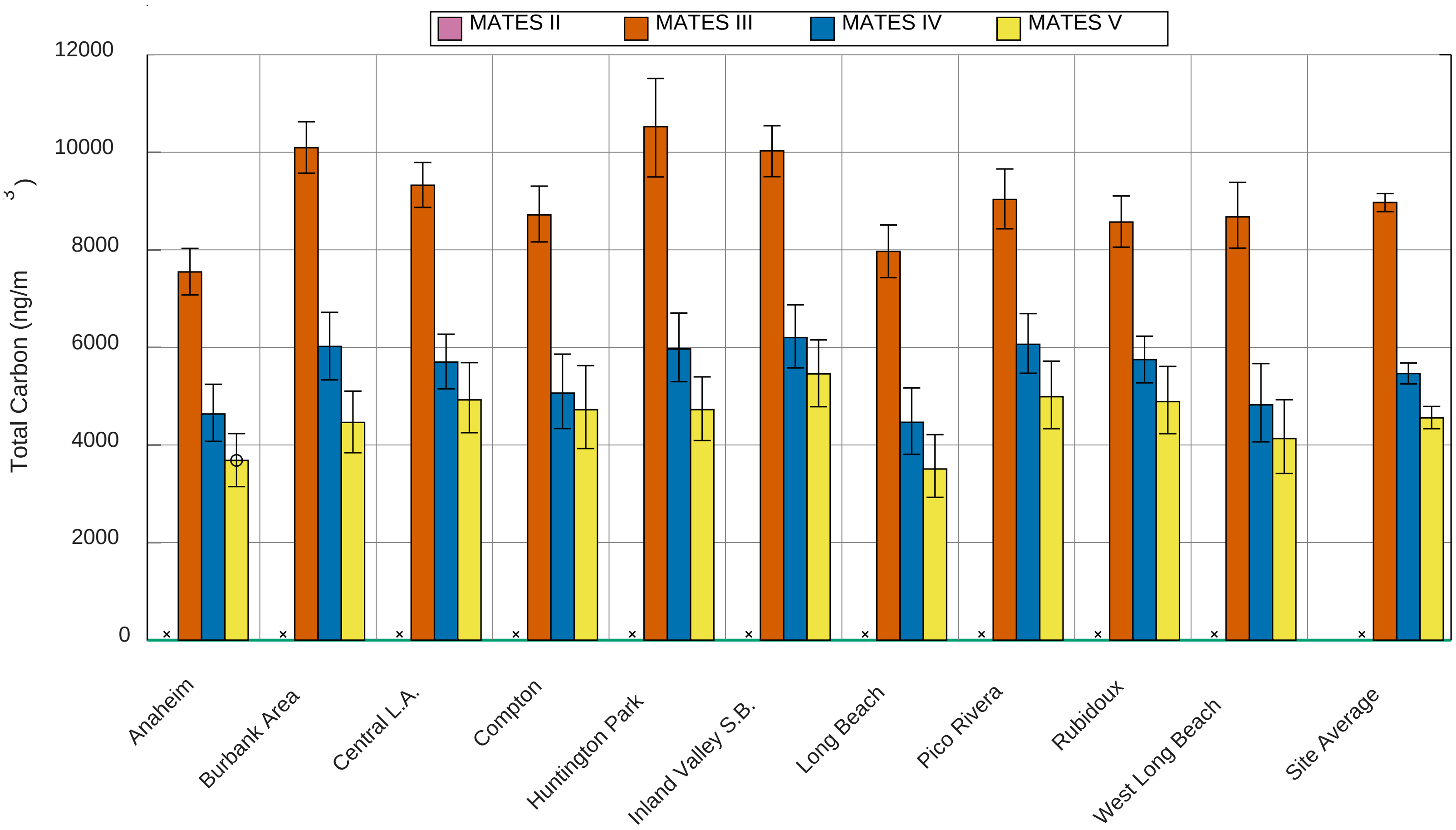


Figure IV-218. Annual Average Concentrations of Total Carbon in the PM2.5 Carbon Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

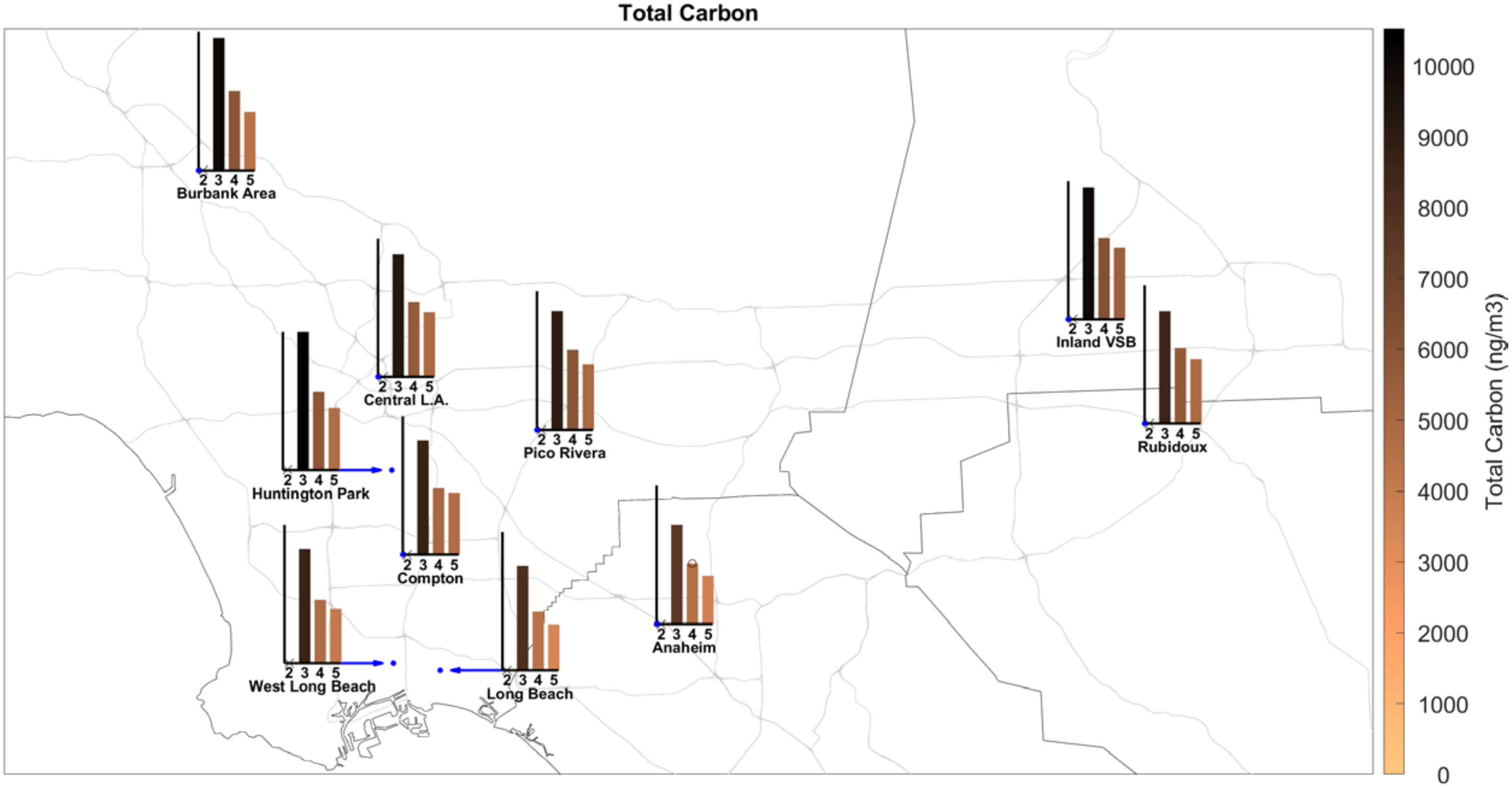


Figure IV-219. Geographic distribution of Total Carbon from the PM2.5 Carbon Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

PM2.5 Ions Analysis

Ammonium Ion

Table IV-112. Ambient Concentrations (ng/m^3) of Ammonium Ion from the PM2.5 Ions analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	1690	2100	1810	2300	1790	1780	2160	1730	2690	1690
95% CI LB	1450	1820	1580	2010	1440	1550	1880	1410	2370	1480
95% CI UB	1940	2390	2080	2620	2160	2050	2450	2060	3040	1910
N	242	241	234	236	118	228	239	116	234	226
% < MDL	9.5	7.9	8.5	7.6	12.7	10.5	9.2	9.5	11.1	8
Max	11300	11400	10300	21900	10300	11000	12200	9080	20600	9280
MATES IV										
Average	888	1300	1190	1210	1300	930	1310	1360	1400	888
95% CI LB	728	1060	978	967	1040	754	1050	1110	1160	722
95% CI UB	1060	1540	1400	1450	1580	1130	1560	1660	1660	1080
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	3.4	1.6	0	0	0	3.3	0	1.6	1.6
Max	3020	5330	4510	5180	4660	3430	4340	4930	4330	3360
MATES V										
Average	857			1050		727	1040		1080	
95% CI LB	690			879		589	809		918	
95% CI UB	1040			1230		863	1310		1270	
N	56	0	0	60	0	61	61	0	60	0
% < MDL	0			0		0	0		0	
Max	3190			3540		2500	6330		3780	

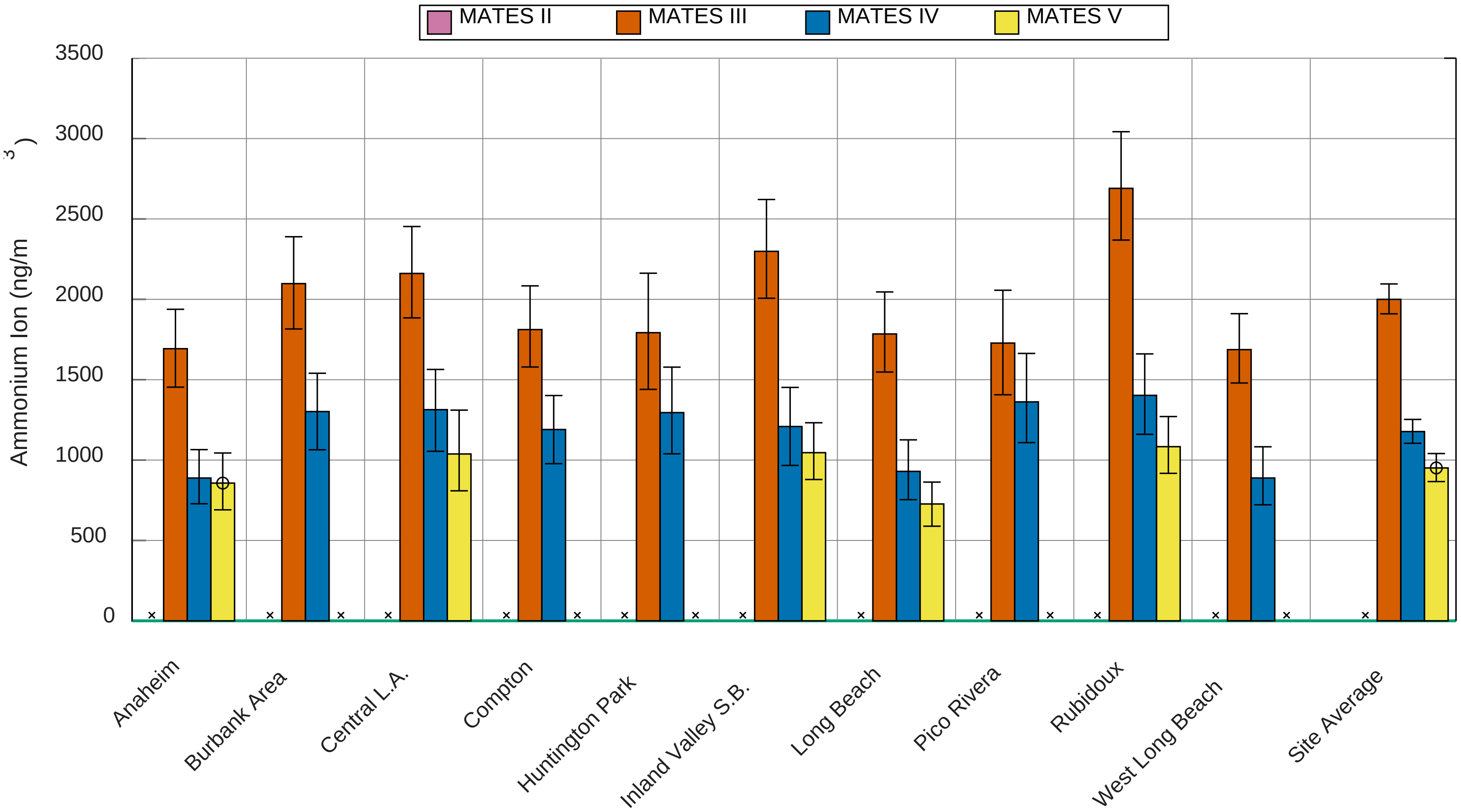


Figure IV-220. Annual Average Concentrations of Ammonium Ion in the PM2.5 Ions Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

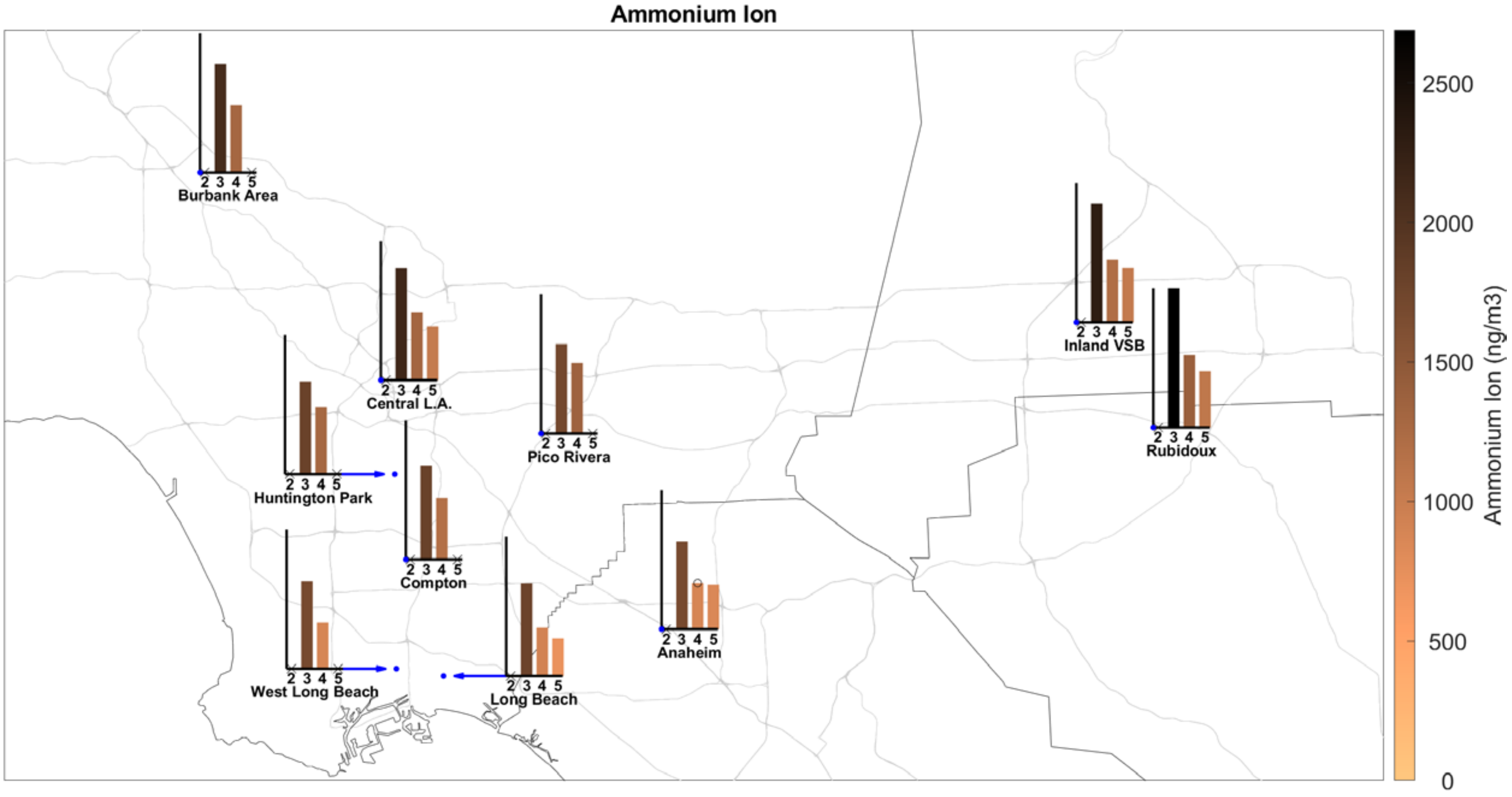


Figure IV-221. Geographic distribution of Ammonium Ion from the PM2.5 Ions Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Chloride

Table IV-113. Ambient Concentrations (ng/m^3) of Chloride from the PM2.5 Ions analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	466	383	532	358	551	540	427	545	403	487
95% CI LB	428	354	490	326	497	497	398	480	369	448
95% CI UB	505	411	578	395	607	589	456	610	439	532
N	236	238	230	232	115	226	236	115	229	224
% < MDL	9.3	11.3	5.2	23.3	5.2	4.9	7.2	4.3	19.7	5.4
Max	2090	1230	2400	2340	1700	2870	1330	1850	1570	2590
MATES IV										
Average	187	185	241	169	234	212	189	323	166	236
95% CI LB	169	163	197	157	202	184	170	212	154	187
95% CI UB	211	214	299	182	273	244	213	473	182	306
N	59	59	61	60	59	61	60	59	61	61
% < MDL	62.7	66.1	47.5	80	39	52.5	51.7	49.2	78.7	52.5
Max	650	840	1370	400	890	680	640	3260	490	1820
MATES V										
Average	194			163		226	187		166	
95% CI LB	173			157		200	172		160	
95% CI UB	218			173		256	205		173	
N	56	0	0	60	0	61	61	0	60	0
% < MDL	57.1			76.7		36.1	50.8		65	
Max	540			310		840	420		270	

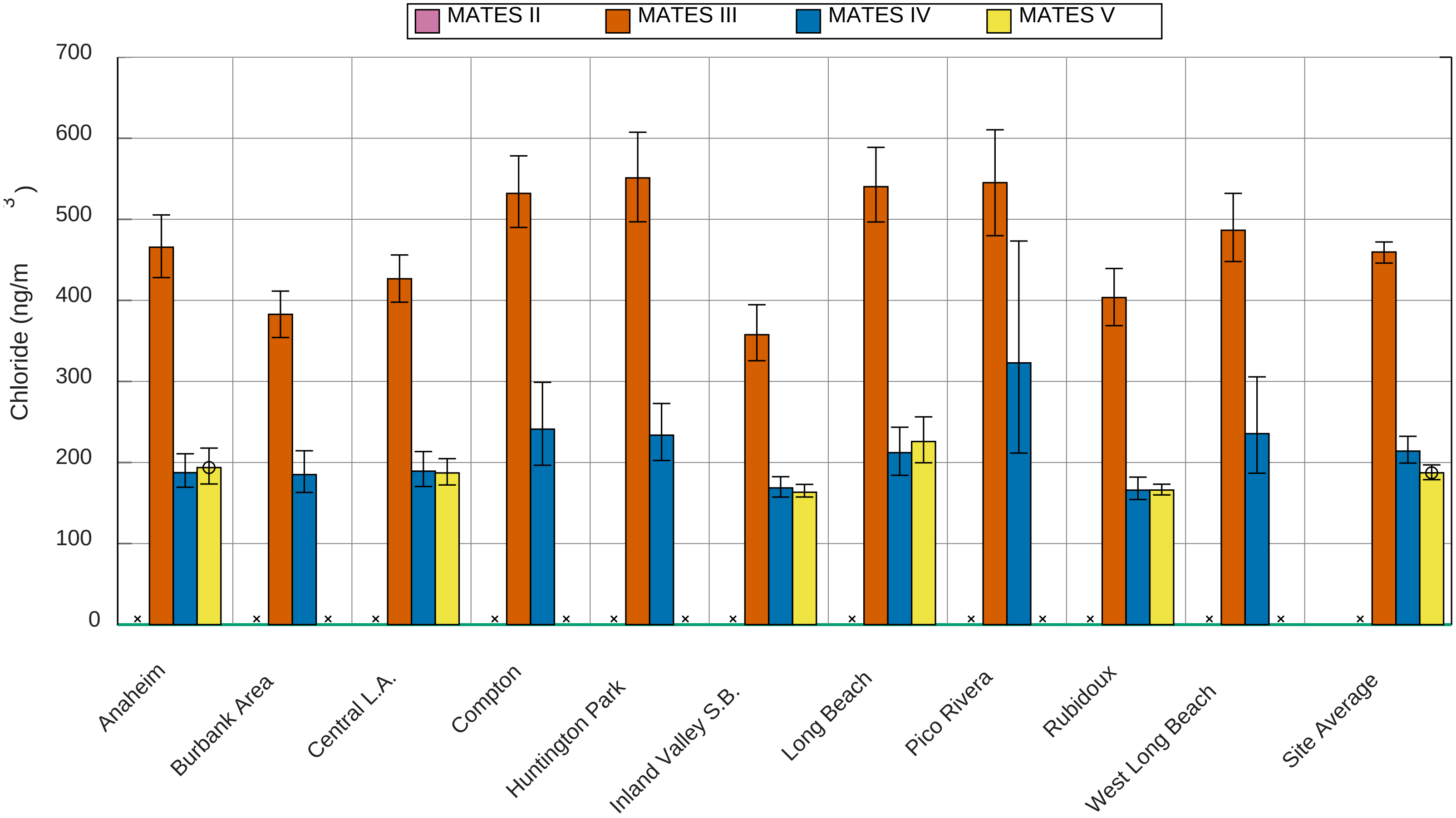


Figure IV-222. Annual Average Concentrations of Chloride in the PM2.5 Ions Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

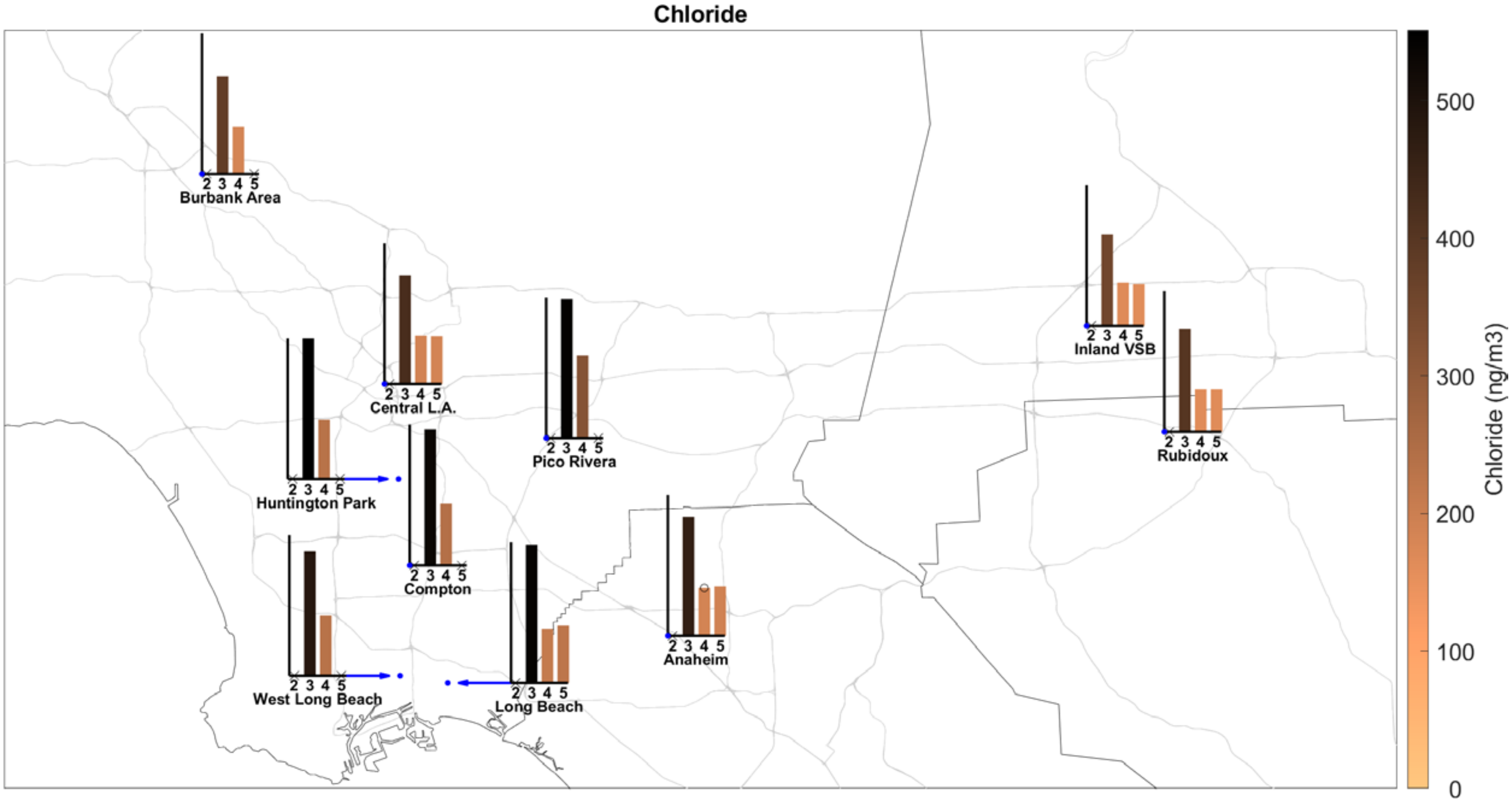


Figure IV-223. Geographic distribution of Chloride from the PM2.5 Ions Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Nitrate

Table IV-114. Ambient Concentrations (ng/m^3) of Nitrate from the PM2.5 Ions analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	4360	5520	4400	6650	5420	3990	5620	5450	7950	3480
95% CI LB	3870	4960	3920	5910	4620	3580	5000	4670	7080	3110
95% CI UB	4900	6230	4930	7450	6260	4450	6300	6310	8880	3890
N	236	238	230	232	115	226	236	115	229	224
% < MDL	0.4	1.7	0.4	0	0.9	0.9	0	0.9	0.4	0.4
Max	29000	28900	25500	52800	24100	26200	30400	25900	55600	21400
MATES IV										
Average	1640	2510	1950	2510	2430	1650	2460	2240	2730	1500
95% CI LB	1320	2030	1570	1940	1940	1350	1970	1830	2200	1210
95% CI UB	2010	3010	2380	3160	2990	1990	2980	2680	3280	1830
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	1.7	1.6	0	0	1.6	3.3	0	1.6	1.6
Max	6630	11000	9300	11500	10200	6360	8550	7350	9950	5970
MATES V										
Average	1860			2590		1640	2430		2580	
95% CI LB	1420			2010		1240	1760		2030	
95% CI UB	2400			3240		2120	3230		3190	
N	56	0	0	60	0	61	61	0	60	0
% < MDL	0			0		0	0		0	
Max	9480			12900		11300	17000		10700	

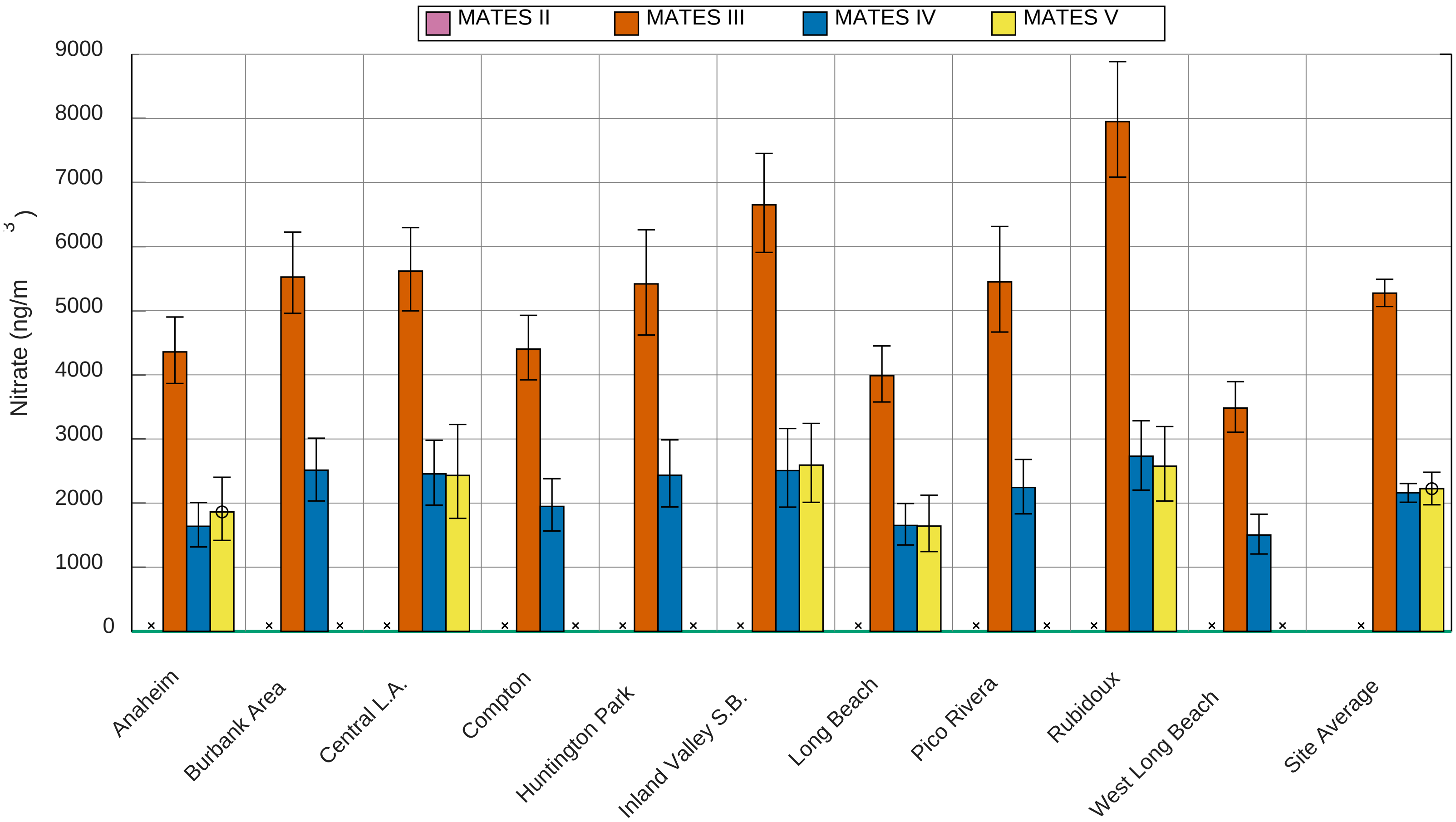


Figure IV-224. Annual Average Concentrations of Nitrate in the PM2.5 Ions Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

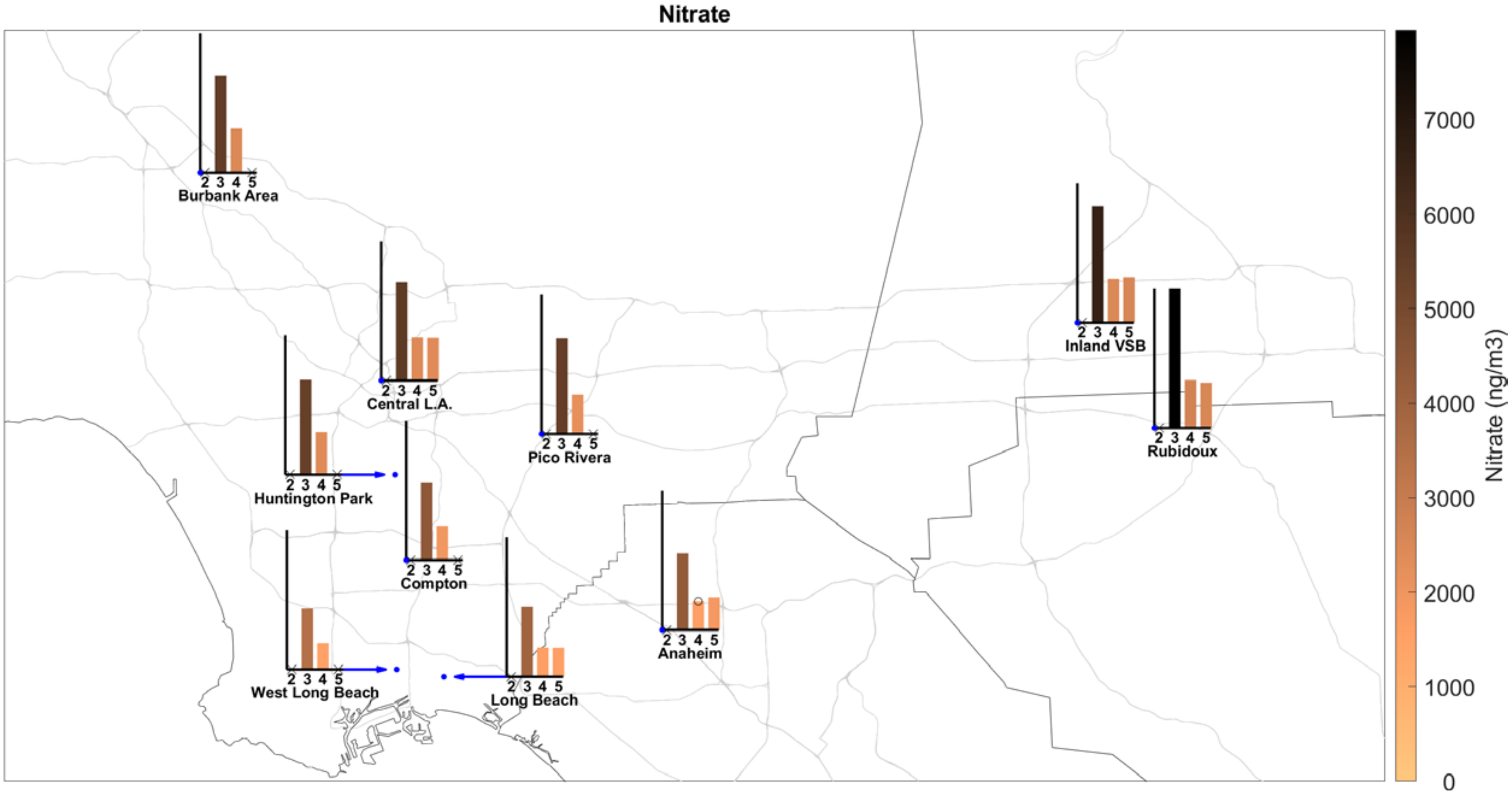


Figure IV-225. Geographic distribution of Nitrate from the PM2.5 Ions Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Potassium Ion

Table IV-115. Ambient Concentrations (ng/m^3) of Potassium Ion from the PM2.5 Ions analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	138			97		89.7	95.5		128	
95% CI LB	120			88.6		84.2	86.1		115	
95% CI UB	157			107		96.3	108		142	
N	56	0	0	60	0	61	61	0	60	0
% < MDL	19.6			63.3		78.7	77		33.3	
Max	460			310		200	310		330	

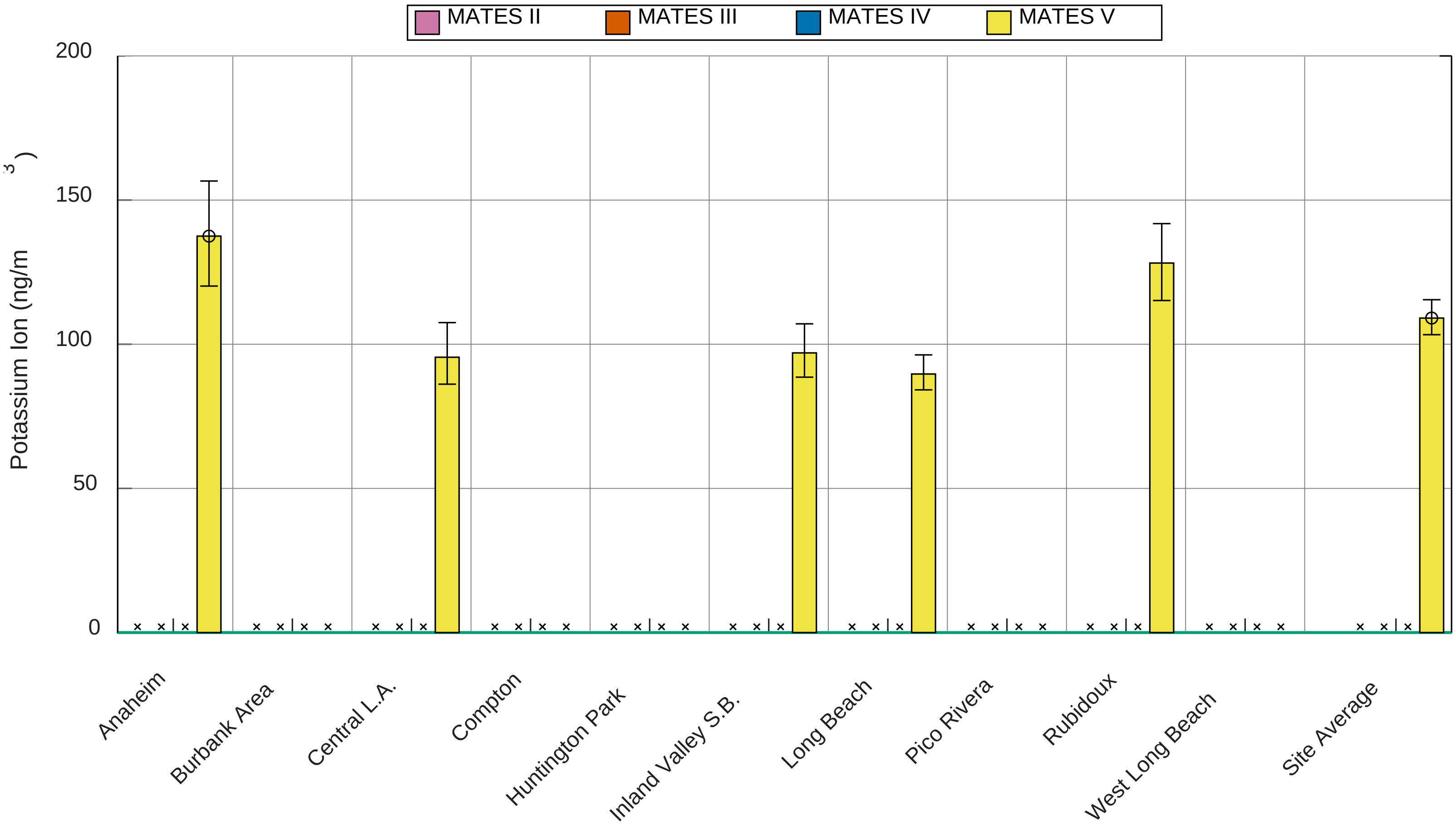


Figure IV-226. Annual Average Concentrations of Potassium Ion in the PM2.5 Ions Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

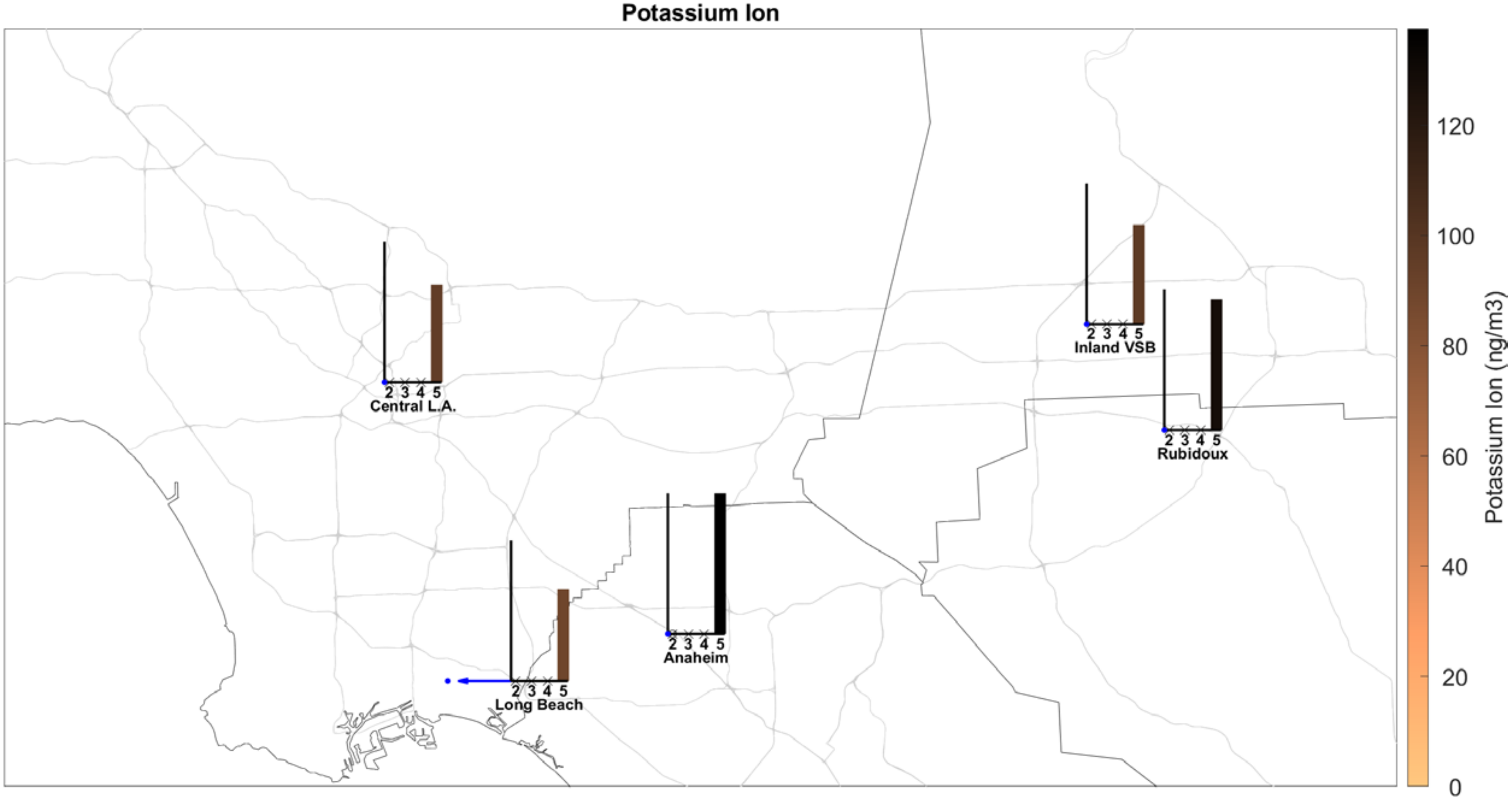


Figure IV-227. Geographic distribution of Potassium Ion from the PM2.5 Ions Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Sodium

Table IV-116. Ambient Concentrations (ng/m^3) of Sodium from the PM2.5 Ions analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	487	410	445	381	705	516	429	700	378	545
95% CI LB	411	335	372	309	598	441	362	596	307	460
95% CI UB	568	489	517	458	818	599	498	809	467	634
N	242	241	234	236	118	228	239	116	234	226
% < MDL	40.1	43.6	38	50	11.9	32	38.5	12.9	51.7	33.6
Max	3600	3210	2710	3040	2680	3430	2360	2560	3870	3820
MATES IV										
Average	593	548	487	431	583	650	474	550	416	611
95% CI LB	496	455	393	346	468	538	377	441	336	507
95% CI UB	694	644	583	520	706	768	579	666	500	721
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	3.4	1.6	0	0	0	3.3	0	1.6	1.6
Max	1710	1480	1700	1470	1910	2150	1720	1670	1530	1680
MATES V										
Average	689			280		467	357		414	
95% CI LB	617			222		382	292		349	
95% CI UB	765			344		552	426		480	
N	56	0	0	60	0	61	61	0	60	0
% < MDL	0			1.7		0	0		0	
Max	1680			1020		1710	1180		1050	

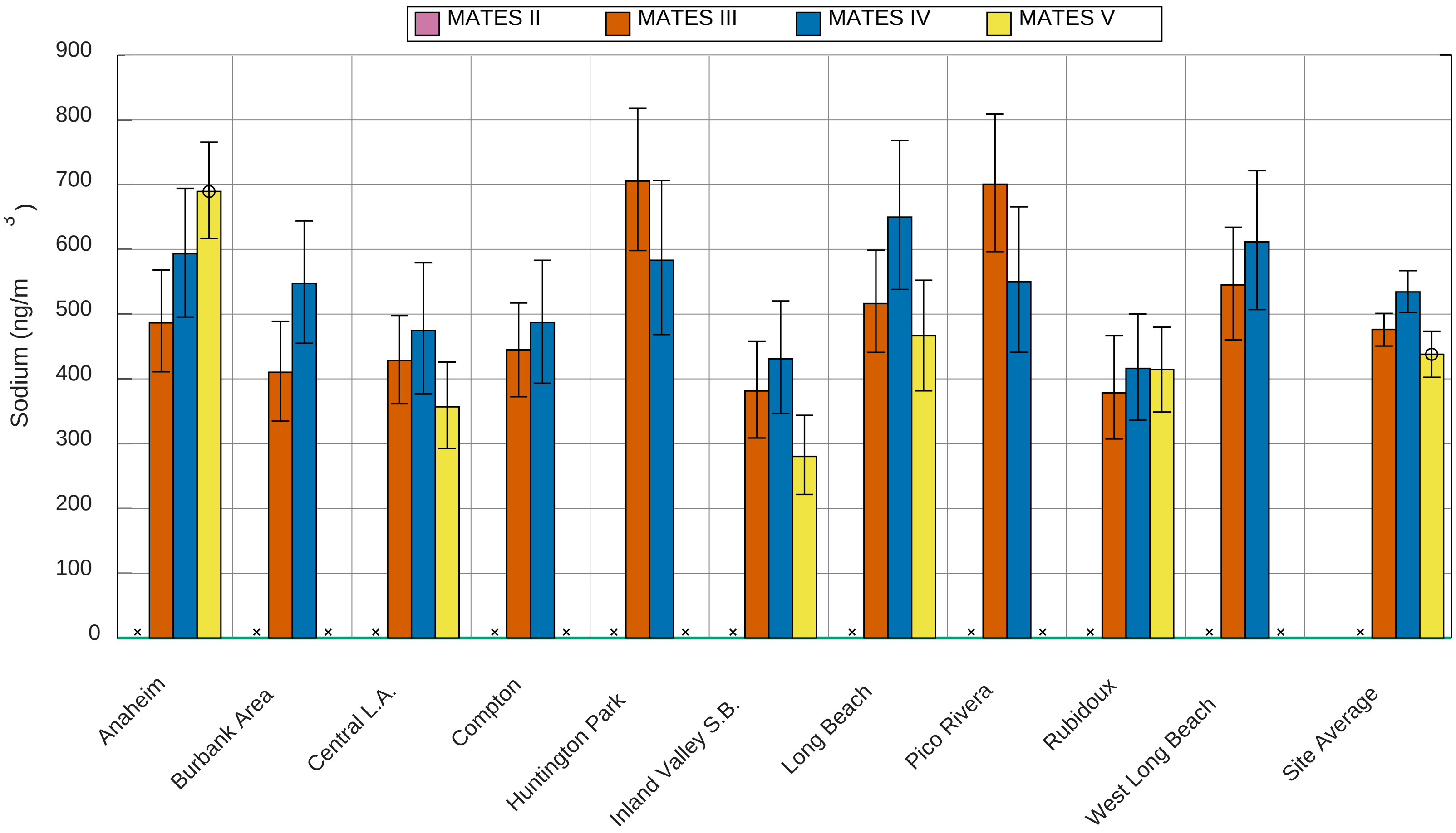


Figure IV-228. Annual Average Concentrations of Sodium in the PM2.5 Ions Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

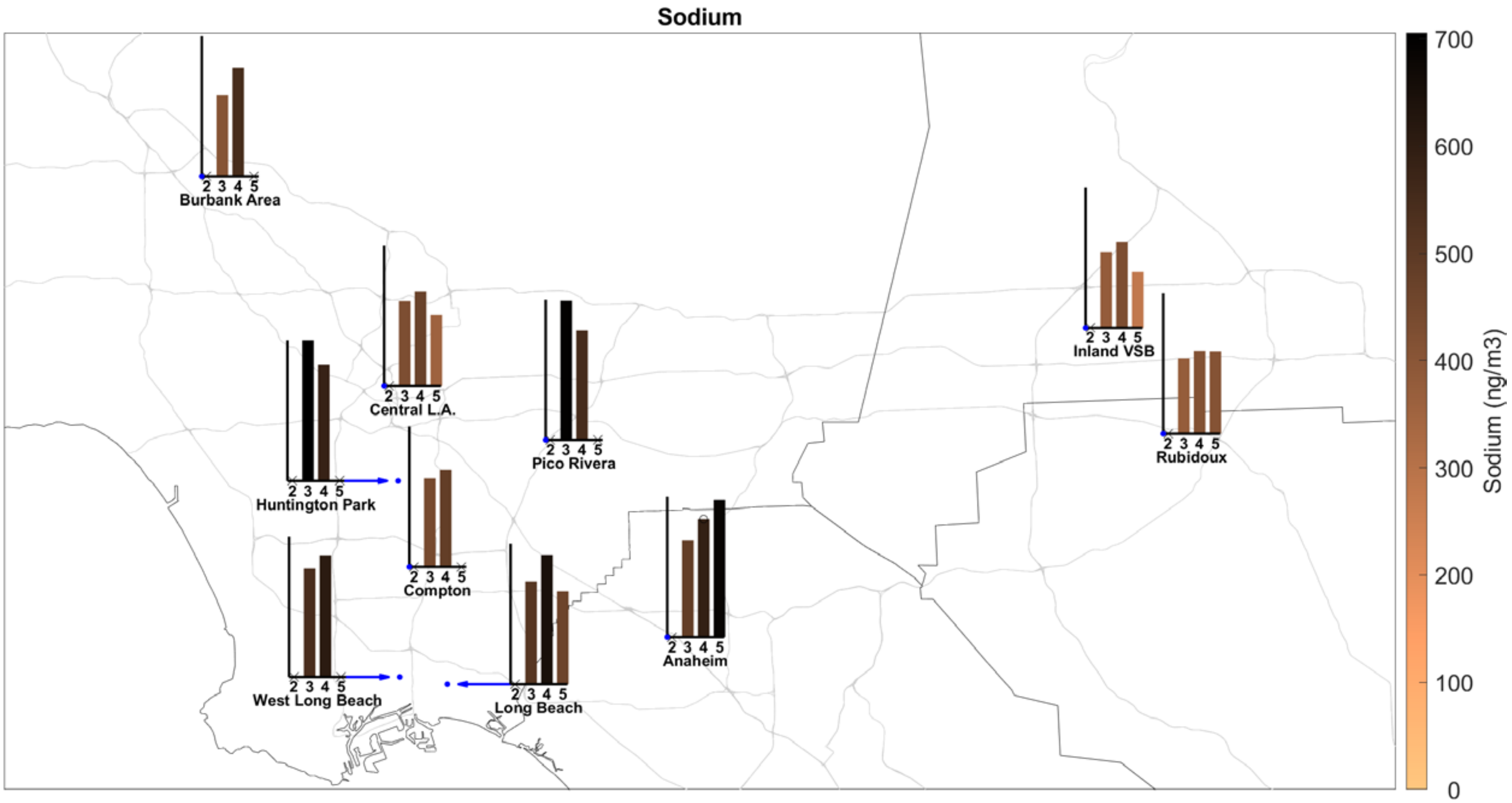


Figure IV-229. Geographic distribution of Sodium from the PM2.5 Ions Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Sulfate

Table IV-117. Ambient Concentrations (ng/m^3) of Sulfate from the PM2.5 Ions analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	3620	3560	4060	3410	4560	4470	3960	4300	3310	4710
95% CI LB	3270	3190	3660	3020	3960	4040	3560	3740	2940	4240
95% CI UB	3980	3920	4470	3830	5190	4890	4380	4870	3740	5170
N	236	238	230	232	115	226	236	115	229	224
% < MDL	5.9	7.1	4.8	4.7	0.9	2.7	3	1.7	4.4	4.9
Max	14300	13300	15800	30800	15200	18100	18300	16500	27900	20100
MATES IV										
Average	1460	1530	1540	1410	1660	1600	1500	1550	1300	1610
95% CI LB	1220	1270	1290	1170	1360	1350	1230	1290	1070	1370
95% CI UB	1700	1810	1790	1670	1950	1870	1790	1840	1540	1880
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	1.7	1.6	1.7	0	0	3.3	0	1.6	1.6
Max	3600	3810	4160	3790	4580	3950	4240	4230	3050	3980
MATES V										
Average	1130			1150		1270	1290		1060	
95% CI LB	946			967		1070	1050		887	
95% CI UB	1330			1350		1470	1530		1240	
N	56	0	0	60	0	61	61	0	60	0
% < MDL	0			1.7		0	0		3.3	
Max	2740			2790		3360	3780		2480	

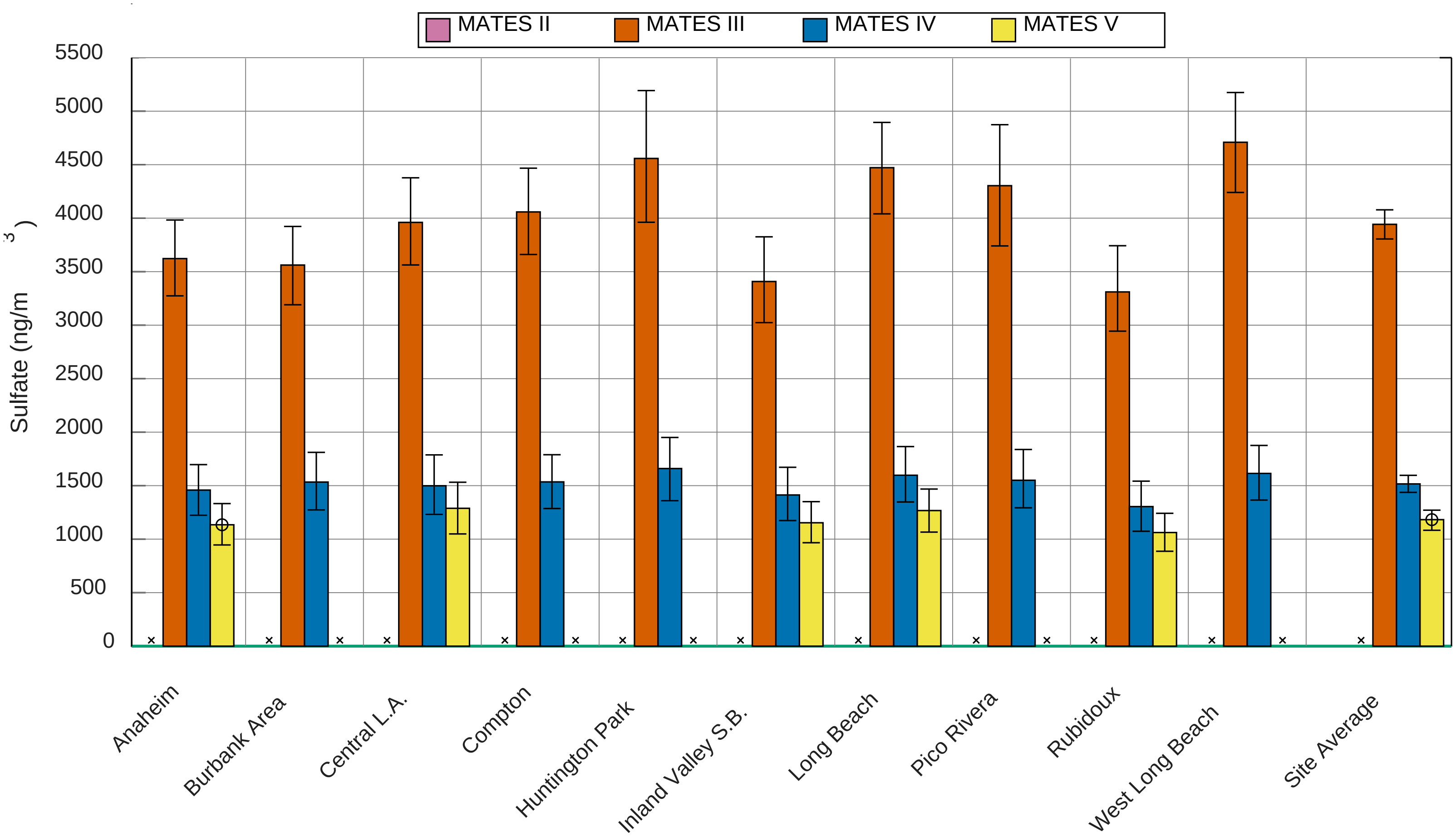


Figure IV-230. Annual Average Concentrations of Sulfate in the PM2.5 Ions Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

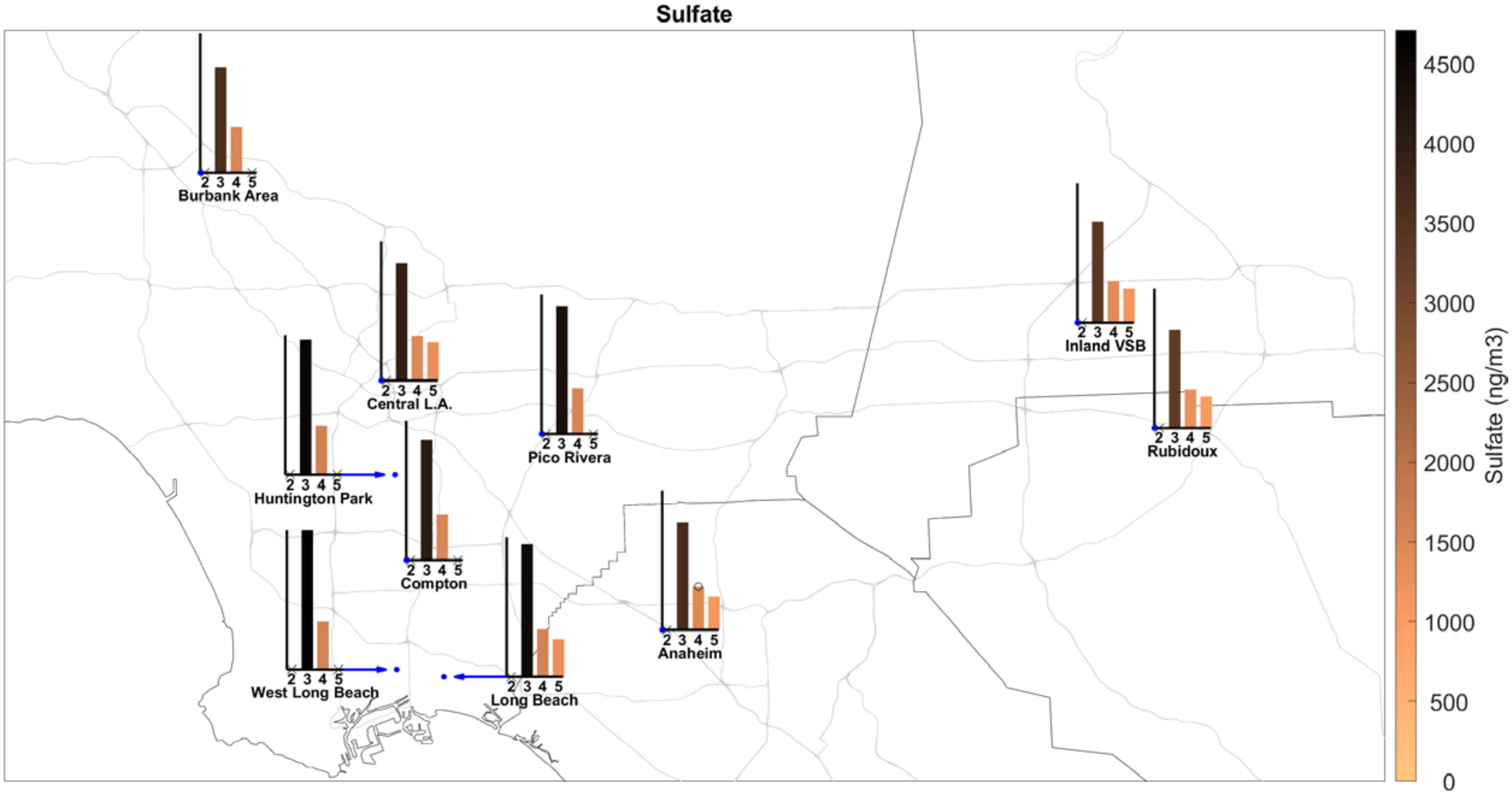


Figure IV-231. Geographic distribution of Sulfate from the PM2.5 Ions Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

PM2.5 Metals Analysis

Aluminum

Table IV-118. Ambient Concentrations (ng/m^3) of Aluminum from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	61.1	100	75.3	121	55.8	92.2	79.8	61.2	81.3	107
95% CI LB	47.5	67.9	58.3	98.2	37.8	73.4	61.3	41.3	63.1	85.4
95% CI UB	76.4	143	94.1	146	76.6	113	101	84.9	102	130
N	240	239	234	238	117	228	237	116	236	228
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	773	4360	1100	926	673	898	1130	786	1300	951
MATES IV										
Average	56.8	53.9	54.1	75.7	59	57.7	59.2	59.3	65	73.7
95% CI LB	50.3	49	46.4	65.4	50.4	49.5	50.9	53.1	57.8	62
95% CI UB	64.1	59.2	64.2	87.8	71.9	67	68.9	65.5	73.3	87.2
N	59	59	61	60	59	61	60	59	61	61
% < MDL	61	50.8	67.2	26.7	59.3	54.1	56.7	49.2	42.6	50.8
Max	176	119	286	286	317	285	214	130	161	290
MATES V										
Average	48.7	49.1	49.6	62.9	52.9	13.2, 47[a]	46.5	54.5	76.2	54.8
95% CI LB	45.1	44.9	45.9	55.2	46.1	6.21[a]	43.9	49.3	60.2	48.3
95% CI UB	53.1	54.3	54.1	72.2	60.8	52.8[a]	49.6	60.4	99.2	62.1
N	54	59	61	60	60	61[a]	61	59	56	57
% < MDL	72.2	67.8	70.5	43.3	70	80.3[a]	75.4	49.2	42.9	54.4
Max	113	144	114	242	171	185[a]	99	157	566	148

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

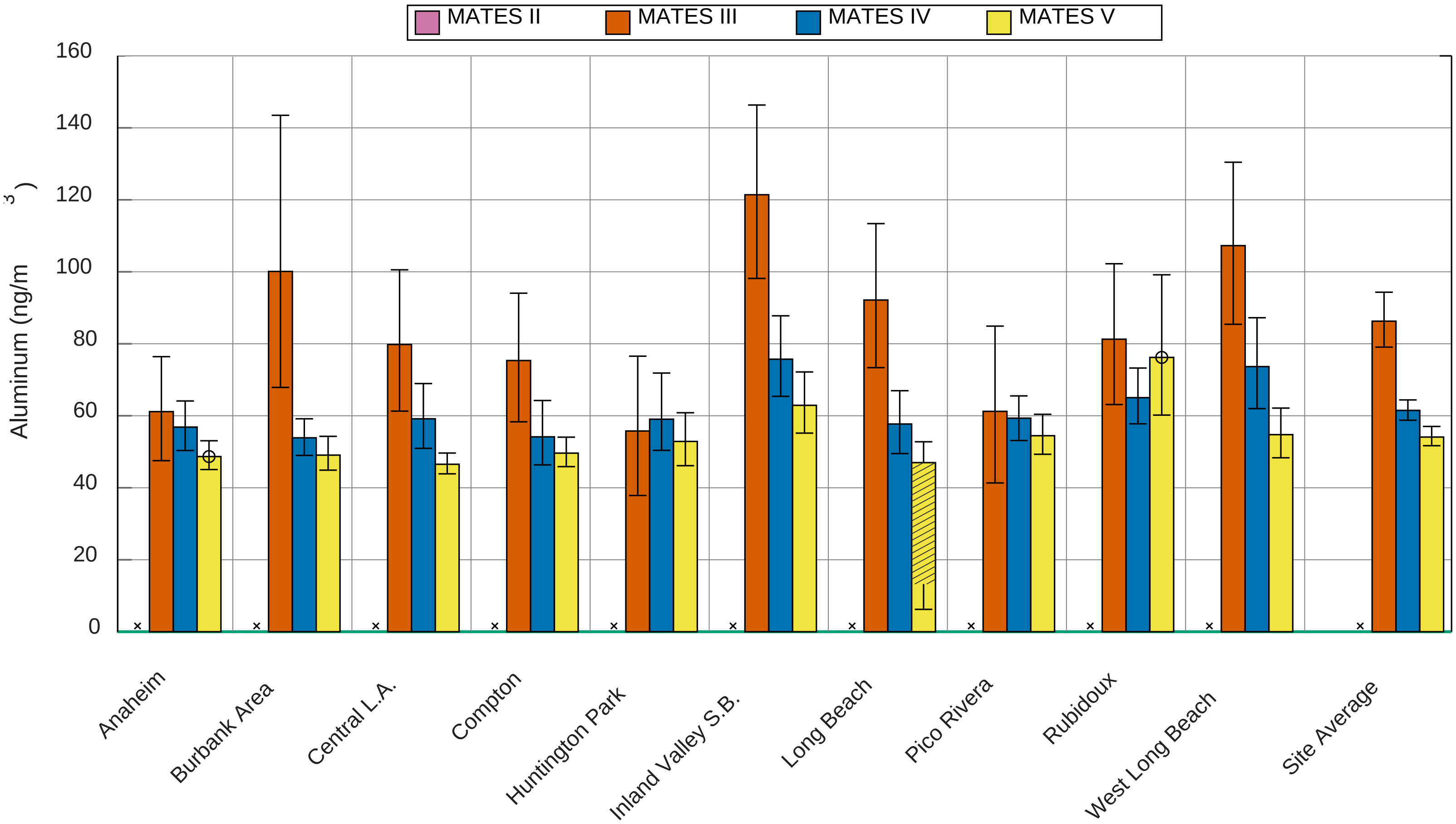


Figure IV-232. Annual Average Concentrations of Aluminum in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

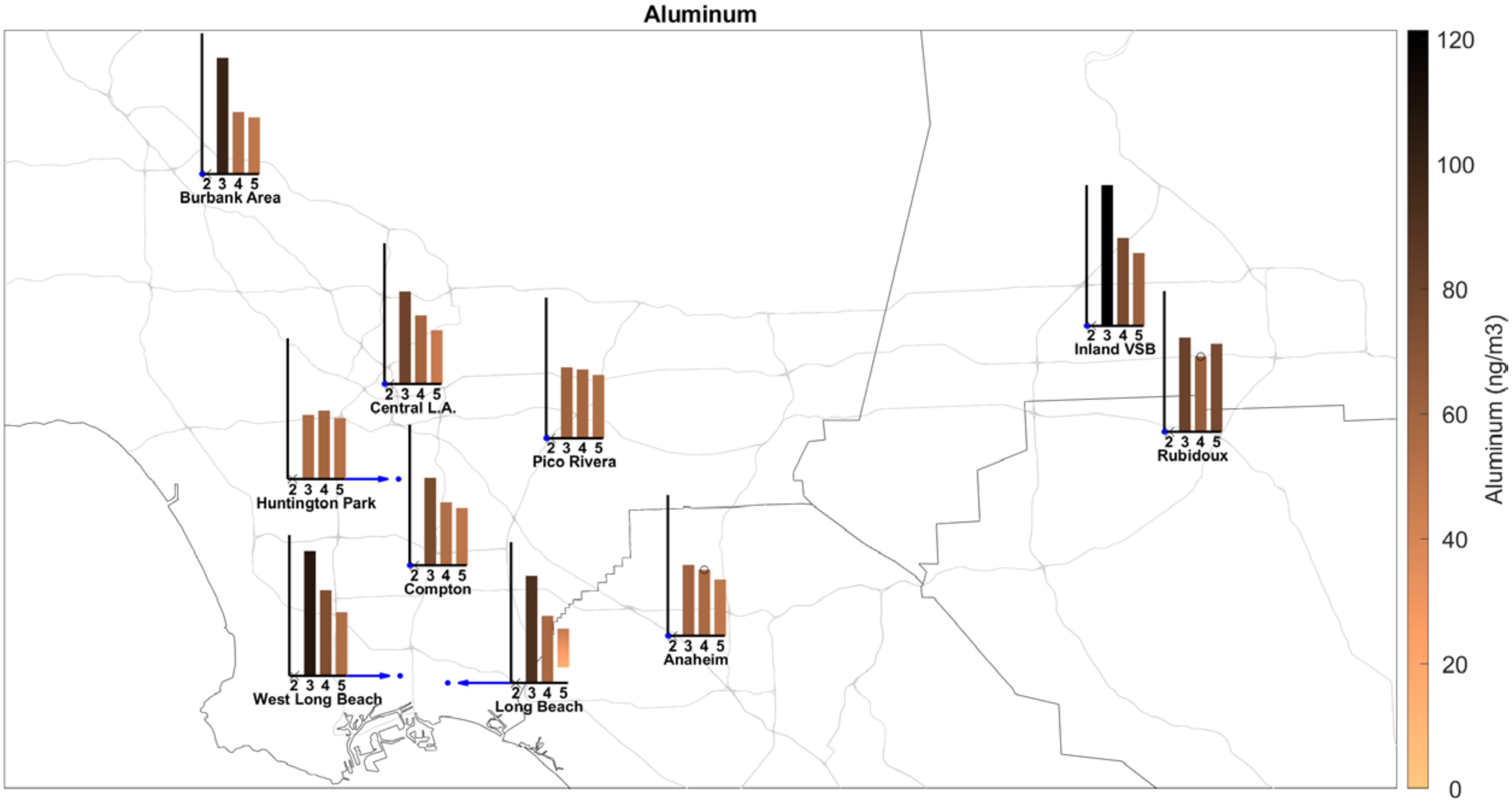


Figure IV-233. Geographic distribution of Aluminum from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Antimony

Table IV-119. Ambient Concentrations (ng/m^3) of Antimony from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	8.17, 9.38[a]	7.82, 4.18[b]	6.21, 7.43[a]	8.53, 9.69[a]	0, 1.4[a]	4.18, 5.43[a]	6.67, 3.54[b]	0, 3.16[b]	6.57, 7.82[a]	5.95, 7.19[a]
95% CI LB	4.92[a]	4.64[b]	3.34[a]	5.22[a]	0[a]	1.9[a]	3.76[b]	0[b]	3.73[a]	3.19[a]
95% CI UB	13[a]	4.7[b]	10.7[a]	13.4[a]	1.4[a]	8.18[a]	3.88[b]	3.57[b]	11.1[a]	10.4[a]
N	240[a]	239[b]	234[a]	238[a]	117[a]	228[a]	237[b]	116[b]	236[a]	228[a]
% < MDL	86.3[a]	85.8[b]	86.8[a]	83.2[a]	100[a]	89[a]	86.1[b]	100[b]	89.4[a]	88.6[a]
Max	132[a]	132[b]	127[a]	133[a]	< MDL[a]	139[a]	123[b]	< MDL[b]	122[a]	138[a]
MATES IV										
Average	1.22, 2.45[b]	2.32, 5.07[b]	0, 3.97[b]	0, 4.5[b]	0, 4.95[b]	1, 3.28[b]	0, 6.06[b]	0, 6.09[b]	1.07, 3.98[b]	2.07, 2.76[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	3.04[b]	6.09[b]	4.92[b]	5.03[b]	5.9[b]	4.1[b]	7.22[b]	7.3[b]	4.94[b]	3.43[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	98.3[b]	96.6[b]	100[b]	100[b]	100[b]	98.4[b]	100[b]	100[b]	98.4[b]	96.7[b]
Max	72[b]	69[b]	< MDL[b]	< MDL[b]	< MDL[b]	61[b]	< MDL[b]	< MDL[b]	65[b]	63[b]
MATES V										
Average	0, 4.49[b]	0, 3.54[b]	0, 4.76[b]	0, 5.37[b]	0, 4.43[b]	0, 3.26[b]	0, 5.41[b]	0, 5.3[b]	0, 4.84[b]	0, 3.48[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	5.71[b]	4.06[b]	5.93[b]	6.13[b]	5.5[b]	4.14[b]	6.29[b]	6.29[b]	5.66[b]	4.43[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

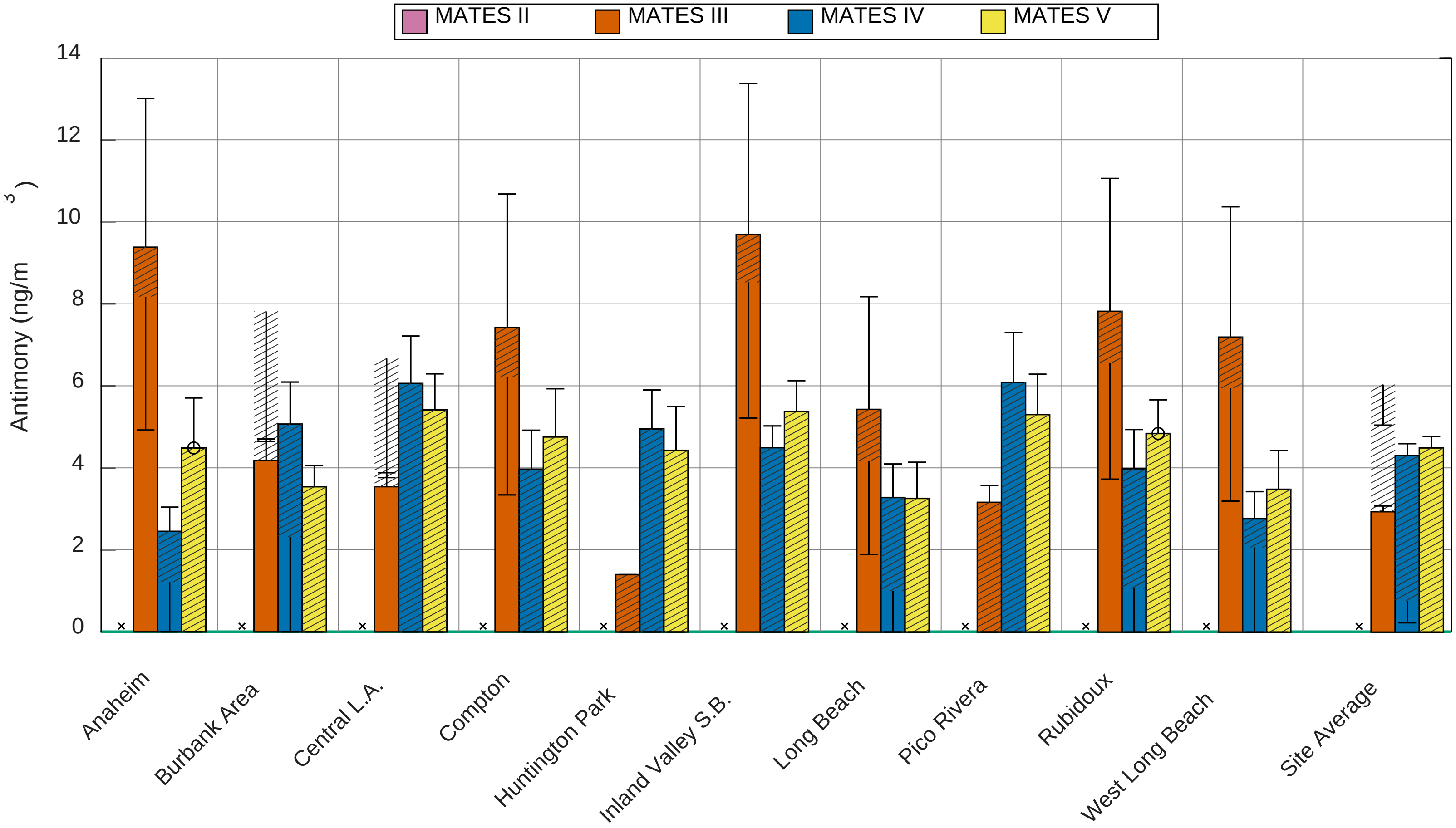


Figure IV-234. Annual Average Concentrations of Antimony in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

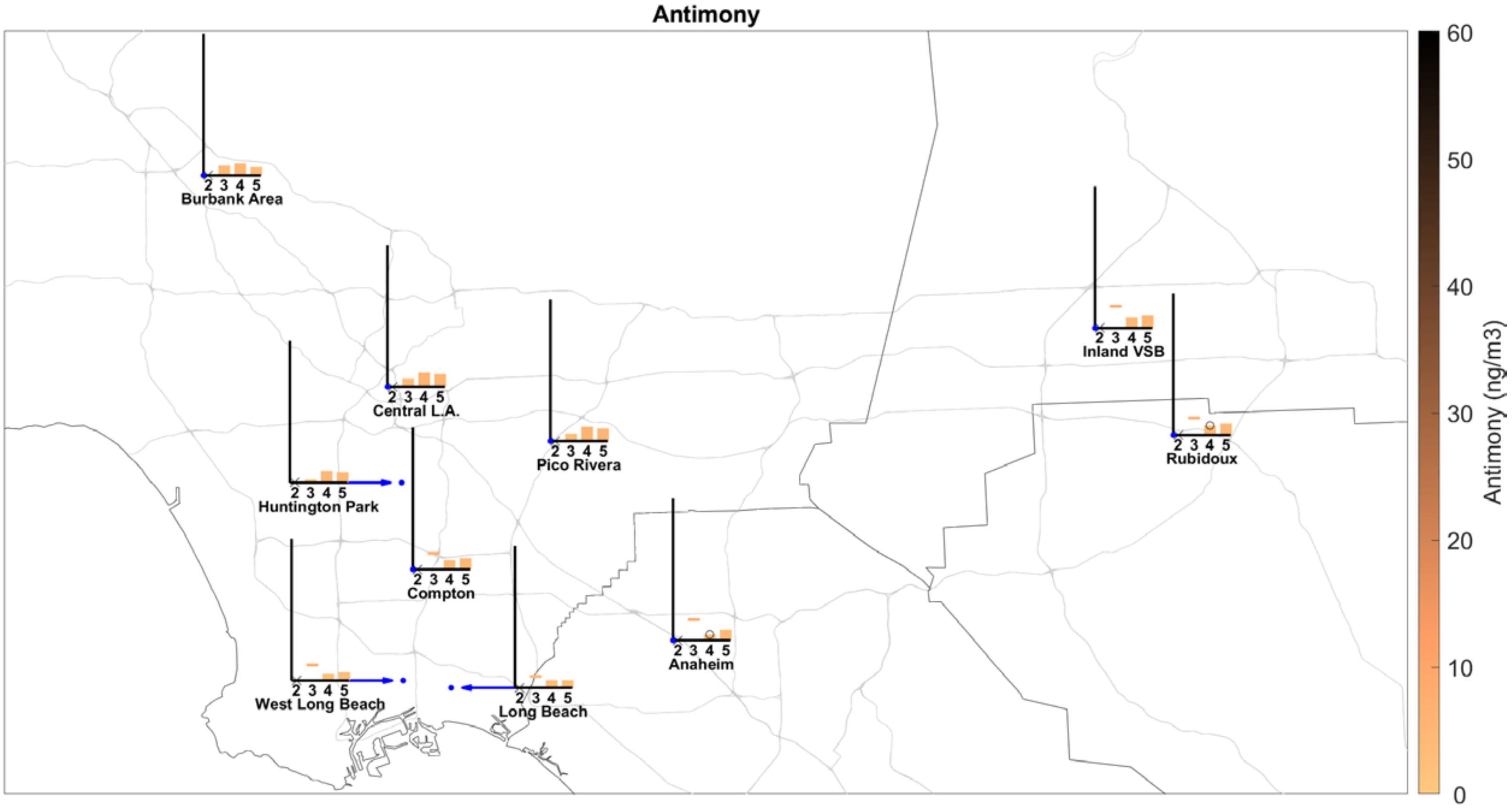


Figure IV-235. Geographic distribution of Antimony from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Arsenic

Table IV-120. Ambient Concentrations (ng/m^3) of Arsenic from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	0.611	0.572	0.555	0.652	0.822	0.553	0.544	0.847	0.58	0.625
95% CI LB	0.538	0.499	0.483	0.56	0.707	0.475	0.478	0.699	0.487	0.541
95% CI UB	0.696	0.649	0.628	0.752	0.939	0.642	0.613	1.01	0.666	0.716
N	240	239	234	238	117	228	237	116	236	228
% < MDL	65.8	68.6	68.8	63.4	46.2	70.6	64.6	50	69.5	65.4
Max	3.71	2.48	3.7	7.42	2.48	3.71	3.1	4.96	4.97	3.72
MATES IV										
Average	0, 0.238[b]	0, 0.447[b]	0, 0.502[b]	0, 0.909[b]	0, 0.557[b]	0, 0.396[b]	0, 0.637[b]	0, 0.566[b]	0, 0.757[b]	0, 0.497[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.271[b]	0.502[b]	0.596[b]	1.03[b]	0.653[b]	0.458[b]	0.745[b]	0.629[b]	0.993[b]	0.583[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]
MATES V										
Average	0, 0.36[b]	0, 0.459[b]	0, 0.441[b]	0, 0.885[b]	0, 0.413[b]	0, 0.376[b]	0, 0.412[b]	0, 0.663[b]	0, 0.663[b]	0, 0.466[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.414[b]	0.524[b]	0.528[b]	1.04[b]	0.489[b]	0.452[b]	0.477[b]	0.759[b]	0.743[b]	0.561[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

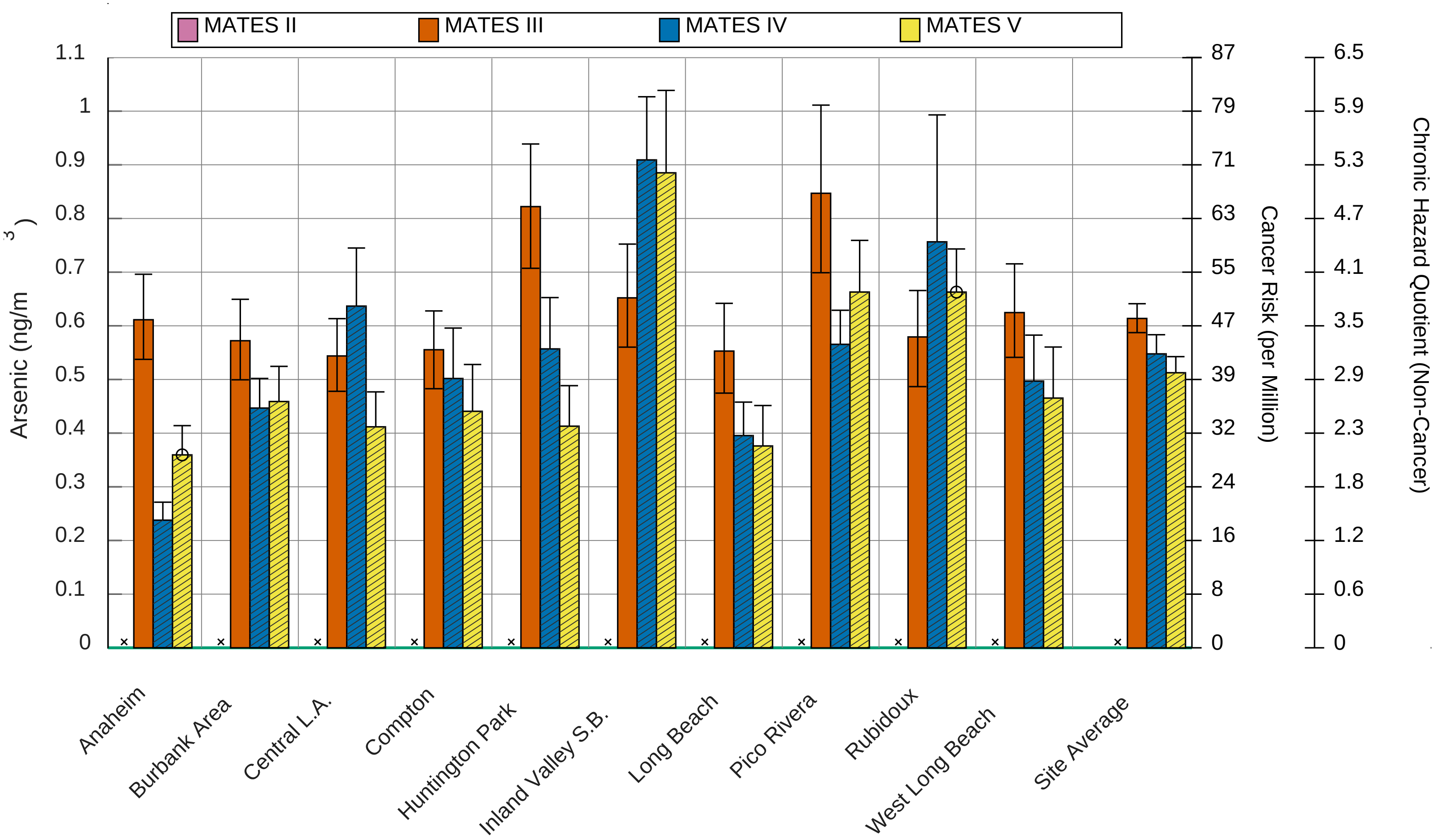


Figure IV-236. Annual Average Concentrations of Arsenic in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

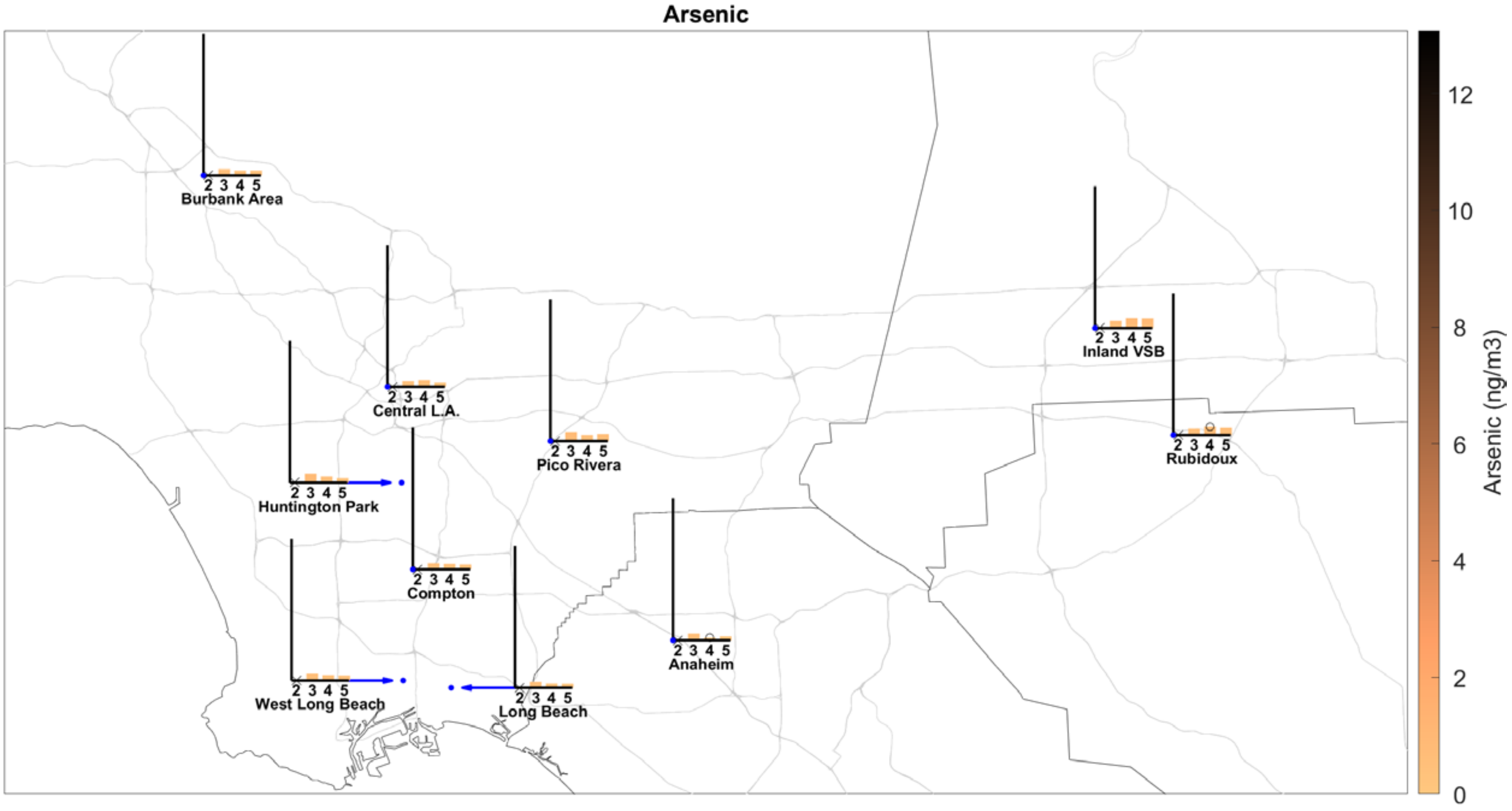


Figure IV-237. Geographic distribution of Arsenic from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Barium

Table IV-121. Ambient Concentrations (ng/m^3) of Barium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	30.1	33.4	28.7	36.1	26.2	26.8	31.1	29.4	28.5	24.7
95% CI LB	26.6	29.9	25.5	27.9	22.9	24.3	28	23.4	22.5	22.3
95% CI UB	34.4	37.5	32.1	49.8	30.3	29.5	34.4	38.8	38.1	27.2
N	240	239	234	238	117	228	237	116	236	228
% < MDL	22.1	20.1	27.4	23.9	23.9	23.7	17.7	19.8	31.4	34.6
Max	355	316	211	1450	144	121	244	486	999	129
MATES IV										
Average	3.49, 29.4[b]	2.93, 57.3[b]	0, 46.3[b]	0, 69.7[b]	0, 55.6[b]	0, 43.4[b]	4.32, 67.1[b]	0, 61.1[b]	0, 58.5[b]	0, 57[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	36.6[b]	68.1[b]	54.1[b]	85.5[b]	66[b]	51.3[b]	79.8[b]	70.7[b]	73.6[b]	67.6[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	98.3[b]	98.3[b]	100[b]	100[b]	100[b]	100[b]	96.7[b]	100[b]	100[b]	100[b]
Max	206[b]	173[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	135[b]	< MDL[b]	< MDL[b]	< MDL[b]
MATES V										
Average	0, 48.6[b]	0, 46.4[b]	0, 57.7[b]	0, 75[b]	0, 50.7[b]	0, 40[b]	1.27, 60.6[b]	0, 67.9[b]	0, 60[b]	0, 54.6[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	59[b]	52.9[b]	71.1[b]	86.2[b]	61.5[b]	49.8[b]	71.1[b]	78.1[b]	69.9[b]	66.5[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	98.4[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	77.5[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

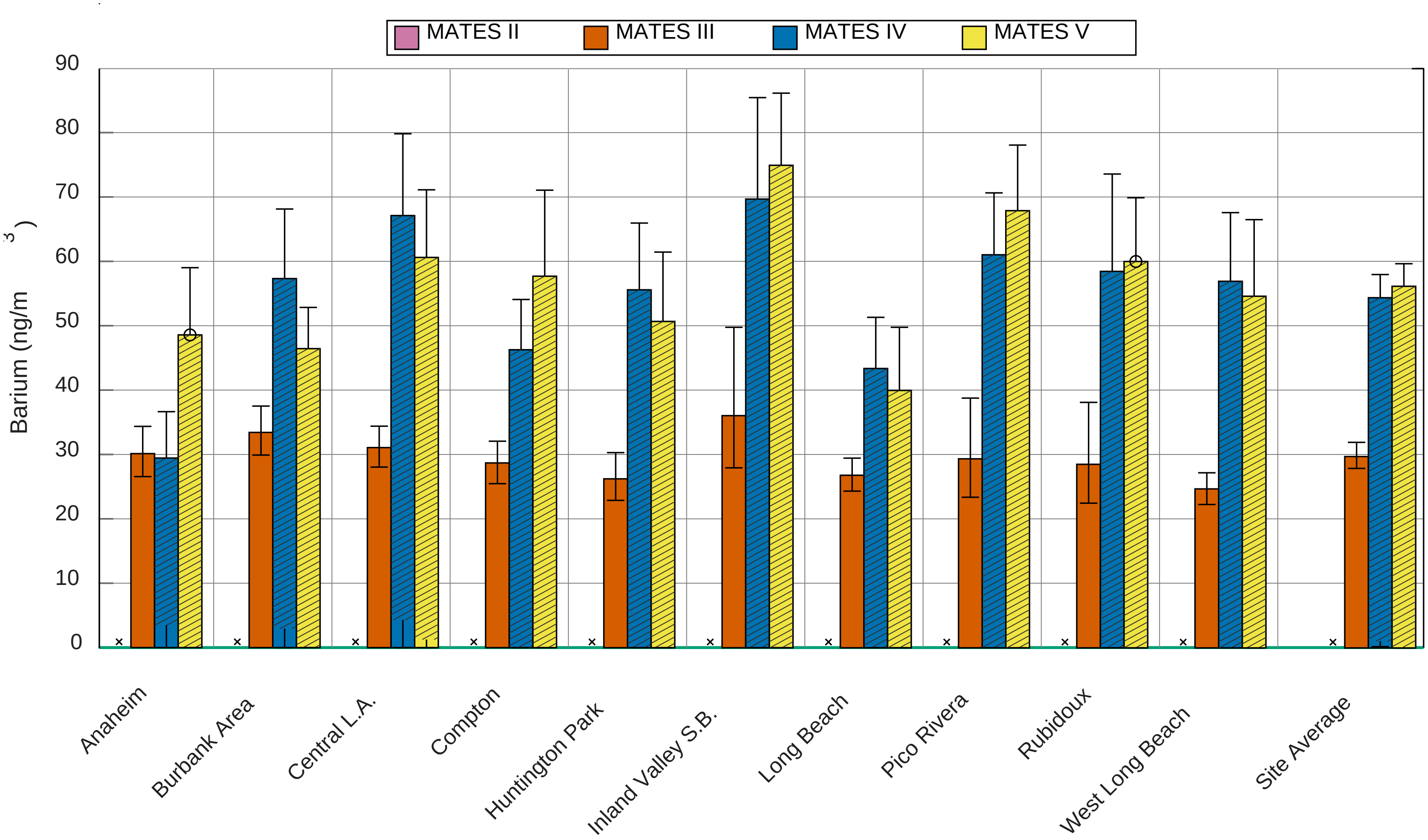


Figure IV-238. Annual Average Concentrations of Barium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

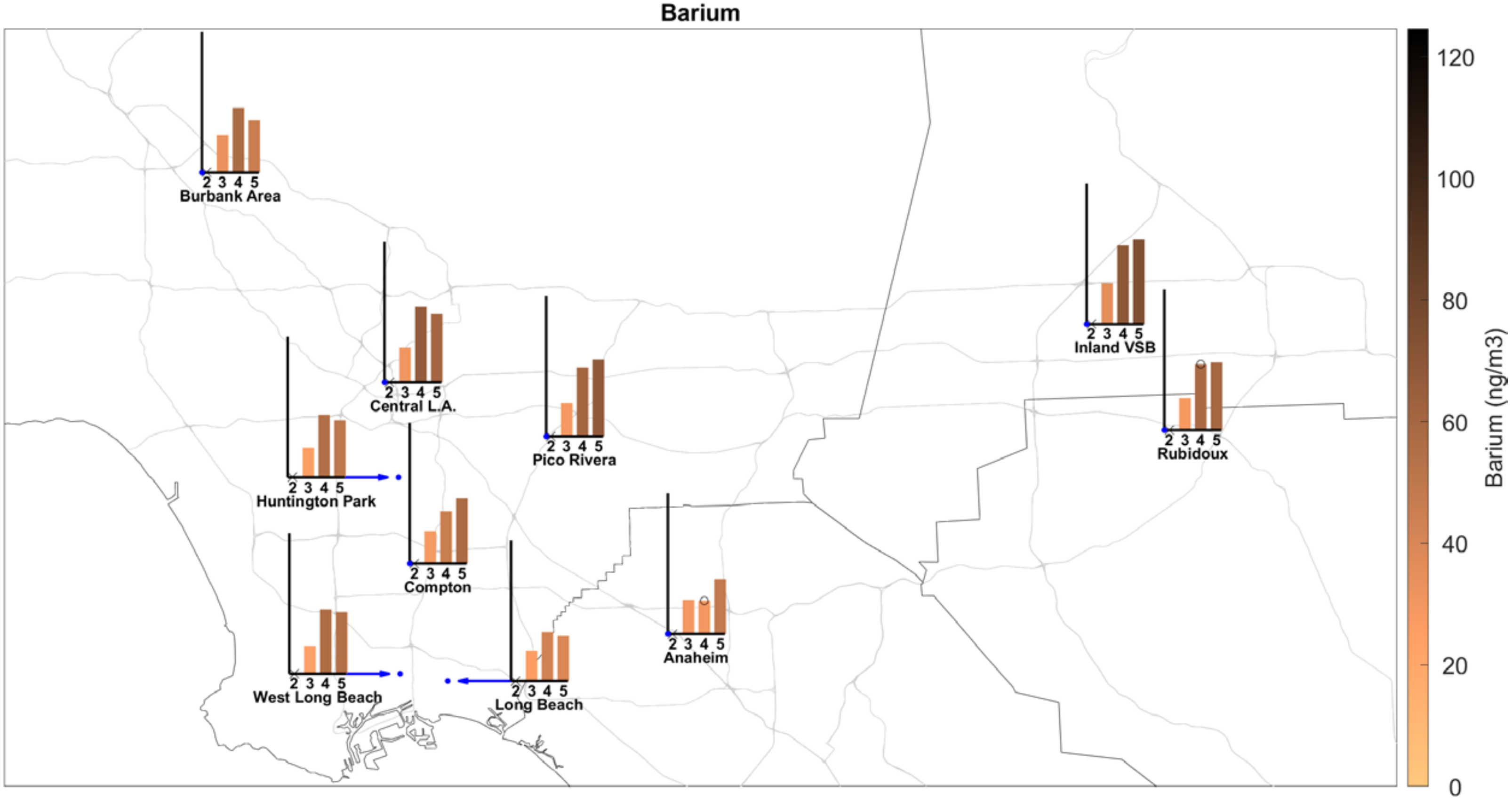


Figure IV-239. Geographic distribution of Barium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Cadmium

Table IV-122. Ambient Concentrations (ng/m^3) of Cadmium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	2.18	1.78	1.93	1.85	2.02	1.81	1.75	2.07	1.83	1.91
95% CI LB	1.74	1.54	1.68	1.64	1.69	1.53	1.58	1.51	1.61	1.68
95% CI UB	2.83	2.05	2.21	2.06	2.39	2.17	1.92	2.96	2.07	2.16
N	240	239	234	238	117	228	237	116	236	228
% < MDL	52.1	59.8	54.3	52.1	39.3	55.3	53.2	41.4	50.4	53.9
Max	65.6	16.1	17.2	9.91	12.4	32	10.5	44.6	11.2	11.1
MATES IV										
Average	0, 0.0876[b]	0, 0.134[b]	0, 0.168[b]	0, 0.283[b]	0, 0.181[b]	0, 0.227[b]	0, 0.26[b]	0, 0.124[b]	0, 0.131[b]	0, 0.127[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.0947[b]	0.164[b]	0.211[b]	0.346[b]	0.222[b]	0.36[b]	0.491[b]	0.148[b]	0.164[b]	0.152[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]
MATES V										
Average	0, 0.244[b]	0, 0.69[b]	0, 0.249[b]	0, 0.311[b]	0, 0.449[b]	0, 0.088[b]	0, 0.15[b]	0, 0.144[b]	0, 0.588[b]	0, 0.771[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.306[b]	1.76[b]	0.359[b]	0.394[b]	0.751[b]	0.129[b]	0.219[b]	0.214[b]	1.04[b]	1.05[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

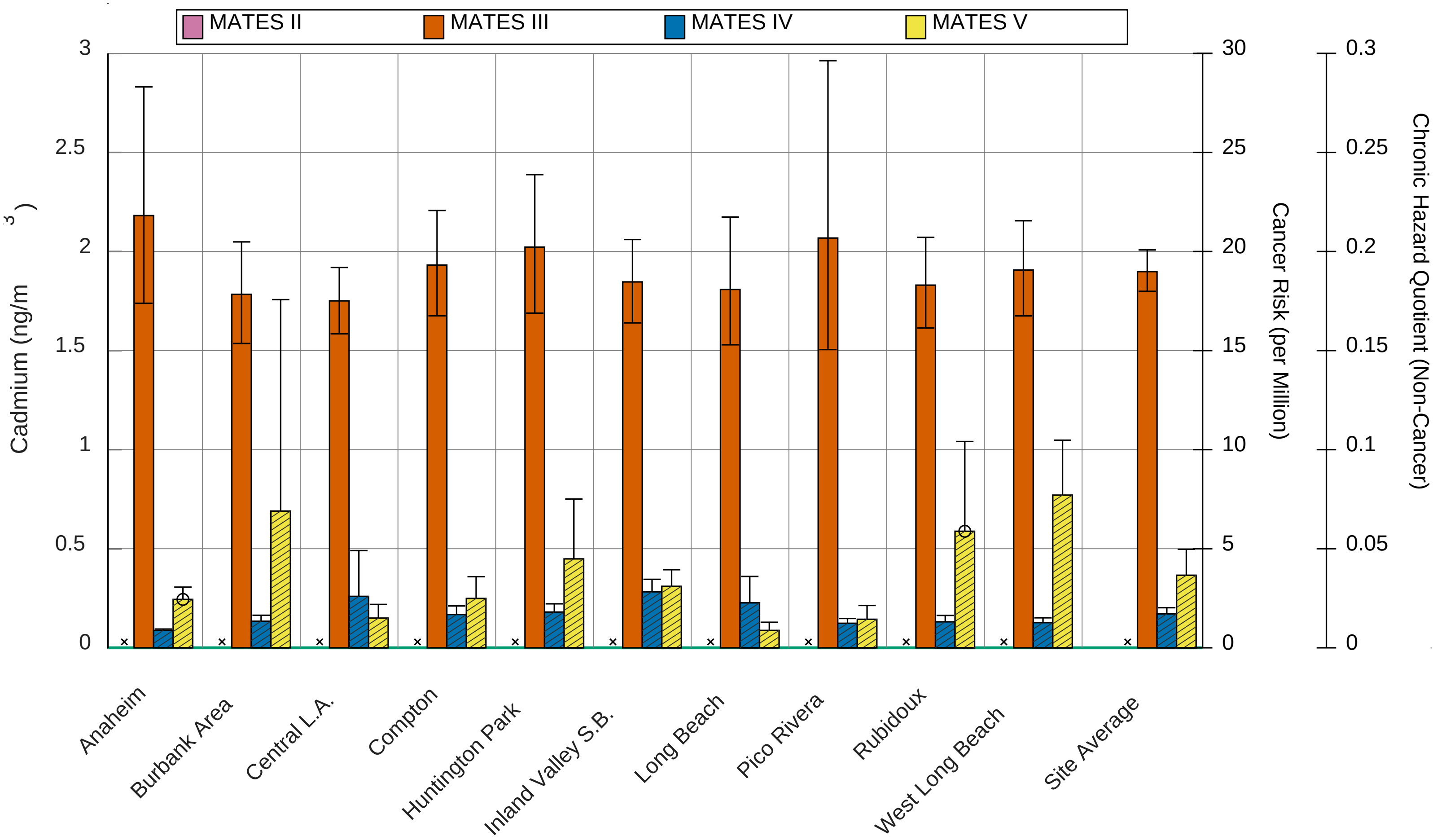


Figure IV-240. Annual Average Concentrations of Cadmium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

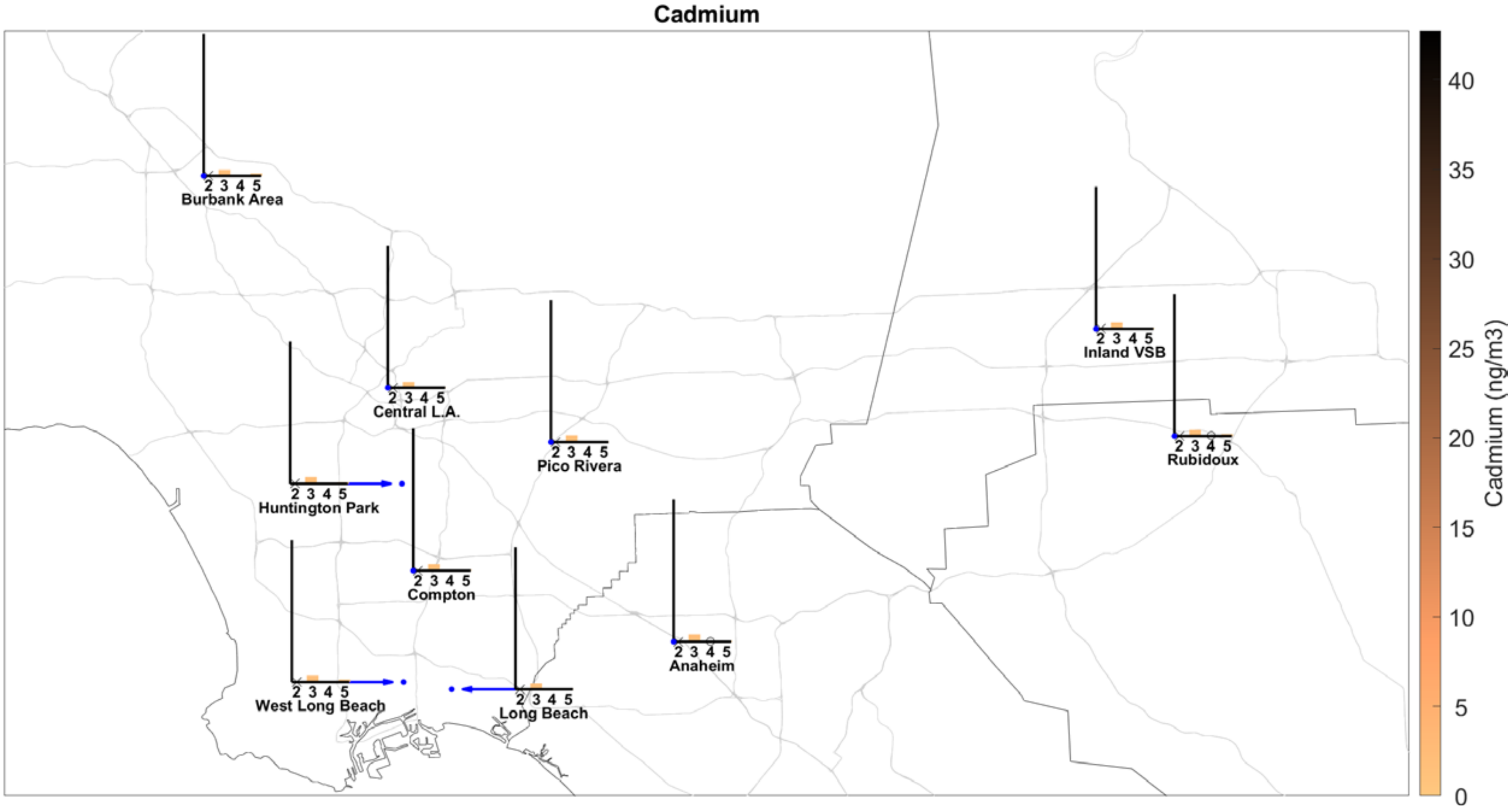


Figure IV-241. Geographic distribution of Cadmium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Calcium

Table IV-123. Ambient Concentrations (ng/m^3) of Calcium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	96.6	124	94	199	105	89.7	109	103	194	118
95% CI LB	87.2	109	86.3	182	89.5	83.9	99.3	92.7	174	110
95% CI UB	107	143	102	219	125	96	120	113	215	128
N	240	239	234	238	117	228	237	116	236	228
% < MDL	0	0	0	0	0.9	0	0	0	0	0
Max	740	1890	619	1560	948	298	601	328	817	574
MATES IV										
Average	46.1	55.4	44.2	92.5	50.6	47	53.5	51.1	72.5	80.1
95% CI LB	39	47.5	35.4	75.2	42.8	39.8	43.8	43.3	60.5	64.9
95% CI UB	53.9	63.7	54.7	112	59.1	55.3	65.6	59.2	85.5	96.7
N	59	59	61	60	59	61	60	59	61	61
% < MDL	10.2	10.2	24.6	8.3	15.3	13.1	11.7	10.2	8.2	6.6
Max	166	132	259	424	142	194	298	138	260	288
MATES V										
Average	46.3	44.4	52.2	85.1	55.6	44.1	53.9	59.3	83.3	61.2
95% CI LB	39.7	38.4	45.9	72.4	48	38.4	47.2	51.1	68.3	53.6
95% CI UB	53.4	50.8	58.6	98.3	63.5	50.5	60.8	68.5	99.9	68.9
N	54	59	61	60	60	61	61	59	56	57
% < MDL	7.4	8.5	3.3	0	1.7	8.2	6.6	0	3.6	1.8
Max	125	121	126	236	145	156	130	189	313	129

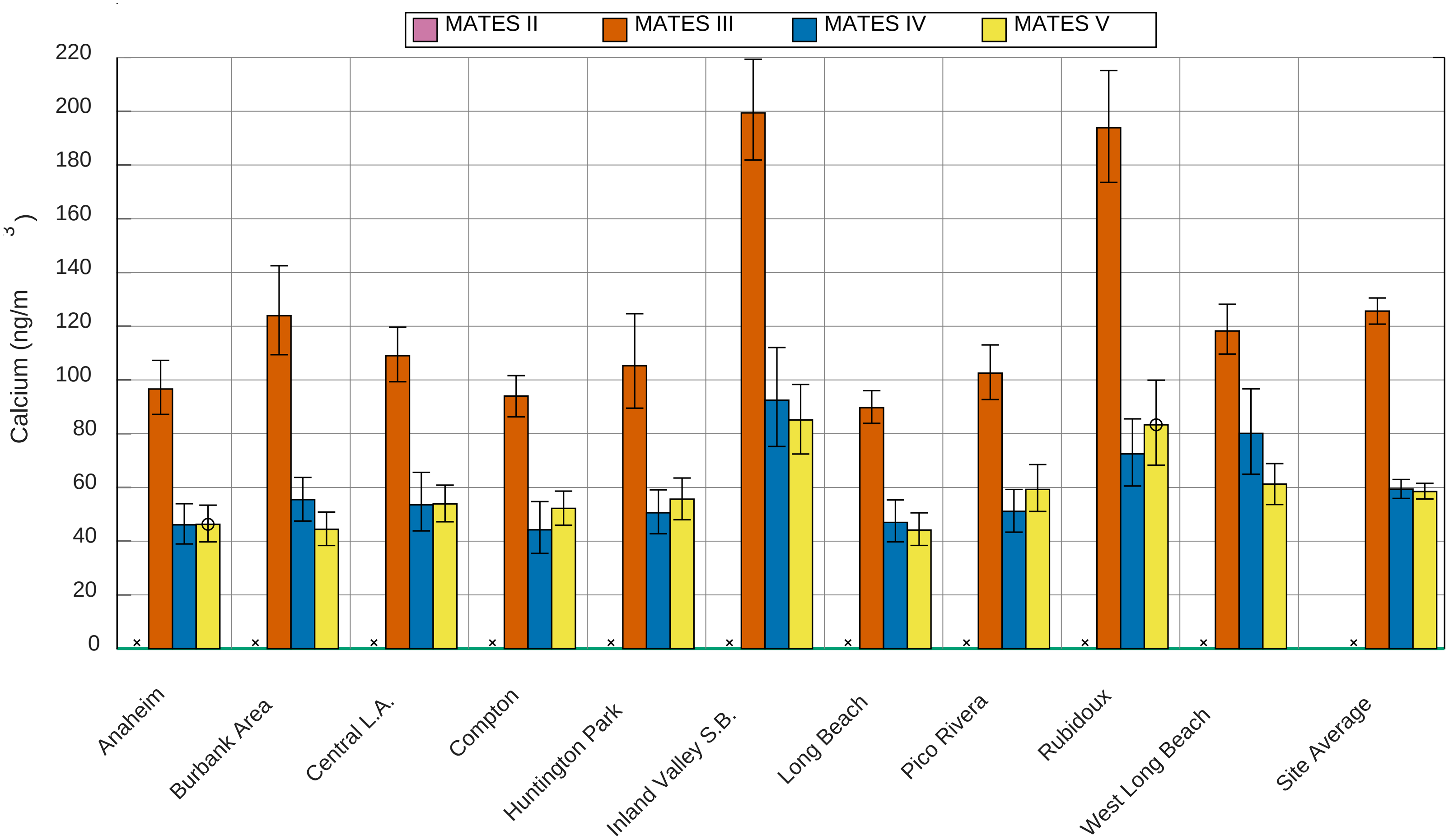


Figure IV-242. Annual Average Concentrations of Calcium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

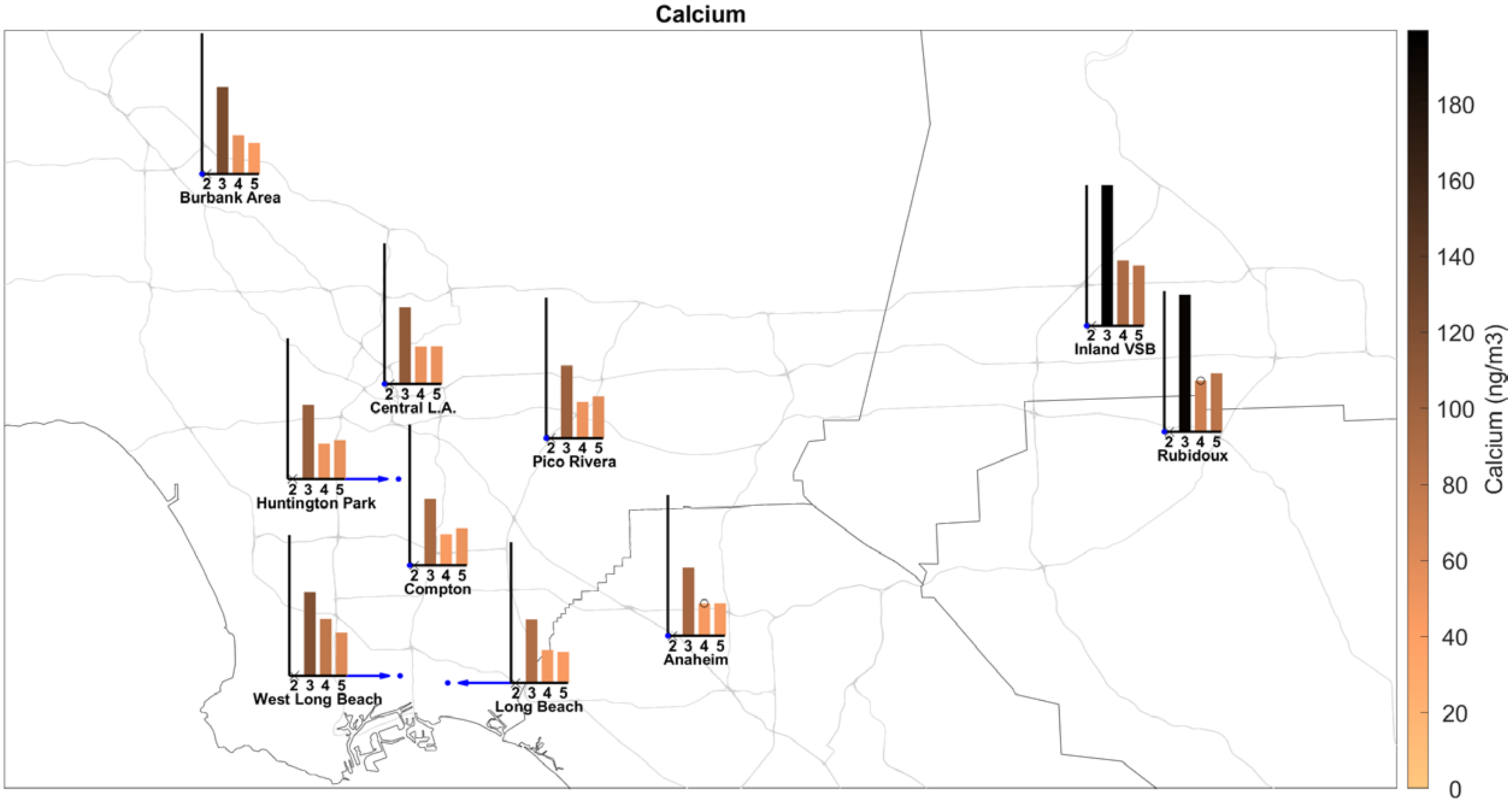


Figure IV-243. Geographic distribution of Calcium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Cesium

Table IV-124. Ambient Concentrations (ng/m^3) of Cesium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	2.64, 155[a]	0, 154[a]	0, 154[a]	0, 154[a]	5.37, 155[a]	2.62, 155[a]	0, 154[a]	0, 154[a]	0, 154[a]	0, 154[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	155[a]	154[a]	154[a]	154[a]	155[a]	155[a]	154[a]	154[a]	154[a]	154[a]
N	59[a]	59[a]	61[a]	60[a]	59[a]	61[a]	60[a]	59[a]	61[a]	61[a]
% < MDL	98.3[a]	100[a]	100[a]	100[a]	96.6[a]	98.4[a]	100[a]	100[a]	100[a]	100[a]
Max	156[a]	< MDL[a]	< MDL[a]	< MDL[a]	160[a]	160[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES V										
Average	0, 0.0757[b]	0, 0.0773[b]	0, 0.0644[b]	0, 0.148[b]	0, 0.0551[b]	0, 0.0581[b]	0, 0.0604[b]	0, 0.109[b]	0, 0.162[b]	0, 0.0746[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.0907[b]	0.0905[b]	0.0788[b]	0.179[b]	0.0671[b]	0.0742[b]	0.0699[b]	0.126[b]	0.188[b]	0.0954[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

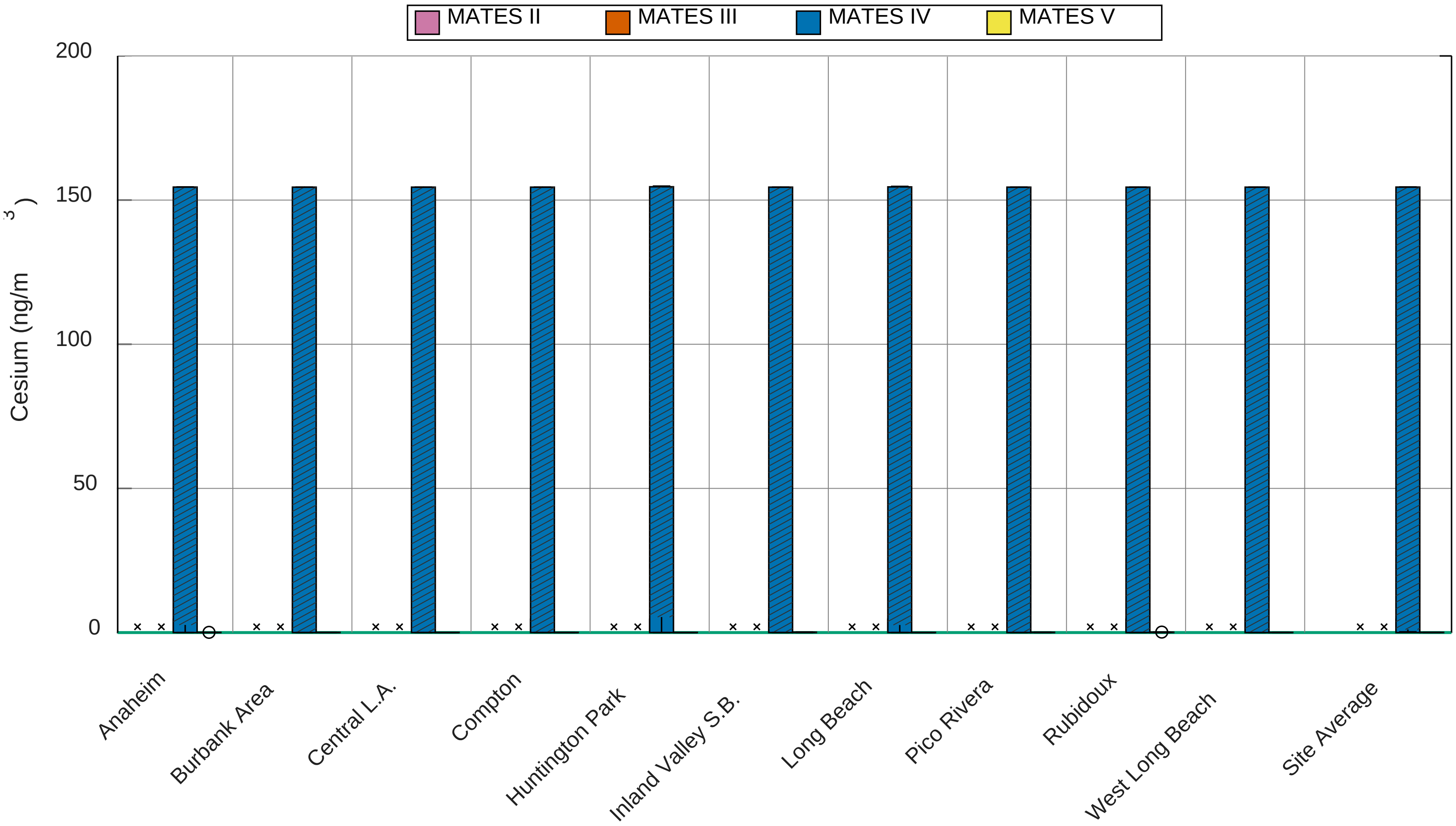


Figure IV-244. Annual Average Concentrations of Cesium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

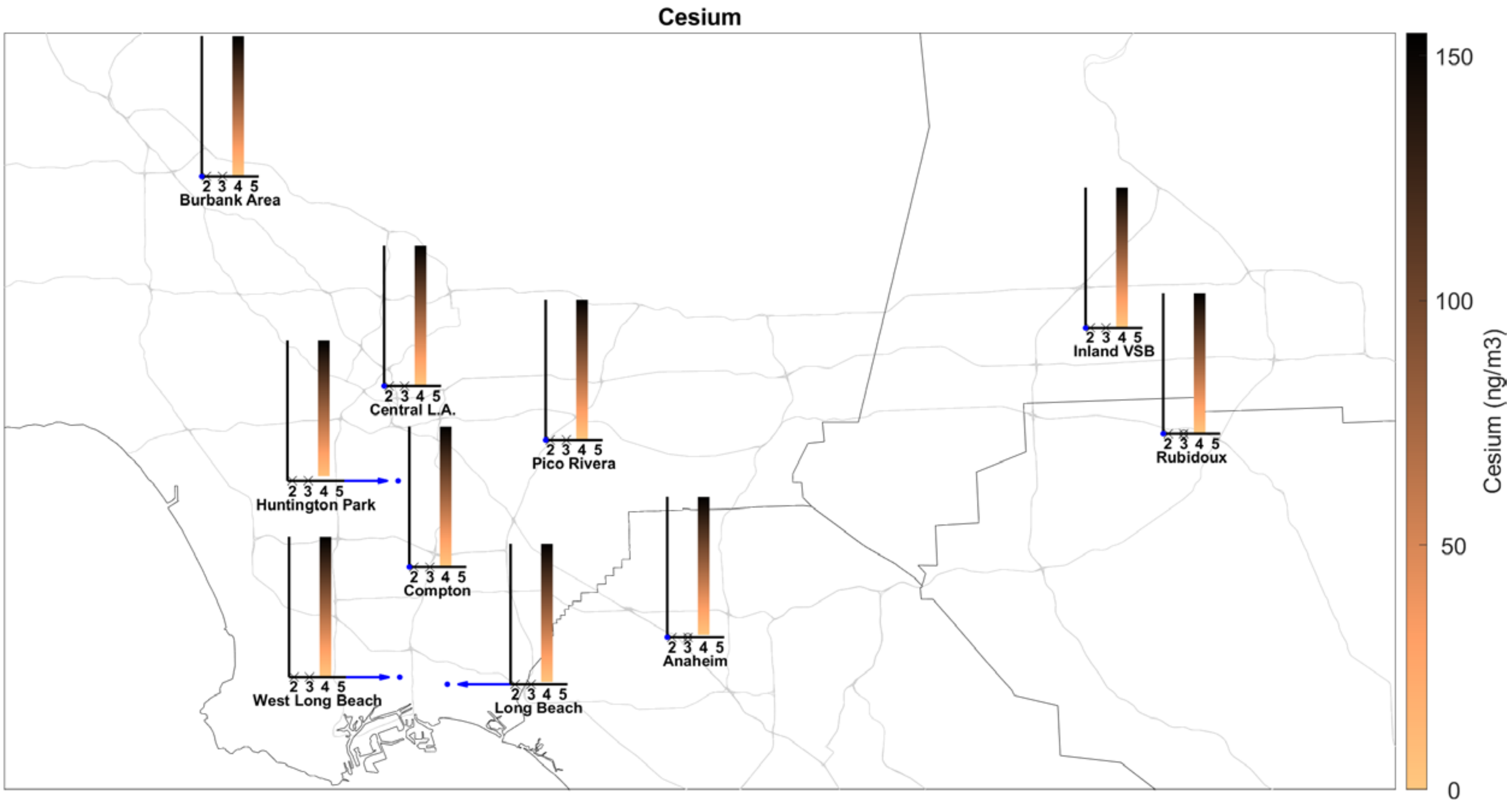


Figure IV-245. Geographic distribution of Cesium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Chlorine

Table IV-125. Ambient Concentrations (ng/m^3) of Chlorine from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	78.7	26.9	88.9	20.5	72.3	128	48	120	17.7	231
95% CI LB	42.3	17	45.7	15.9	38.3	72.5	25.3	43.9	14.5	125
95% CI UB	126	41.5	146	27	118	196	77.5	230	22.1	360
N	59	59	61	60	59	61	60	59	61	61
% < MDL	40.7	59.3	44.3	55	50.8	39.3	53.3	44.1	67.2	45.9
Max	977	357	1250	161	995	1150	609	2460	116	2580
MATES V										
Average	44.2	20.2	53.2	18	40.1	78.6	24.1	28.4	17.9	77
95% CI LB	28.5	15.3	36.1	15.9	27.2	42.7	17.5	19.6	15.3	49
95% CI UB	62.2	26.3	73.7	20.5	56.3	124	34	39.7	21.5	109
N	54	59	61	60	60	61	61	59	56	57
% < MDL	38.9	76.3	32.8	46.7	43.3	41	54.1	45.8	60.7	28.1
Max	278	129	383	63	320	932	252	228	103	486

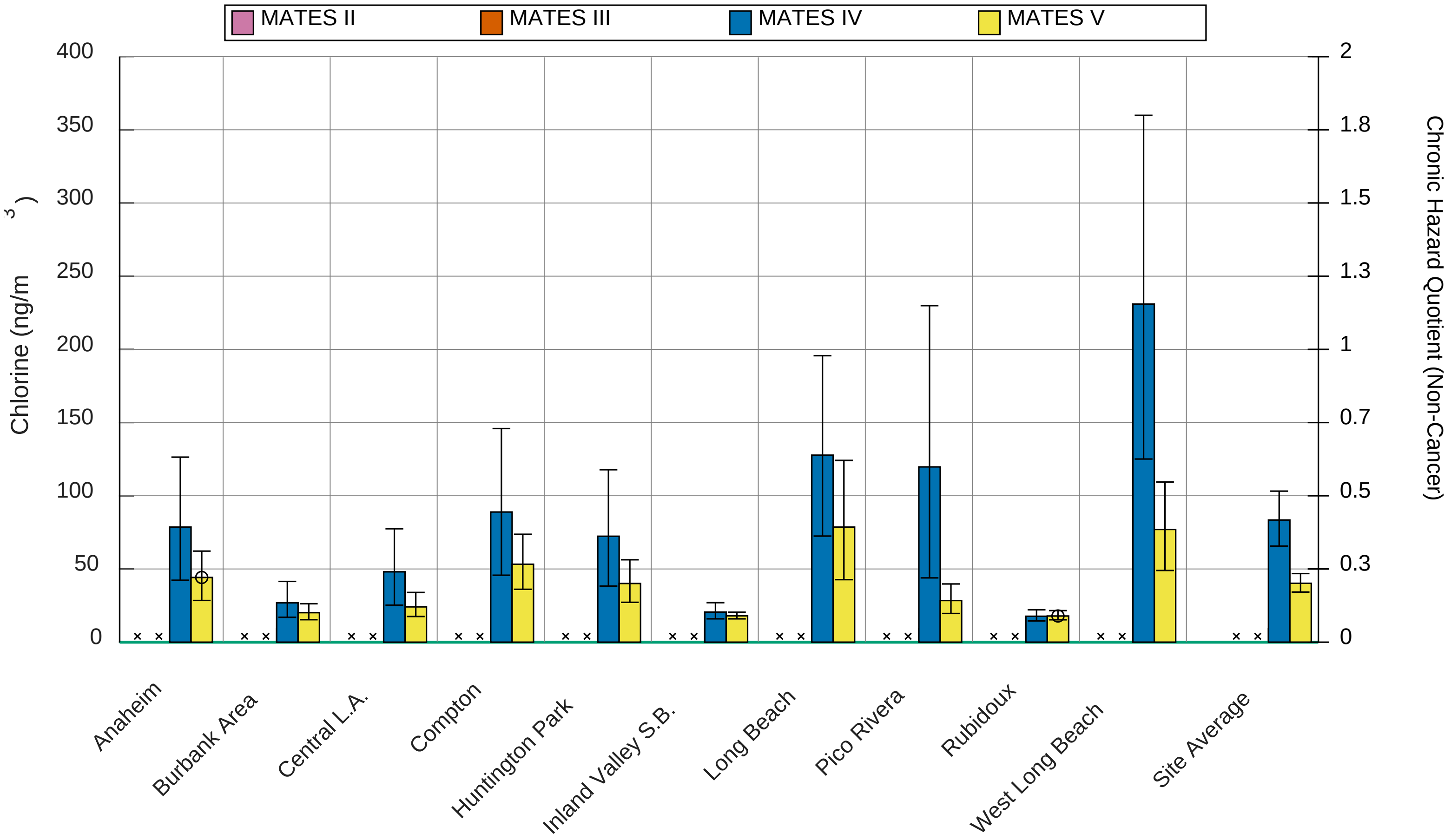


Figure IV-246. Annual Average Concentrations of Chlorine in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

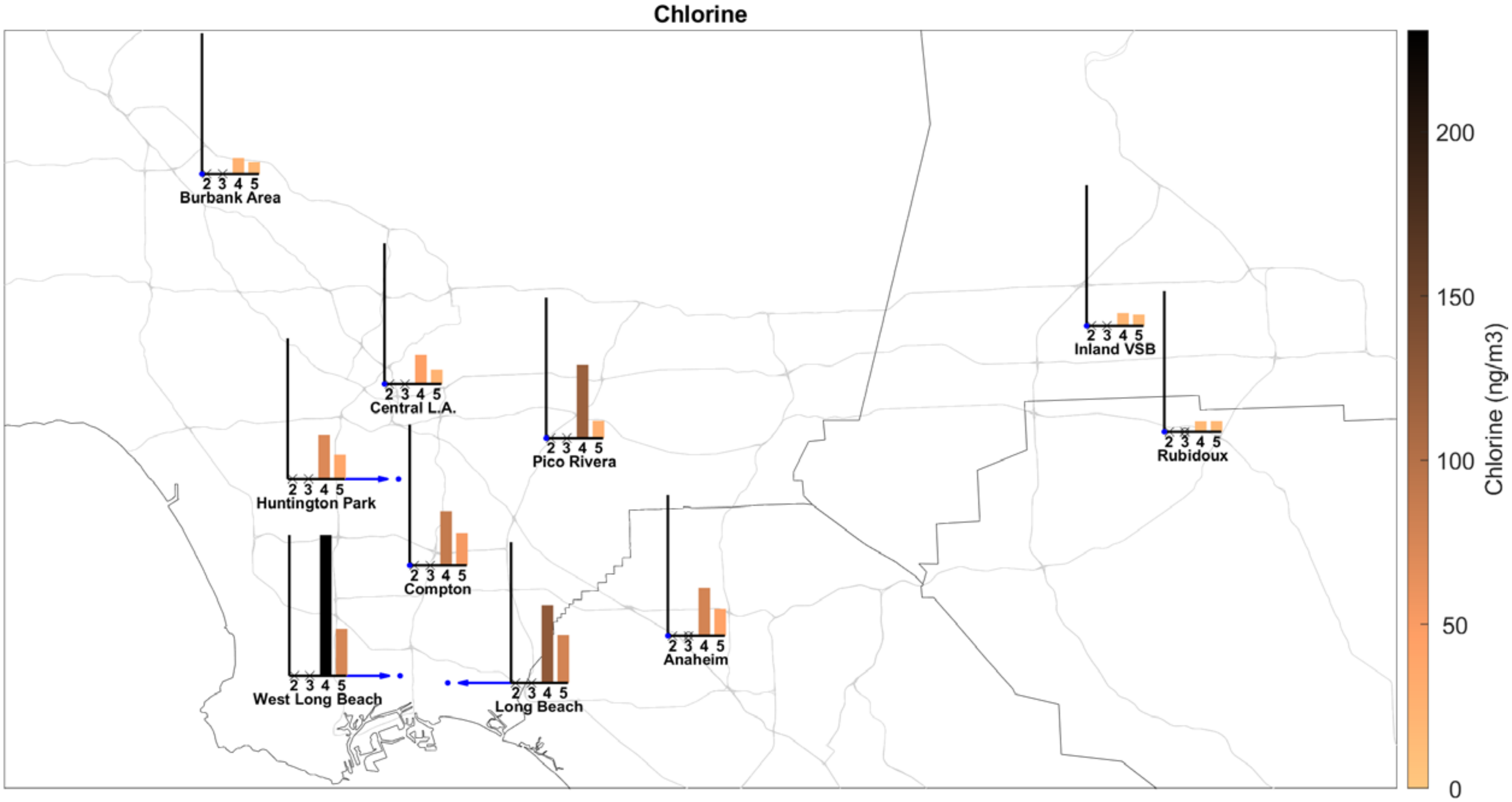


Figure IV-247. Geographic distribution of Chlorine from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Chromium

Table IV-126. Ambient Concentrations (ng/m^3) of Chromium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	2.88	2.71	2.76	3.29	4.57	1.61	2.68	1.86	3.28	3.31
95% CI LB	1.81	1.64	1.82	1.84	3.18	1.43	1.84	1.44	1.82	1.82
95% CI UB	4.35	4.24	4.09	5.43	6.14	1.82	3.94	2.37	5.13	5.26
N	240	239	234	238	117	228	237	116	236	228
% < MDL	55.4	53.6	50	51.3	35	56.1	49.8	45.7	57.2	53.1
Max	111	117	122	192	43.3	9.9	117	17.3	118	121
MATES IV										
Average	0, 1.97[b]	0.186, 3.15[b]	0, 3.66[b]	0, 5.54[b]	3.36, 5.28[b]	1.69, 3.74[b]	0.483, 3.76[b]	0.305, 3.53[b]	0.164, 4.21[b]	0.377, 3.37[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0.89[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	2.21[b]	3.56[b]	4.29[b]	6.46[b]	7.49[b]	5.48[b]	4.14[b]	3.93[b]	5.4[b]	3.84[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	100[b]	98.3[b]	100[b]	100[b]	88.1[b]	95.1[b]	96.7[b]	98.3[b]	98.4[b]	96.7[b]
Max	< MDL[b]	11[b]	< MDL[b]	< MDL[b]	68[b]	76[b]	20[b]	18[b]	10[b]	14[b]
MATES V										
Average	1.17, 2.31[b]	0, 2.69[b]	0.213, 3.32[b]	0, 5.83[b]	0.383, 3.14[b]	0.0984, 2.95[b]	0, 3.03[b]	0.373, 4.19[b]	0, 3.6[b]	0, 3.63[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	2.66[b]	3.03[b]	4.01[b]	6.83[b]	3.92[b]	3.66[b]	3.41[b]	4.71[b]	4.12[b]	4.38[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	98.1[b]	100[b]	96.7[b]	100[b]	98.3[b]	98.4[b]	100[b]	96.6[b]	100[b]	100[b]
Max	63[b]	< MDL[b]	7[b]	< MDL[b]	23[b]	6[b]	< MDL[b]	13[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

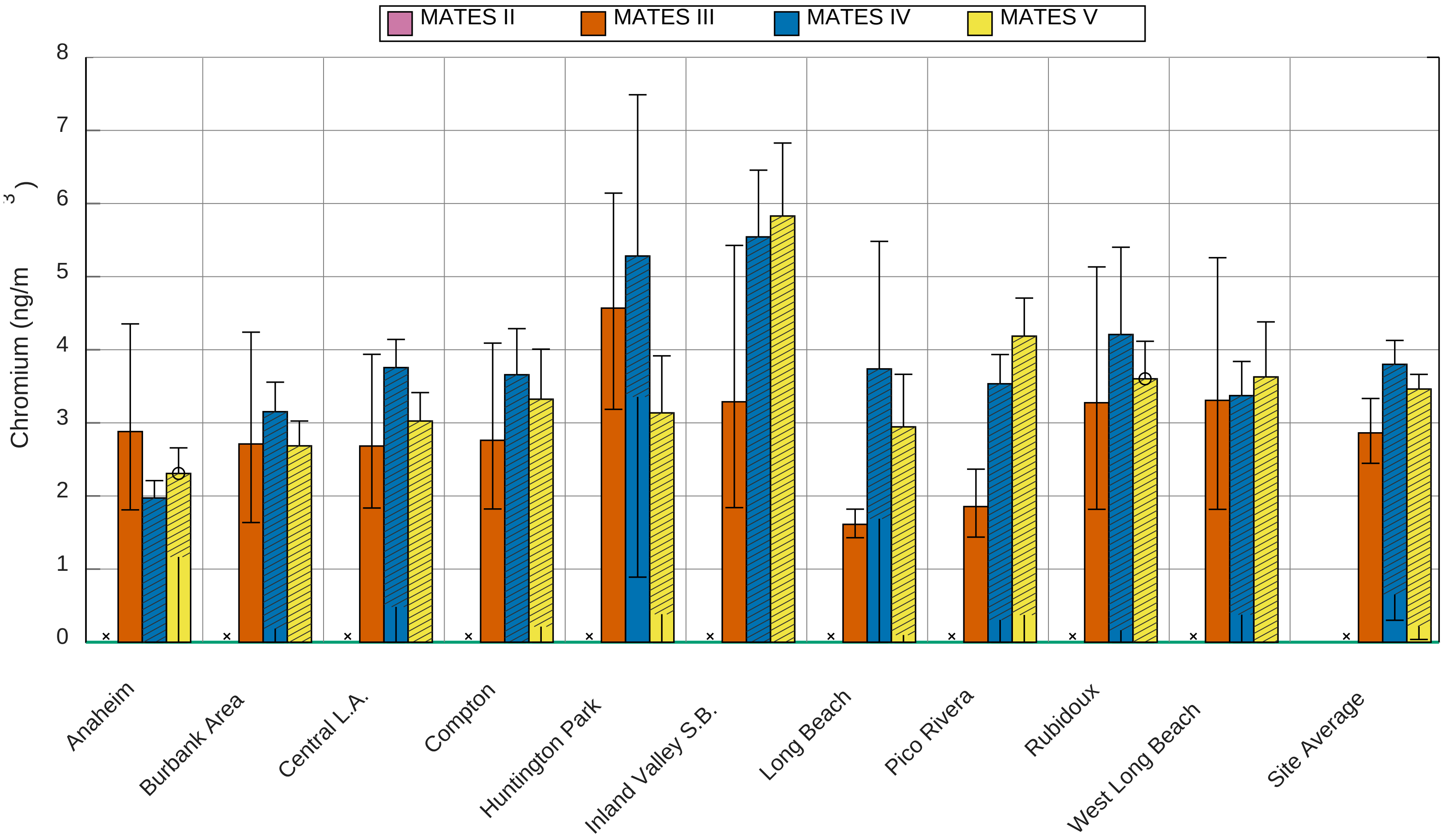


Figure IV-248. Annual Average Concentrations of Chromium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

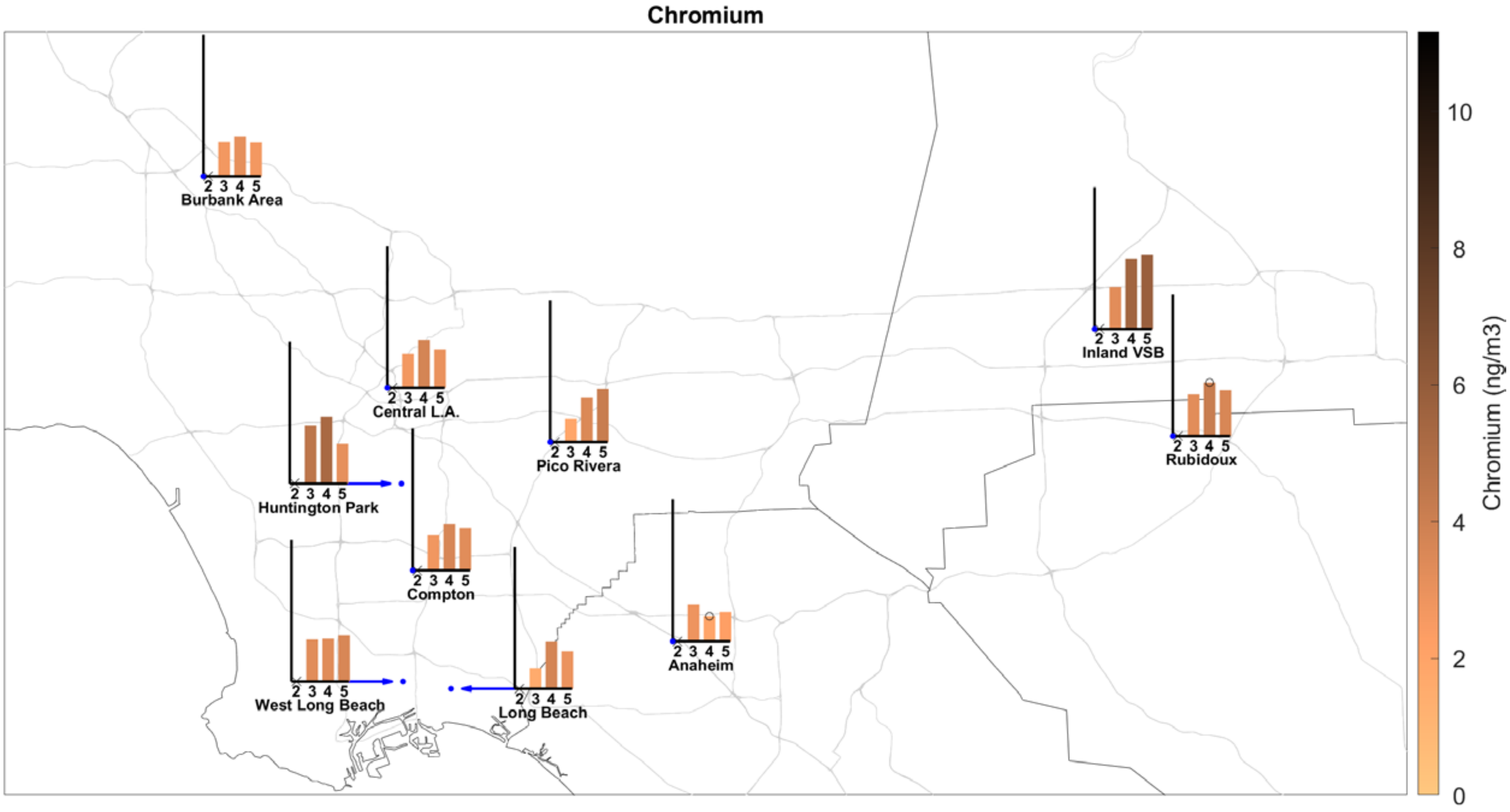


Figure IV-249. Geographic distribution of Chromium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Cobalt

Table IV-127. Ambient Concentrations (ng/m^3) of Cobalt from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	1.06	1.14	1.08	1.2	1.32	1.09	1.17	1.26	1.16	1.24
95% CI LB	0.969	1.03	0.983	1.11	1.18	0.999	1.08	1.11	1.07	1.13
95% CI UB	1.16	1.26	1.17	1.31	1.48	1.19	1.26	1.4	1.25	1.37
N	240	239	234	238	117	228	237	116	236	228
% < MDL	42.1	40.6	41	34	25.6	40.4	24.5	31	36.9	32.9
Max	3.72	6.2	3.72	4.94	3.72	3.71	4.95	4.95	3.72	6.16
MATES IV										
Average	0, 0.217[b]	0, 0.482[b]	0, 0.414[b]	0, 0.792[b]	0, 0.458[b]	0, 0.367[b]	0, 0.426[b]	0, 0.461[b]	0, 0.646[b]	0, 0.562[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.252[b]	0.572[b]	0.477[b]	0.904[b]	0.543[b]	0.425[b]	0.478[b]	0.522[b]	0.791[b]	0.716[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]
MATES V										
Average	0, 0.329[b]	0, 0.454[b]	0, 0.452[b]	0, 0.804[b]	0, 0.366[b]	0, 0.751[b]	0, 0.4[b]	0, 0.674[b]	0, 0.594[b]	0, 0.636[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.38[b]	0.519[b]	0.527[b]	0.96[b]	0.431[b]	1.01[b]	0.455[b]	0.784[b]	0.675[b]	0.79[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

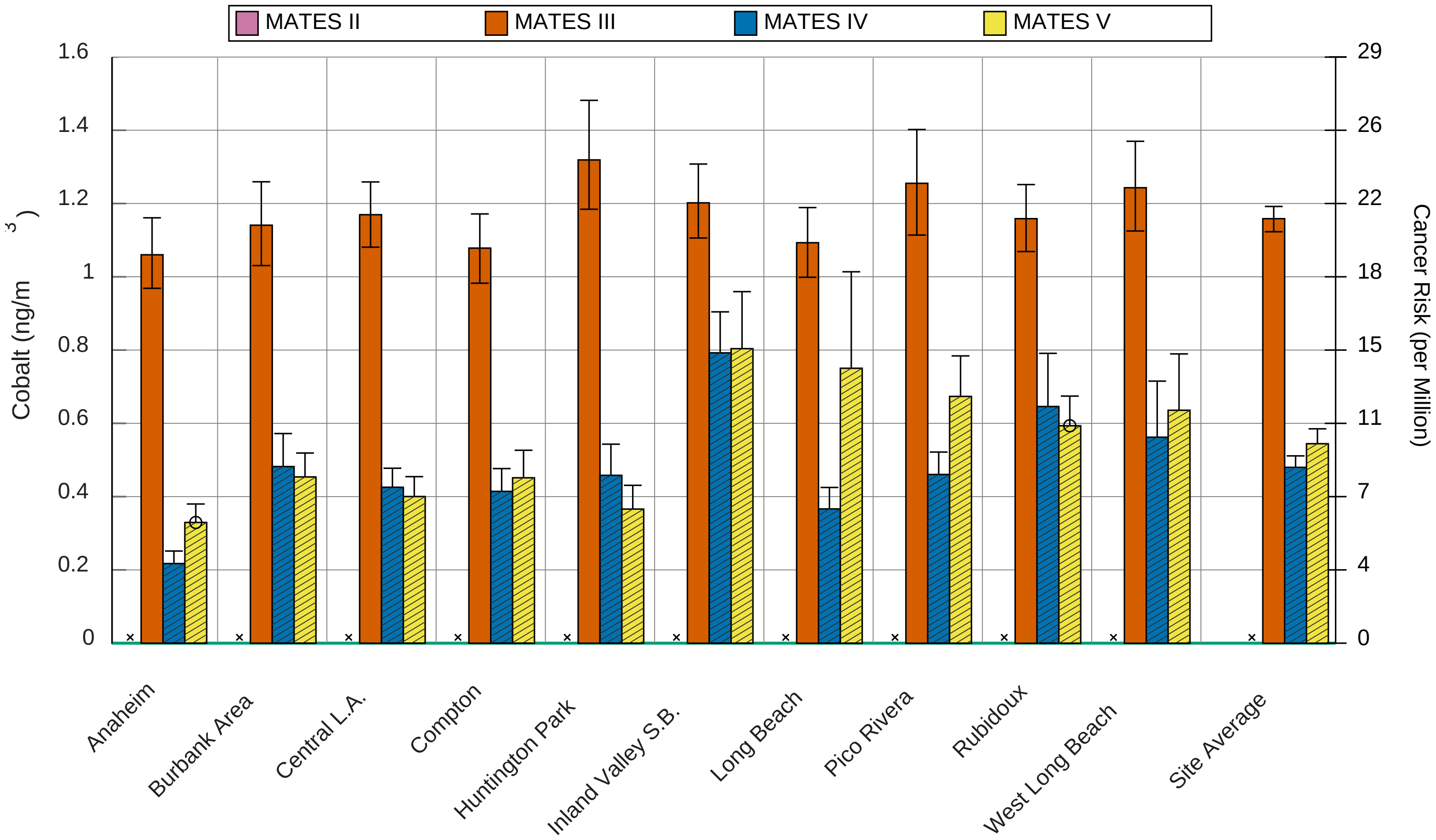


Figure IV-250. Annual Average Concentrations of Cobalt in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

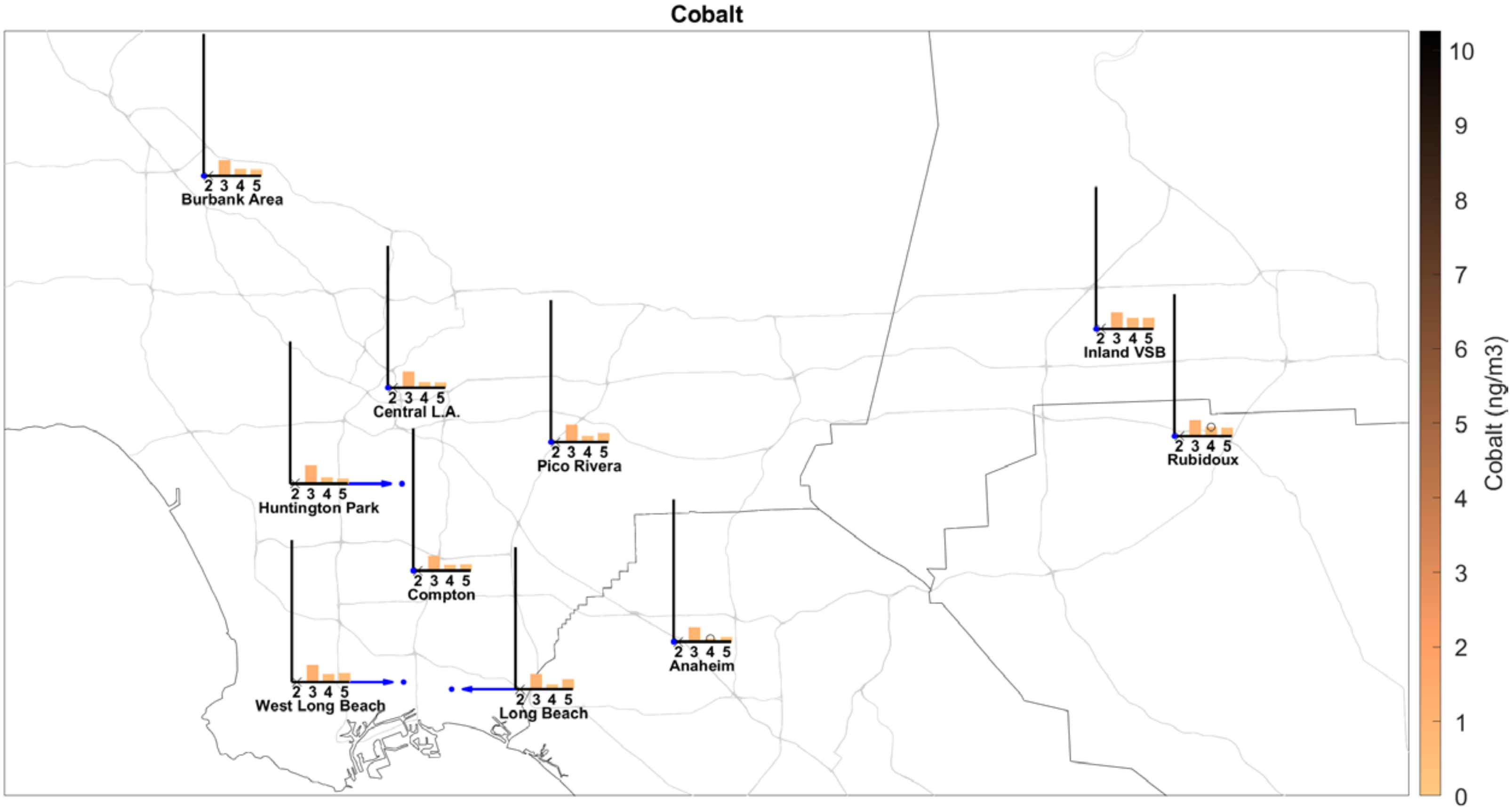


Figure IV-251. Geographic distribution of Cobalt from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Copper

Table IV-128. Ambient Concentrations (ng/m^3) of Copper from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	11	27.1	12.4	29.6	53.9	19.4	20.6	15.8	19	14.6
95% CI LB	9.61	25.5	11.2	19	50	18.1	18.7	12.9	15.9	13.2
95% CI UB	12.8	28.9	13.8	46.7	57.9	20.8	22.6	20.6	24.1	16.2
N	240	239	234	238	117	228	237	116	236	228
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	188	181	108	1640	146	54.4	143	266	544	122
MATES IV										
Average	2.32, 17.3[b]	3.83, 38[b]	2.56, 29.6[b]	13.2	17.8	2.25, 32[b]	13.5	15.1	1.18, 33.4[b]	3.61, 31.6[b]
95% CI LB	0.627[b]	1.83[b]	0.918[b]	12.2	13.8	0.852[b]	12.5	13.9	0.246[b]	1.64[b]
95% CI UB	21.5[b]	45.1[b]	34.8[b]	14.8	24.4	49[b]	14.8	16.5	40.8[b]	42[b]
N	59[b]	59[b]	61[b]	60	59	61[b]	60	59	61[b]	61[b]
% < MDL	89.8[b]	81.4[b]	86.9[b]	68.3	72.9	86.9[b]	70	49.2	91.8[b]	82[b]
Max	35[b]	28[b]	33[b]	51	175	24[b]	30	29	21[b]	44[b]
MATES V										
Average	9.56	7.97	9.84	8.47	10.1	8.69	9.84	9.61	9.93	9.05
95% CI LB	8.41	7.49	8.74	7.82	8.79	7.77	8.65	8.53	8.21	8.16
95% CI UB	10.7	8.49	11.1	9.27	11.6	9.75	11.2	10.9	12.2	10.1
N	54	59	61	60	60	61	61	59	56	57
% < MDL	57.4	59.3	57.4	50	53.3	67.2	55.7	50.8	66.1	56.1
Max	26	14	24	20	32	22	27	29	63	22

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

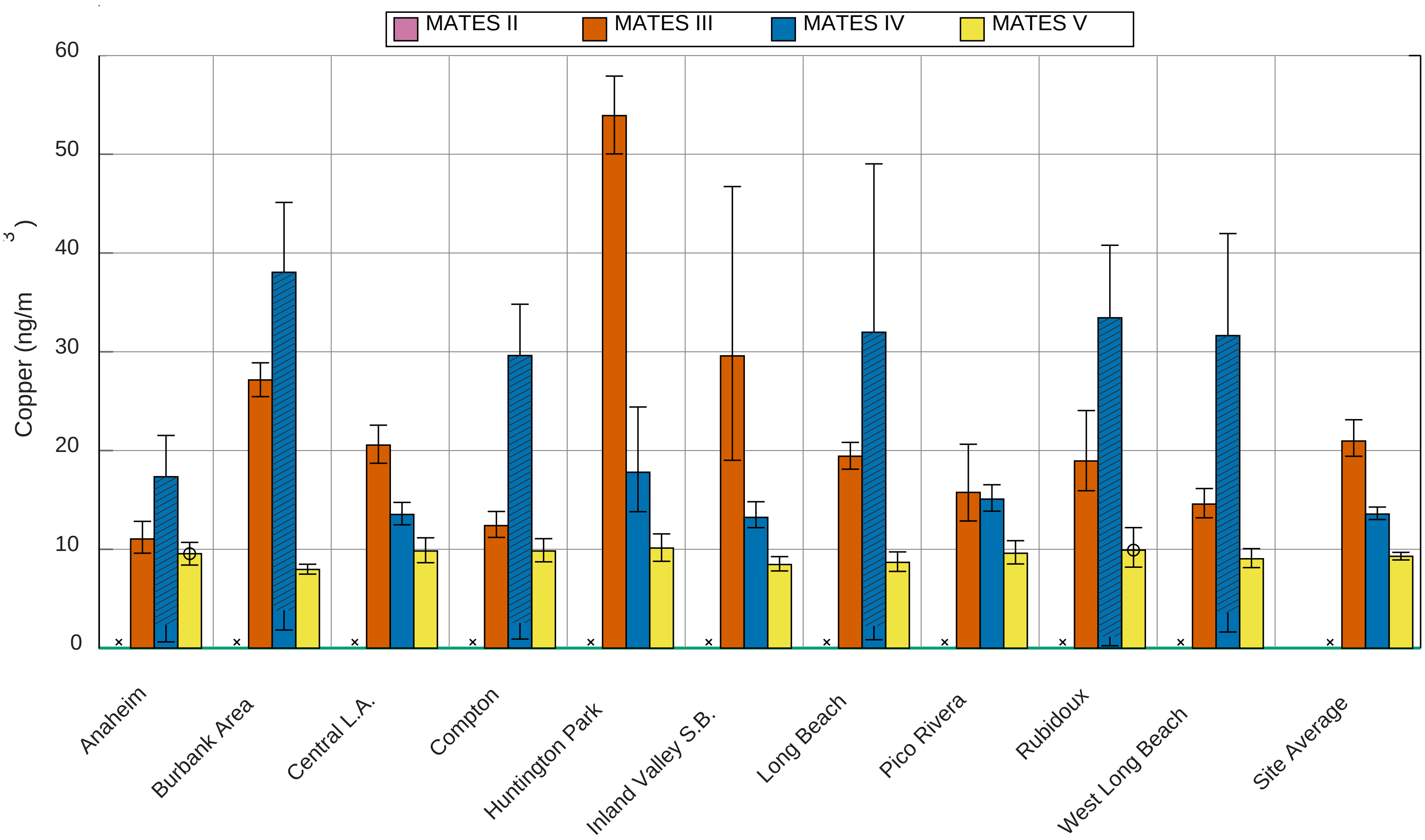


Figure IV-252. Annual Average Concentrations of Copper in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

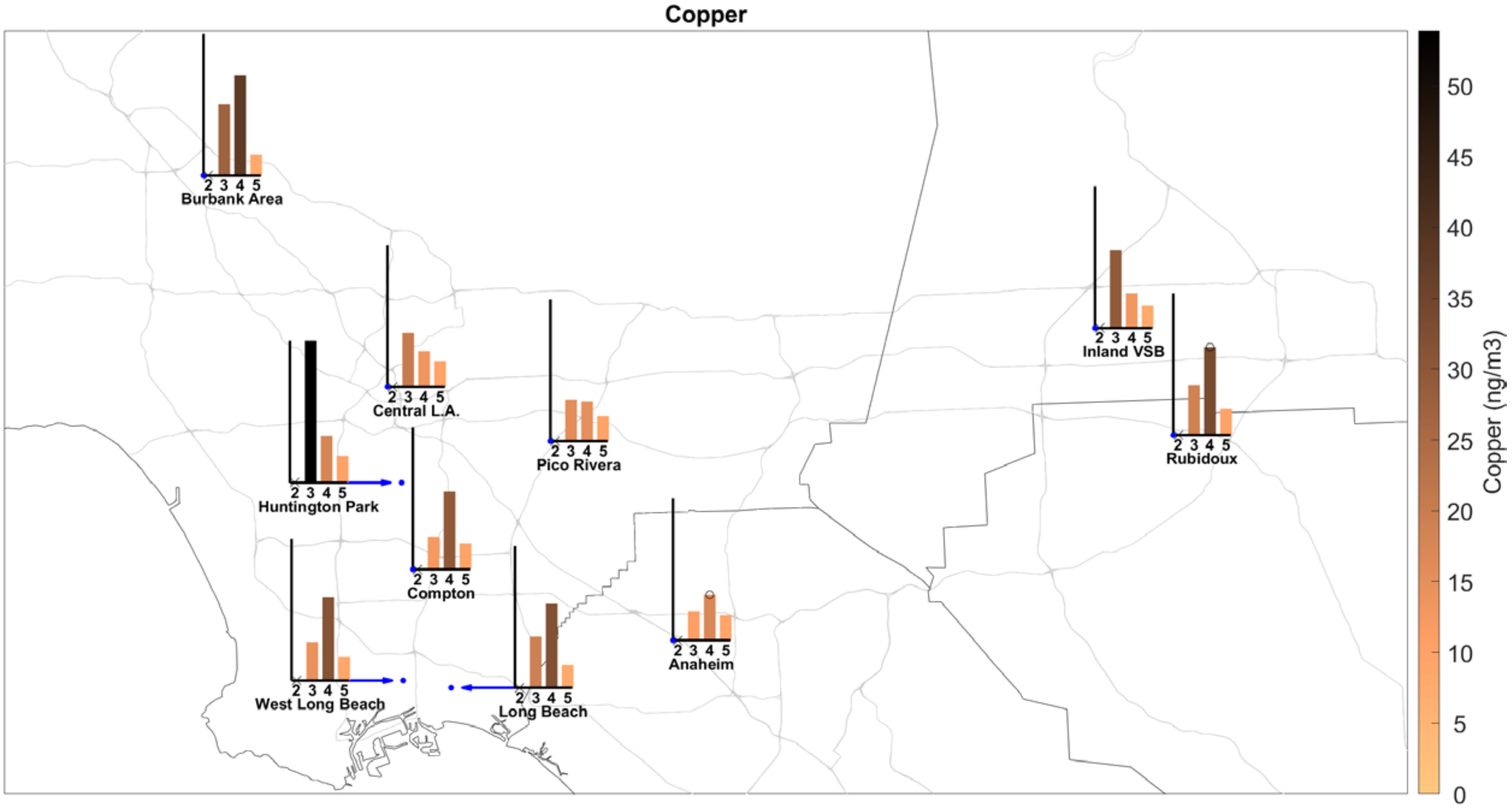


Figure IV-253. Geographic distribution of Copper from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Indium

Table IV-129. Ambient Concentrations (ng/m^3) of Indium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	4.37	4.24	3.89	4.45	2.46	3.25	3.85	2.7	3.6	3.77
95% CI LB	3.61	3.56	3.25	3.68	2.07	2.71	3.24	2.3	2.96	3.14
95% CI UB	5.18	4.89	4.55	5.27	2.9	3.85	4.53	3.21	4.31	4.45
N	240	239	234	238	117	228	237	116	236	228
% < MDL	36.3	36	38.9	32.8	33.3	39.5	32.1	31.9	42.4	35.1
Max	35.8	29.6	30.8	35.8	11.1	33.4	29.1	11.1	33.5	28.3
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

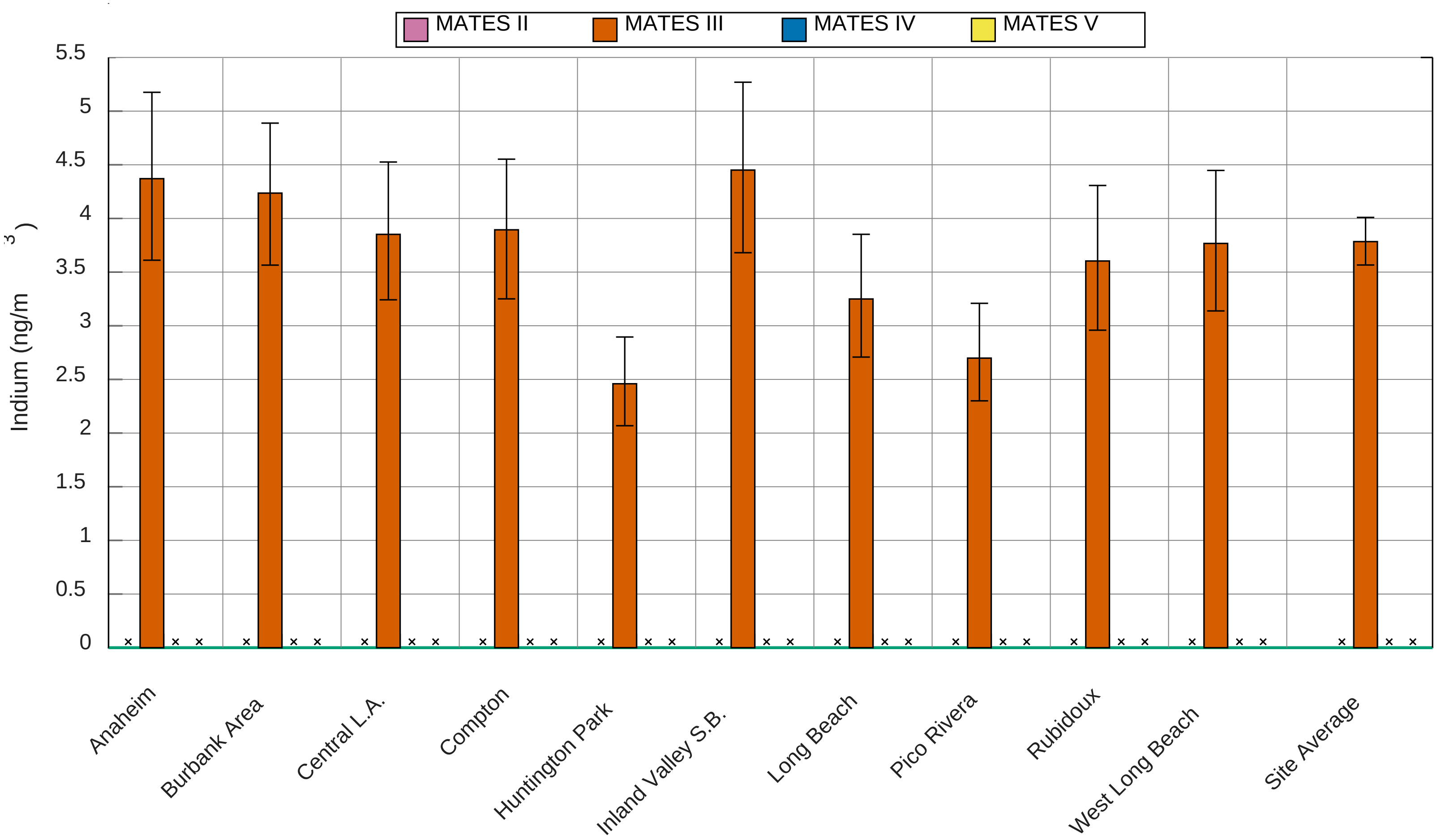


Figure IV-254. Annual Average Concentrations of Indium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

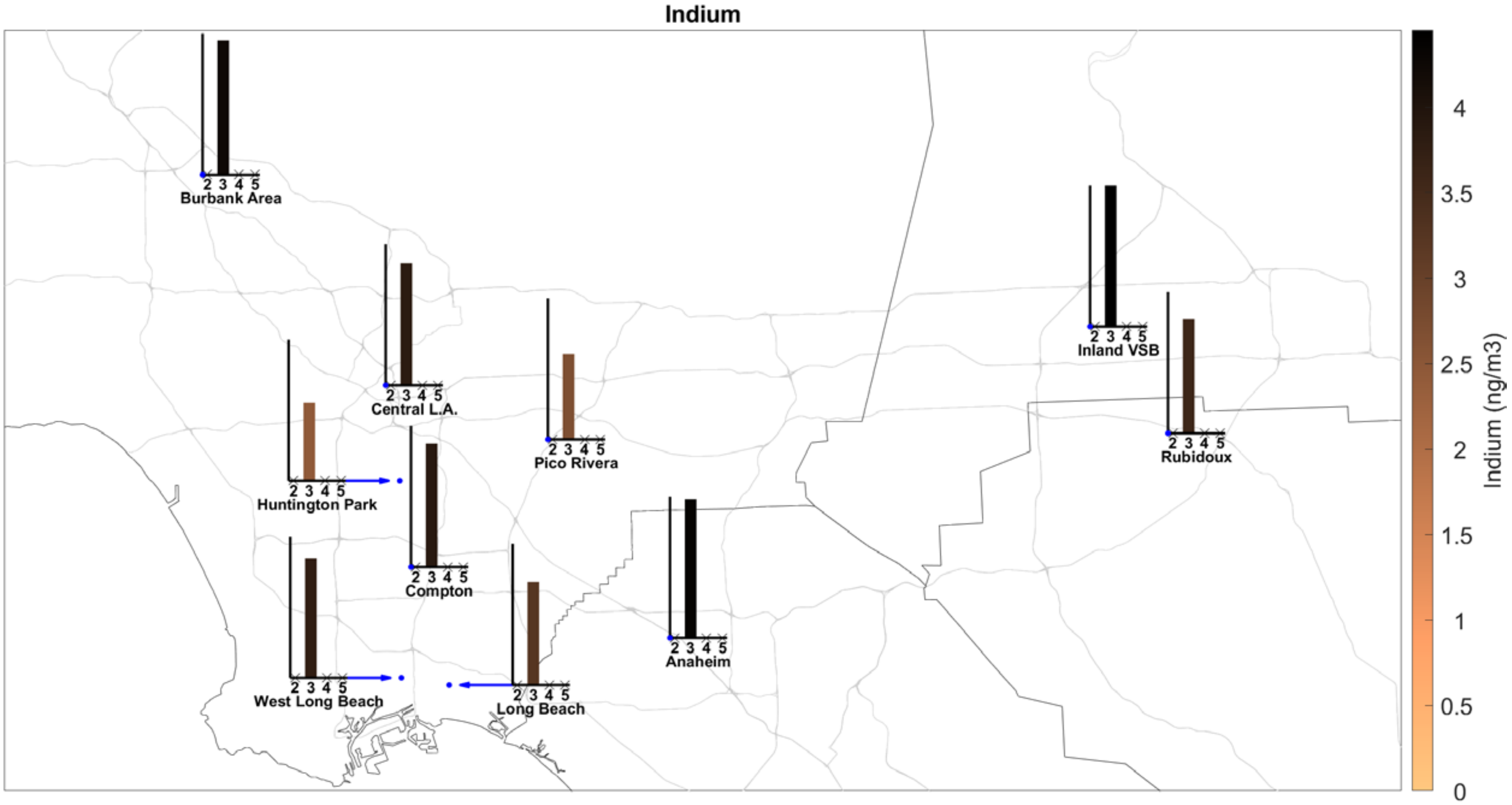


Figure IV-255. Geographic distribution of Indium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Iron

Table IV-130. Ambient Concentrations (ng/m^3) of Iron from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	AN	BU	CP	SB	HP	LB	LA	PR	RU	WLB
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	74	128	76.3	164	95.4	76.2	131	109	84.4	77.2
95% CI LB	63.2	113	65.1	151	75.1	66.3	118	91.9	74.5	63.9
95% CI UB	85.3	146	88.8	179	118	87.7	146	126	94.3	91.5
N	240	239	234	238	117	228	237	116	236	228
% < MDL	6.7	0.8	5.1	0.8	0.9	0.9	0.8	0	3	10.5
Max	561	1500	817	823	816	441	687	398	539	651
MATES IV										
Average	99.1	145	91.3	184	135	96.2	153	136	117	148
95% CI LB	74.5	123	65.4	157	103	75.6	125	113	97.8	113
95% CI UB	129	172	126	214	175	120	185	160	138	188
N	59	59	61	60	59	61	60	59	61	61
% < MDL	5.1	1.7	1.6	0	3.4	0	1.7	1.7	1.6	0
Max	608	472	716	657	612	399	653	379	474	1060
MATES V										
Average	100	90.4	107	166	107	76.2	124	137	136	132
95% CI LB	80.8	79.8	87.3	145	89.8	62.7	109	118	114	112
95% CI UB	121	101	128	189	126	91.3	141	159	158	152
N	54	59	61	60	60	61	61	59	56	57
% < MDL	0	3.4	0	0	0	1.6	1.6	0	0	1.8
Max	346	189	374	394	329	247	362	436	429	371

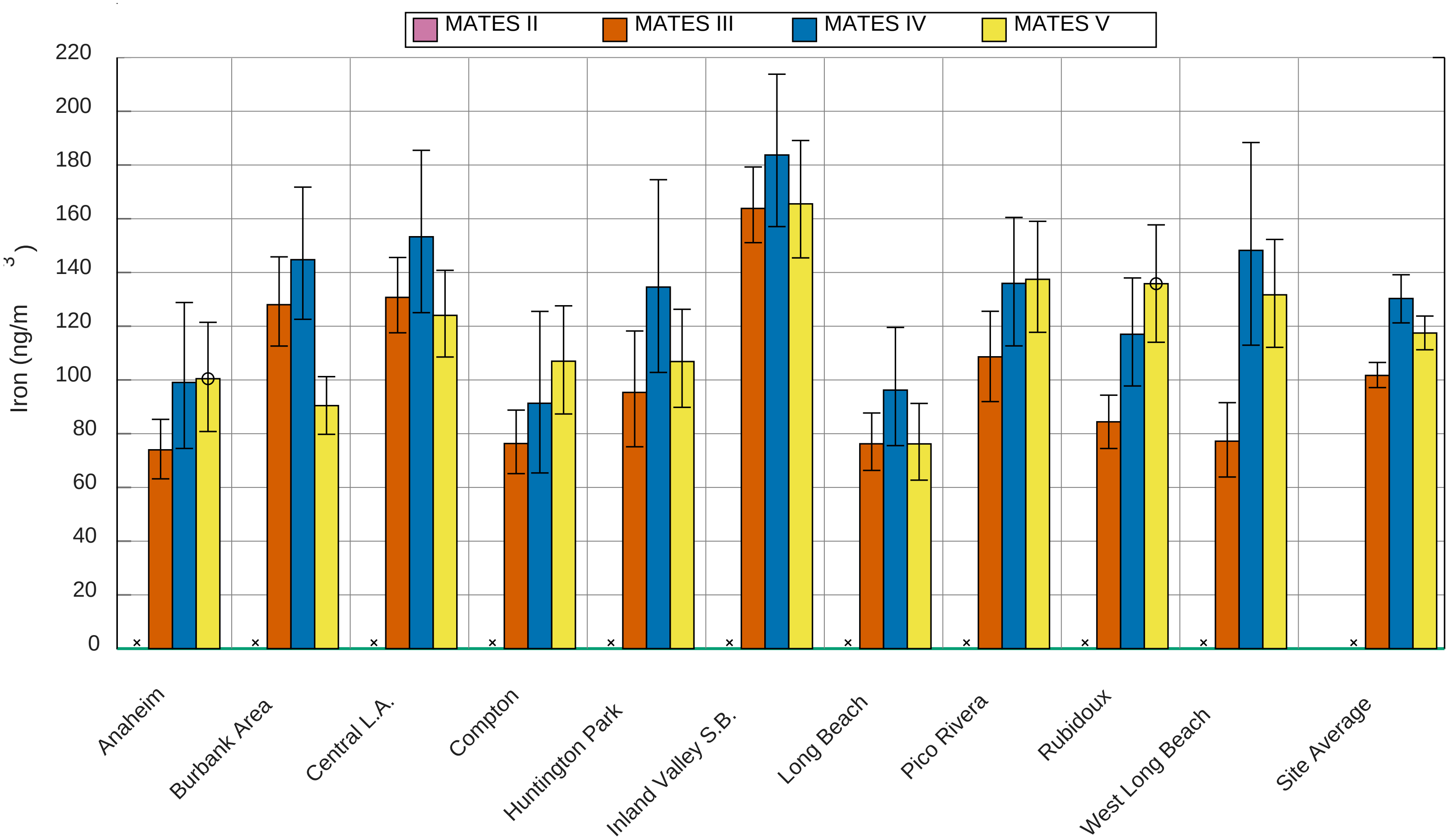


Figure IV-256. Annual Average Concentrations of Iron in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

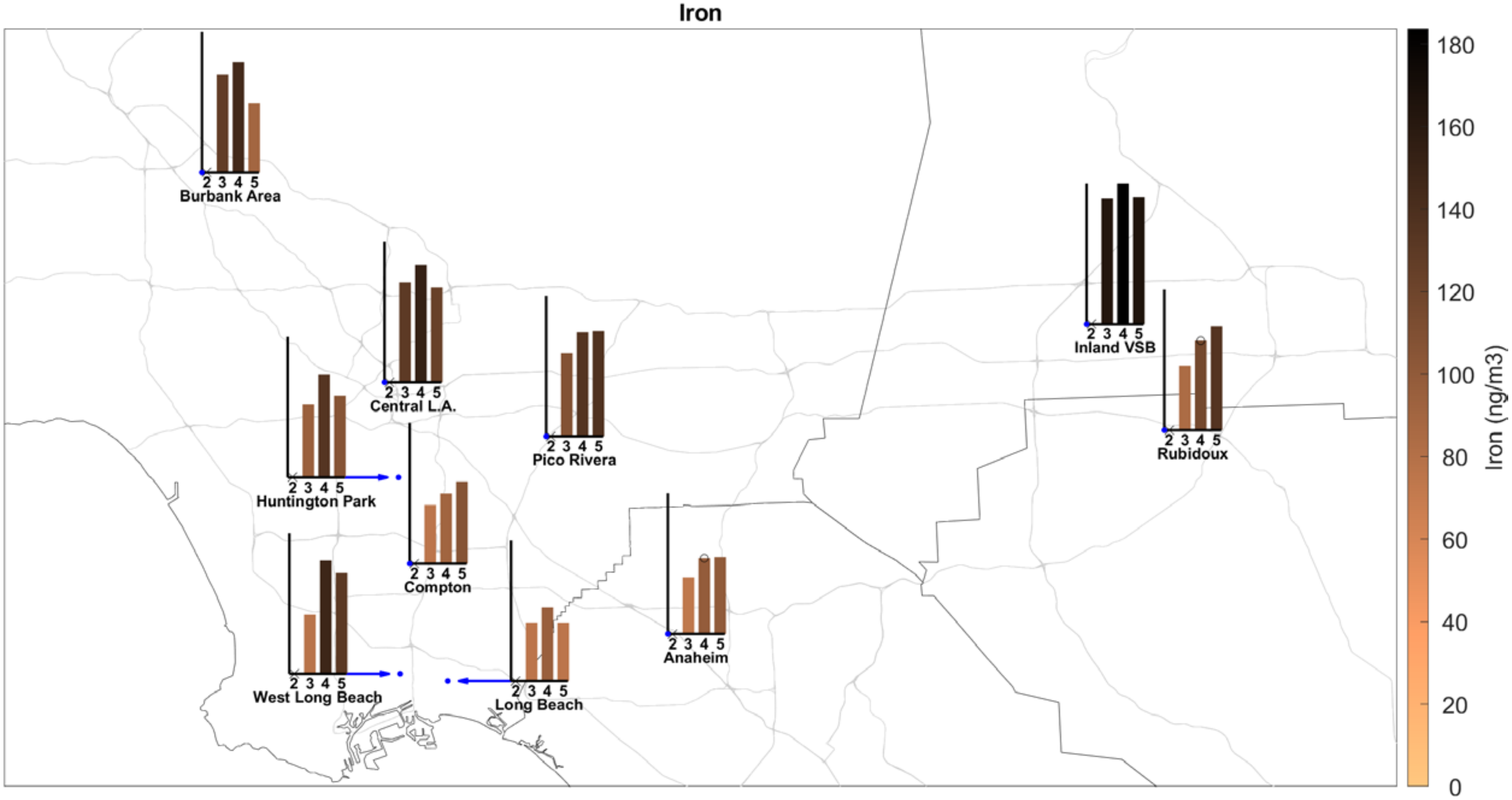


Figure IV-257. Geographic distribution of Iron from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Lead

Table IV-131. Ambient Concentrations (ng/m^3) of Lead from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	4.59	5.54	7.19	10.3	9.47	5.57	5.98	7.33	7.08	8.8
95% CI LB	4.24	5.14	6.42	8.87	7.71	5.09	5.6	6.36	6.26	5.52
95% CI UB	4.98	5.99	8.06	12	11.9	6.09	6.39	8.47	8.05	14.8
N	240	239	234	238	117	228	237	116	236	228
% < MDL	47.9	36.4	34.2	21	18.8	43	20.3	19	28	41.7
Max	33.4	34.7	57	132	113	24.7	19.8	54.4	77	646
MATES IV										
Average	0, 2.12[b]	0, 5.27[b]	0, 6.24[b]	0, 9.8[b]	0, 9.46[b]	0, 4.4[b]	0, 7.34[b]	0, 5.89[b]	0, 6.21[b]	0.541, 5.83[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	2.44[b]	6.02[b]	7.42[b]	11[b]	12.8[b]	5.02[b]	8.19[b]	6.51[b]	7.46[b]	7.57[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	98.4[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	33[b]
MATES V										
Average	0, 2.72[b]	0.593, 6.87[b]	0, 4.81[b]	1.07, 7.66[b]	0, 5.75[b]	0, 3.19[b]	0.262, 4.97[b]	0.271, 4.73[b]	0, 4.46[b]	0, 4.02[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	3.19[b]	7.75[b]	5.83[b]	8.89[b]	9.35[b]	3.96[b]	5.83[b]	5.46[b]	5.17[b]	5.17[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	96.6[b]	100[b]	95[b]	100[b]	100[b]	98.4[b]	98.3[b]	100[b]	100[b]
Max	< MDL[b]	18[b]	< MDL[b]	31[b]	< MDL[b]	< MDL[b]	16[b]	16[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

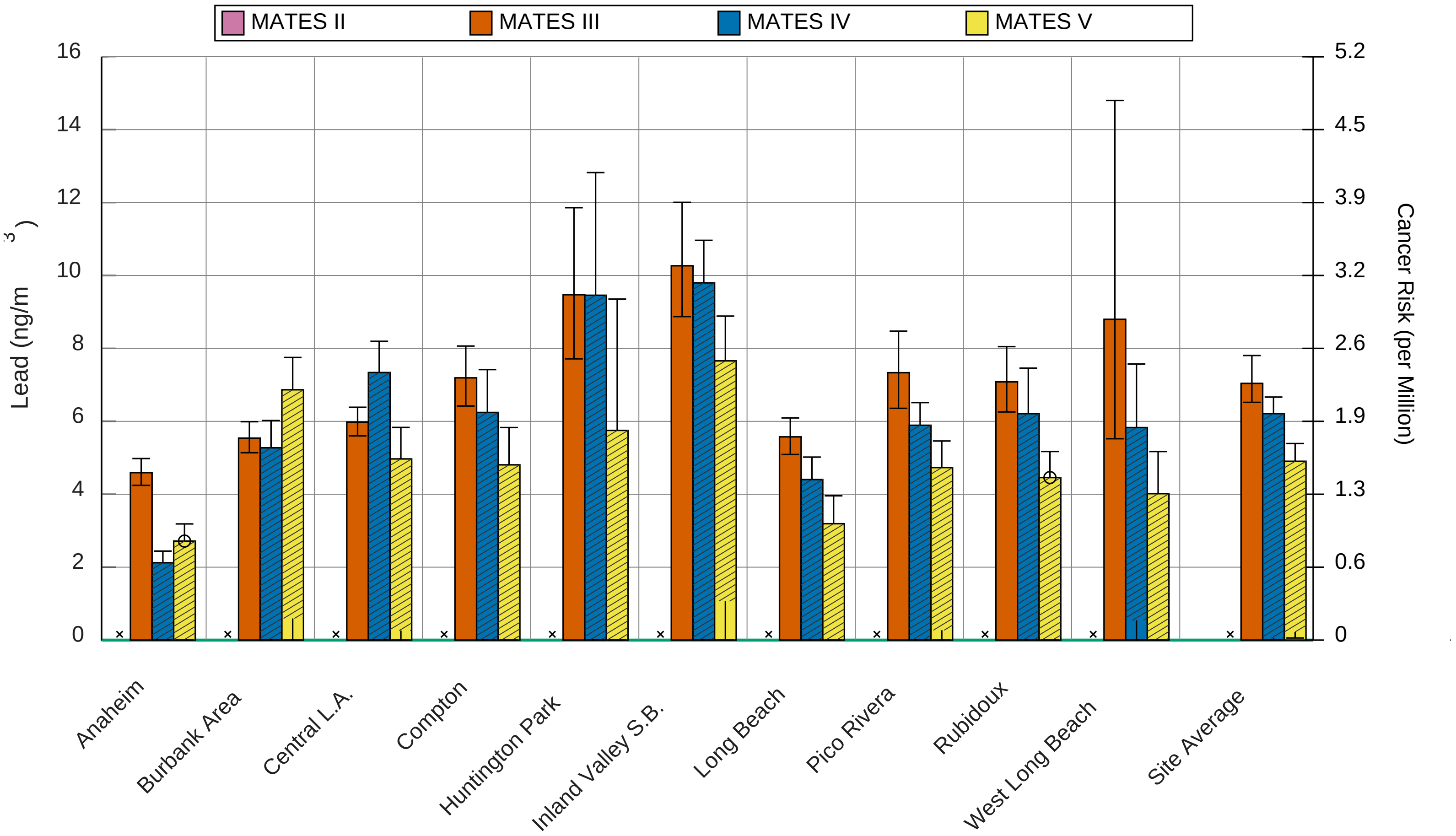


Figure IV-258. Annual Average Concentrations of Lead in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

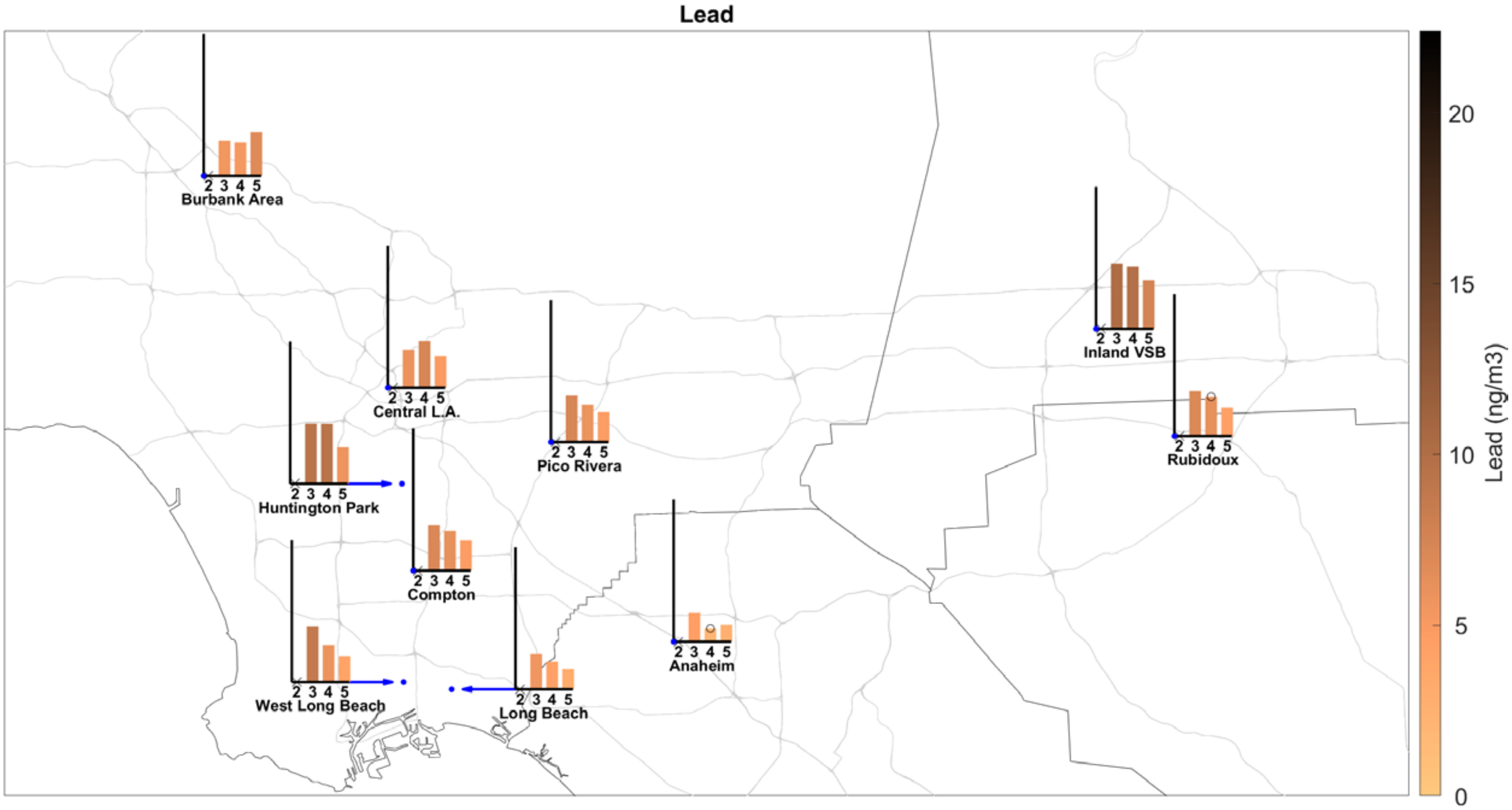


Figure IV-259. Geographic distribution of Lead from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Magnesium

Table IV-132. Ambient Concentrations (ng/m^3) of Magnesium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	83.7	79.4	90.7	85.8	86.1	93.5	86.8	86.2	87.1	92.1
95% CI LB	77.1	74.6	82.9	79.2	79.3	85.5	80.5	80.1	79.7	84.2
95% CI UB	91.5	84.5	99	93.2	94.1	102	93.2	93	95.2	100
N	54	59	61	60	60	61	61	59	56	57
% < MDL	48.1	55.9	45.9	46.7	51.7	41	49.2	50.8	44.6	42.1
Max	194	138	184	199	214	259	181	189	219	199

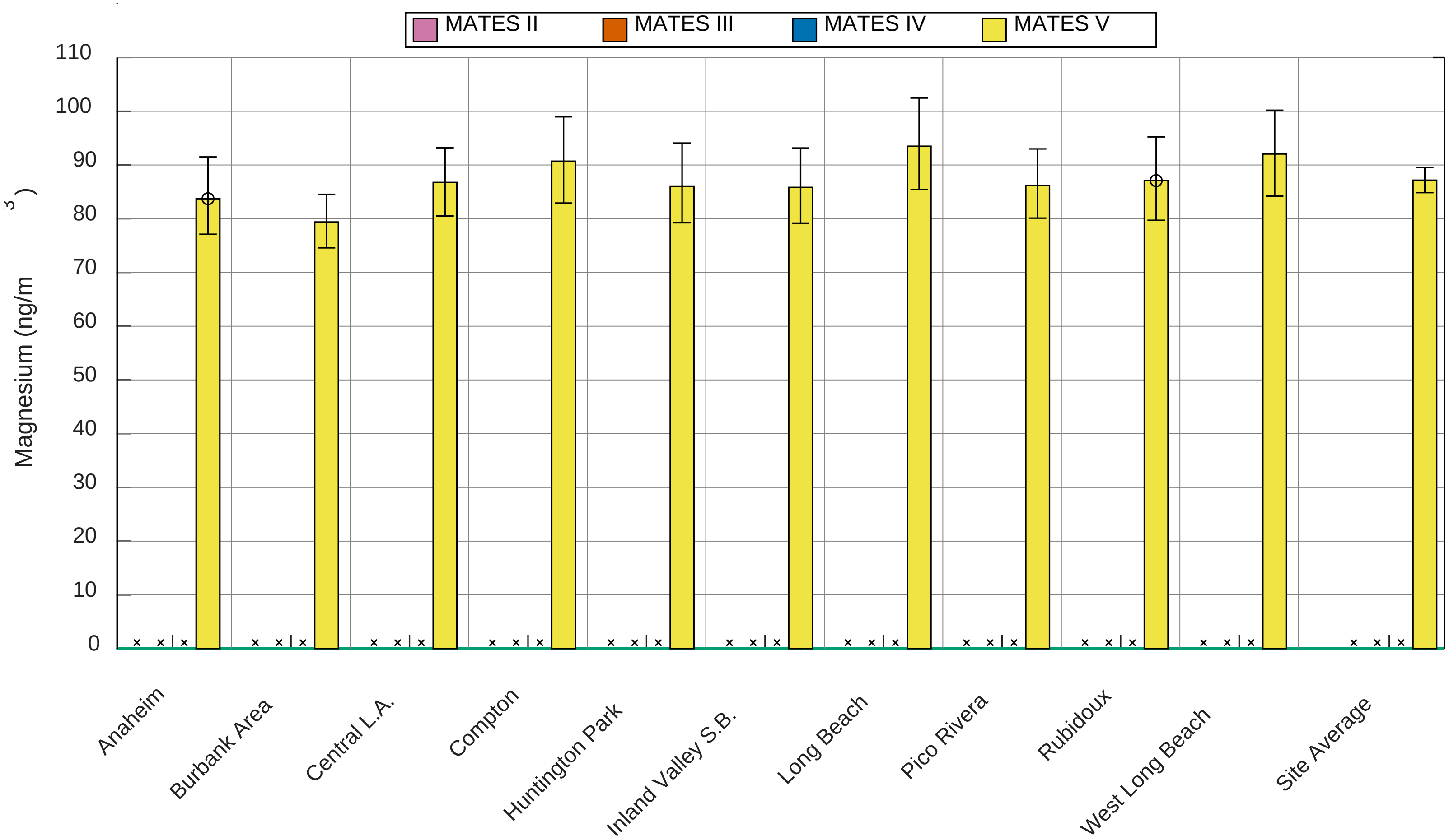


Figure IV-260. Annual Average Concentrations of Magnesium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

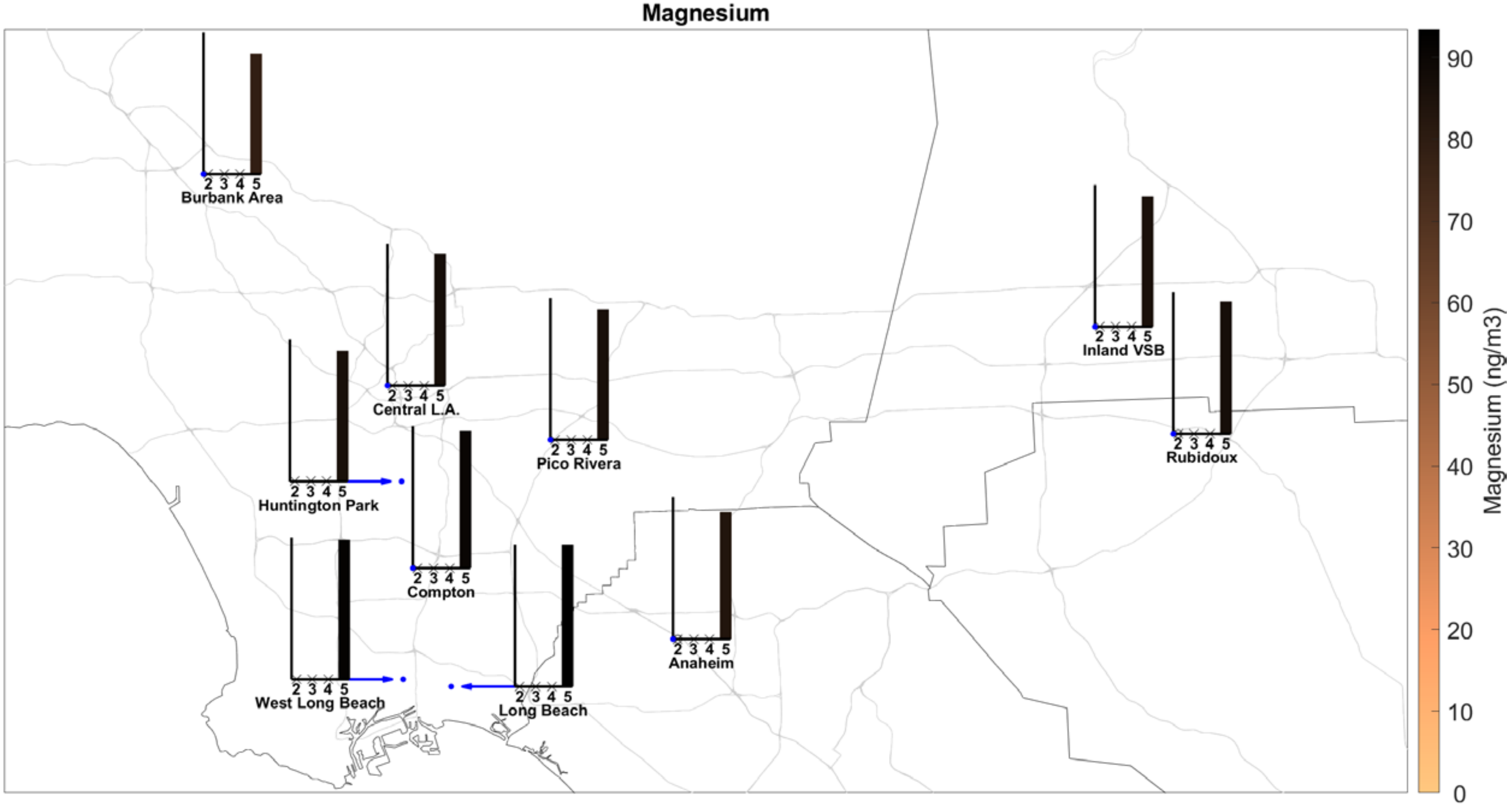


Figure IV-261. Geographic distribution of Magnesium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Manganese

Table IV-133. Ambient Concentrations (ng/m^3) of Manganese from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	2.88	3.3	3.99	6.84	6.55	2.56	5.02	4.16	3.8	3.41
95% CI LB	2.46	2.79	3.41	6.13	5.07	2.23	4.43	3.62	3.24	2.83
95% CI UB	3.4	3.92	4.63	7.6	8.22	2.93	5.64	4.75	4.5	4.1
N	240	239	234	238	117	228	237	116	236	228
% < MDL	29.6	23.4	21.8	14.3	6.8	30.7	14.3	6.9	19.9	26.3
Max	37	40.8	52.9	46.9	44.5	12.4	43.7	13.6	43.2	41.9
MATES IV										
Average	0.915, 8.32[b]	0, 15.2[b]	0, 18.6[b]	3.65, 52[b]	4.42, 22.7[b]	0.525, 14.4[b]	1.7, 19.2[b]	1.76, 21.2[b]	0.279, 33[b]	0.869, 21.3[b]
95% CI LB	0[b]	0[b]	0[b]	1.77[b]	1.34[b]	0[b]	0.533[b]	0.542[b]	0[b]	0[b]
95% CI UB	9.73[b]	17.3[b]	22[b]	60.1[b]	28.6[b]	16.5[b]	21.5[b]	23.8[b]	40.1[b]	24.9[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	94.9[b]	100[b]	100[b]	81.7[b]	88.1[b]	96.7[b]	90[b]	89.8[b]	98.4[b]	95.1[b]
Max	23[b]	< MDL[b]	< MDL[b]	32[b]	82[b]	16[b]	22[b]	23[b]	17[b]	18[b]
MATES V										
Average	0.167, 14.3[b]	0, 19.3[b]	0, 17.8[b]	0.7, 54.1[b]	0, 14.7[b]	0.148, 13.8[b]	0.418, 16.7[b]	0, 29.4[b]	0.232, 31.7[b]	0, 20.2[b]
95% CI LB	0[b]	0[b]	0[b]	0.167[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	16.9[b]	22.3[b]	21.3[b]	64.4[b]	17.3[b]	17.4[b]	19[b]	33.5[b]	36.5[b]	25.1[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	98.1[b]	100[b]	100[b]	93.3[b]	100[b]	98.4[b]	96.7[b]	100[b]	98.2[b]	100[b]
Max	9[b]	< MDL[b]	< MDL[b]	11[b]	< MDL[b]	9[b]	13.5[b]	< MDL[b]	13[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

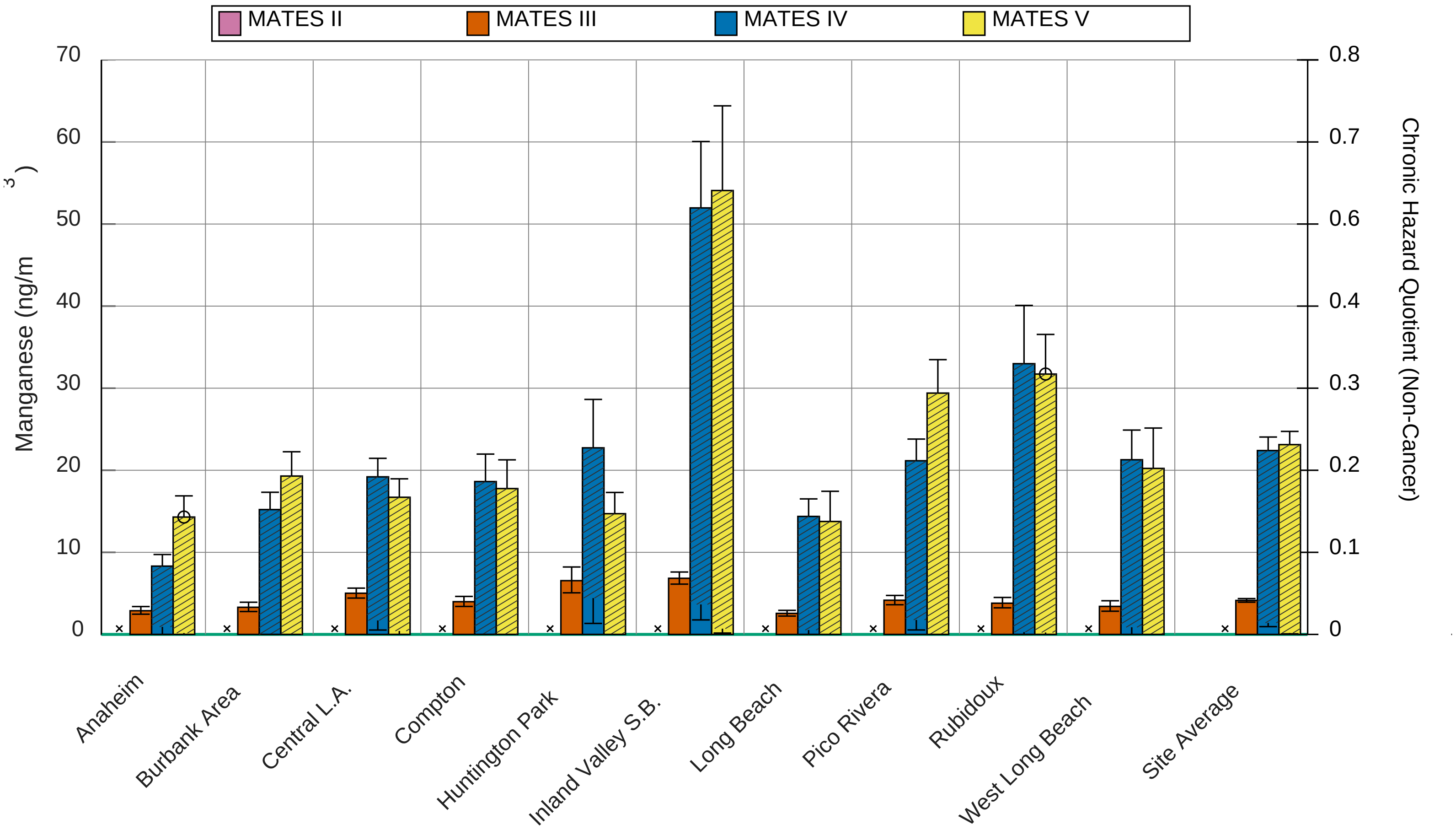


Figure IV-262. Annual Average Concentrations of Manganese in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

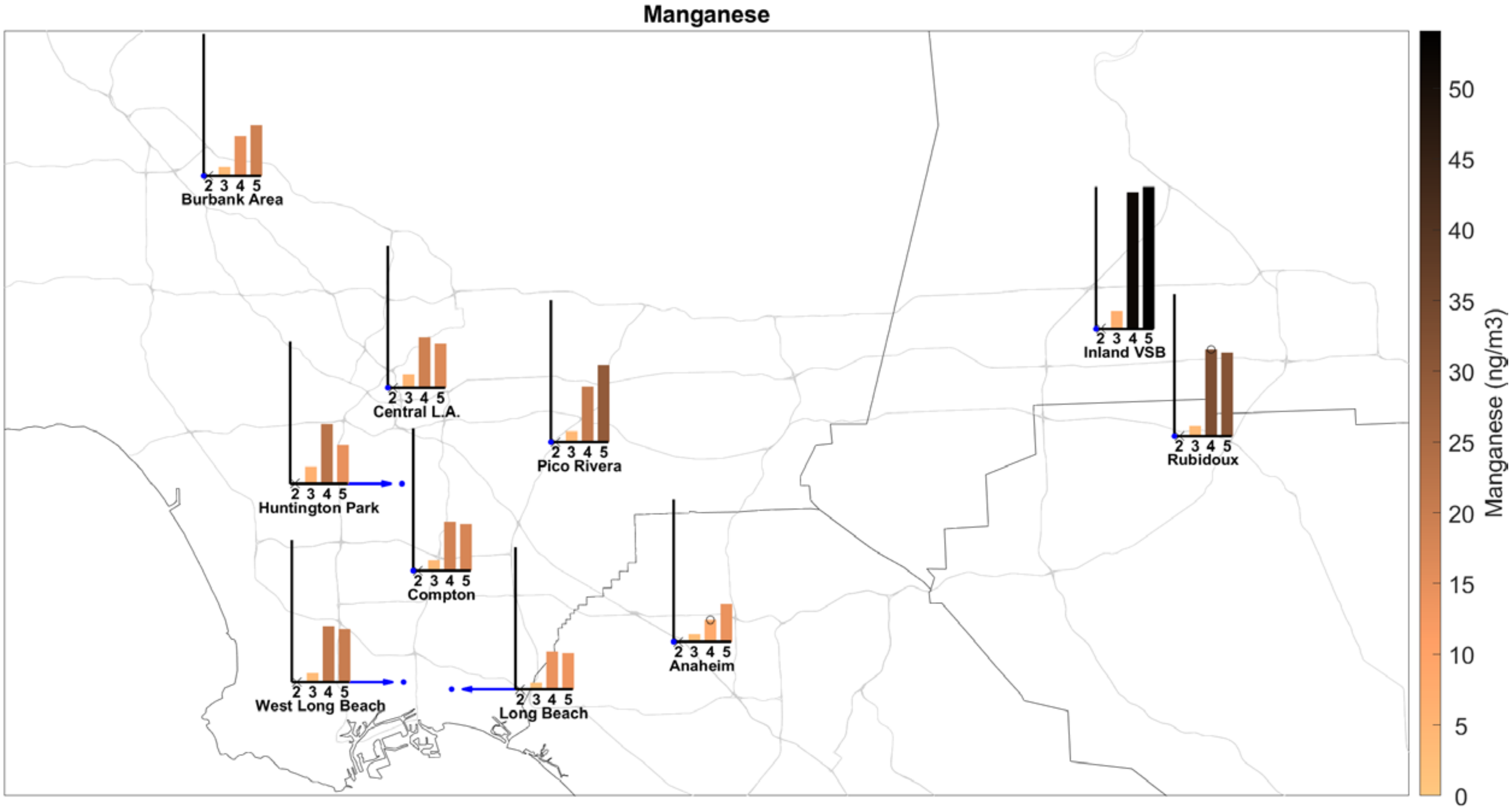


Figure IV-263. Geographic distribution of Manganese from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Molybdenum

Table IV-134. Ambient Concentrations (ng/m^3) of Molybdenum from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	4.27	4.64	4.81	4.68	5.16	4.36	4.72	4.46	4.5	4.61
95% CI LB	4	4.35	4.51	4.35	4.64	4.05	4.51	4.07	4.23	4.32
95% CI UB	4.53	4.96	5.11	5.07	5.75	4.7	4.94	4.83	4.78	4.89
N	240	239	234	238	117	228	237	116	236	228
% < MDL	2.9	1.3	2.6	2.1	1.7	3.5	0	1.7	0.8	0.4
Max	13.6	19.8	14.8	33.5	23.5	16.1	12.3	9.9	12.3	14.8
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	0, 0.793[b]	0, 0.852[b]	0, 1.31[b]	0.3, 1.52[b]	0, 1.25[b]	0, 1[b]	0, 2.45[b]	0, 1.07[b]	0, 0.766[b]	0, 1.17[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.97[b]	0.981[b]	1.61[b]	2.08[b]	1.64[b]	1.35[b]	2.82[b]	1.23[b]	0.873[b]	1.46[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	100[b]	100[b]	98.3[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	18[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

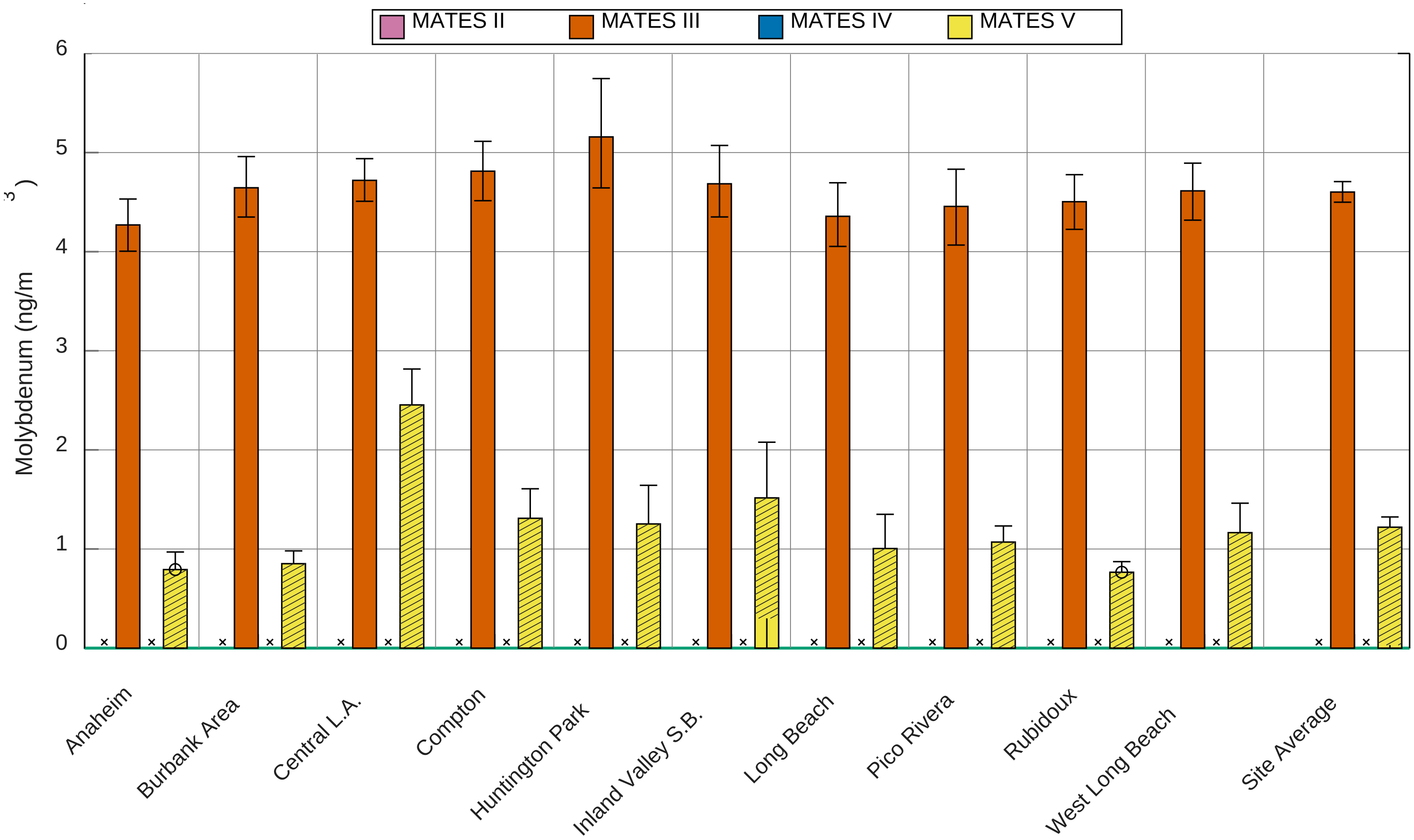


Figure IV-264. Annual Average Concentrations of Molybdenum in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

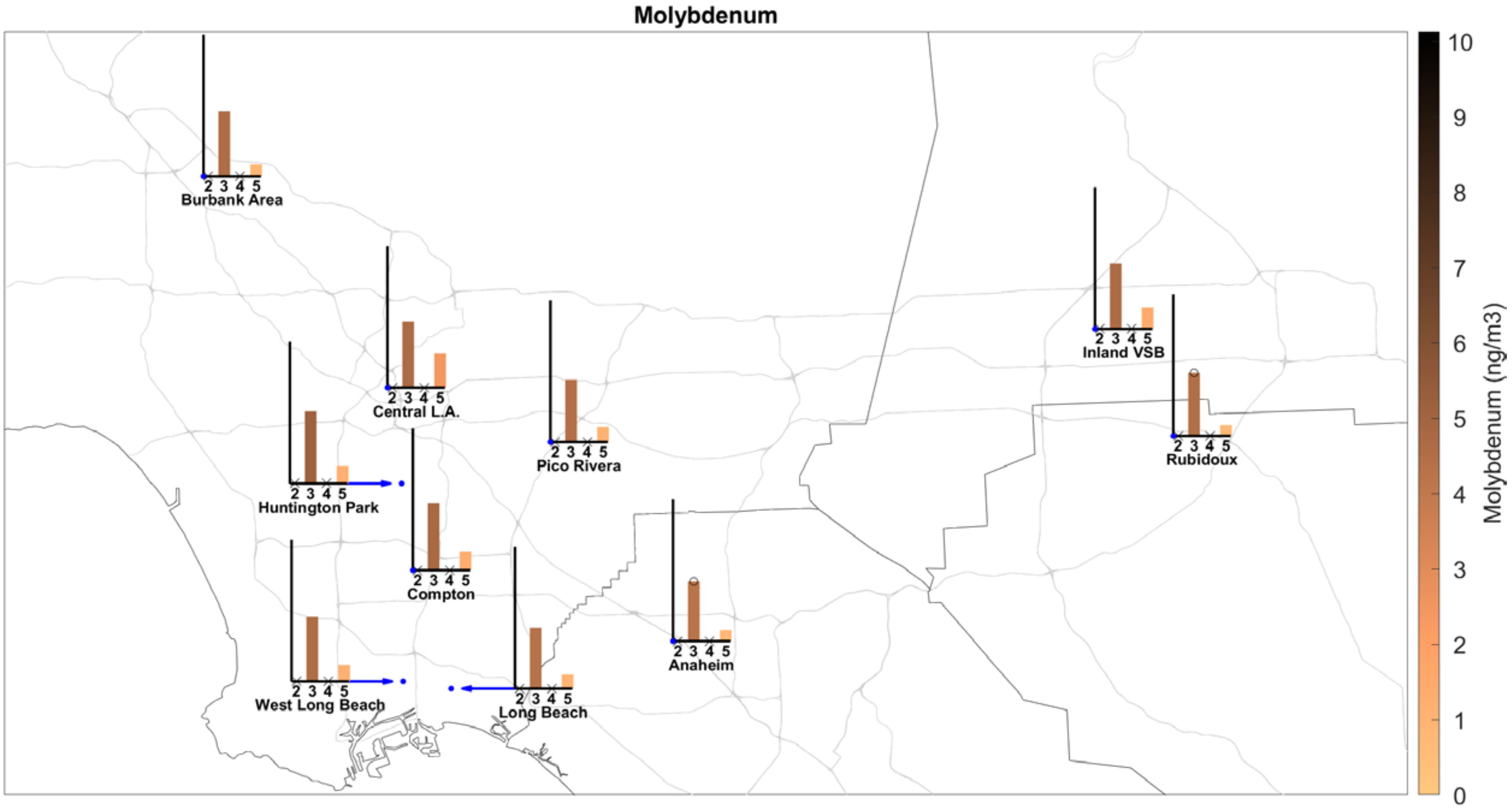


Figure IV-265. Geographic distribution of Molybdenum from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Nickel

Table IV-135. Ambient Concentrations (ng/m^3) of Nickel from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	3.77	2.91	3.85	3.33	4.04	4.39	3.44	2.93	2.77	7.37
95% CI LB	3.29	2.49	3.37	2.52	3.51	3.96	3.01	2.54	2.29	6.66
95% CI UB	4.31	3.37	4.38	4.55	4.61	4.84	3.92	3.37	3.29	8.12
N	240	239	234	238	117	228	237	116	236	228
% < MDL	7.5	14.2	7.7	17.6	3.4	6.1	6.3	6.9	16.9	2.6
Max	33.3	28.4	34.5	120	16.1	18.5	28.3	12.4	32.1	38.2
MATES IV										
Average	0, 1.78[b]	0.22, 3.9[b]	0, 4.06[b]	0, 4.06[b]	0.729, 5.4[b]	0.393, 3.6[b]	0, 3.37[b]	0, 4.47[b]	0, 3.36[b]	0.475, 3.73[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	2.03[b]	6.2[b]	4.75[b]	4.68[b]	7.5[b]	4.34[b]	4.44[b]	5.19[b]	4.02[b]	4.3[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	100[b]	98.3[b]	100[b]	100[b]	96.6[b]	98.4[b]	100[b]	100[b]	100[b]	96.7[b]
Max	< MDL[b]	13[b]	< MDL[b]	< MDL[b]	32[b]	24[b]	< MDL[b]	< MDL[b]	< MDL[b]	20[b]
MATES V										
Average	0.389, 2.17[b]	0, 2.01[b]	0.0656, 2.93[b]	0, 6.31[b]	0.283, 2.64[b]	0, 3.64[b]	0, 2[b]	0, 3[b]	0, 2.41[b]	0.246, 3.74[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	2.58[b]	2.28[b]	3.49[b]	9.66[b]	3.53[b]	4.6[b]	2.26[b]	3.33[b]	2.79[b]	4.48[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	98.1[b]	100[b]	98.4[b]	100[b]	98.3[b]	100[b]	100[b]	100[b]	100[b]	96.5[b]
Max	21[b]	< MDL[b]	4[b]	< MDL[b]	17[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	10[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

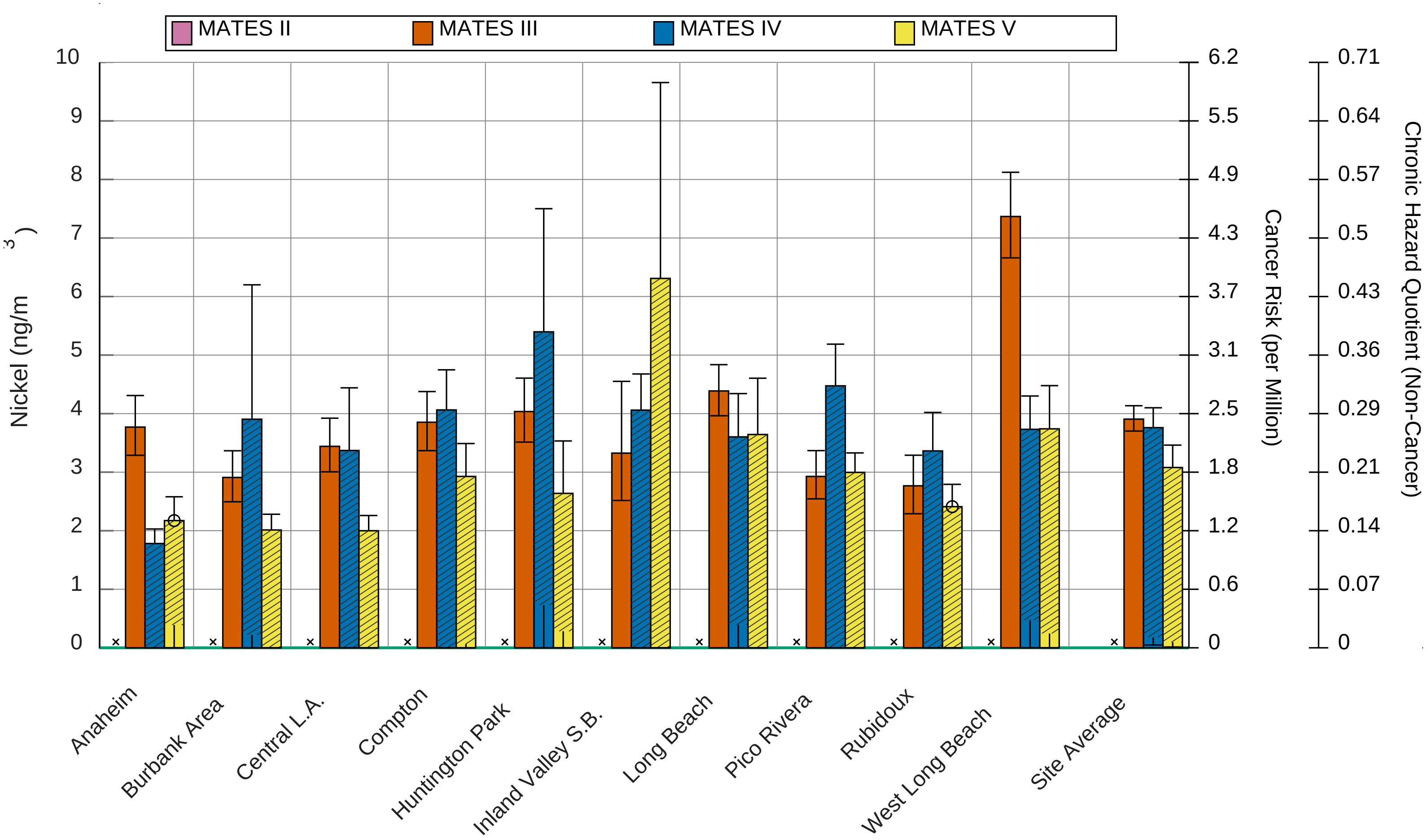


Figure IV-266. Annual Average Concentrations of Nickel in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

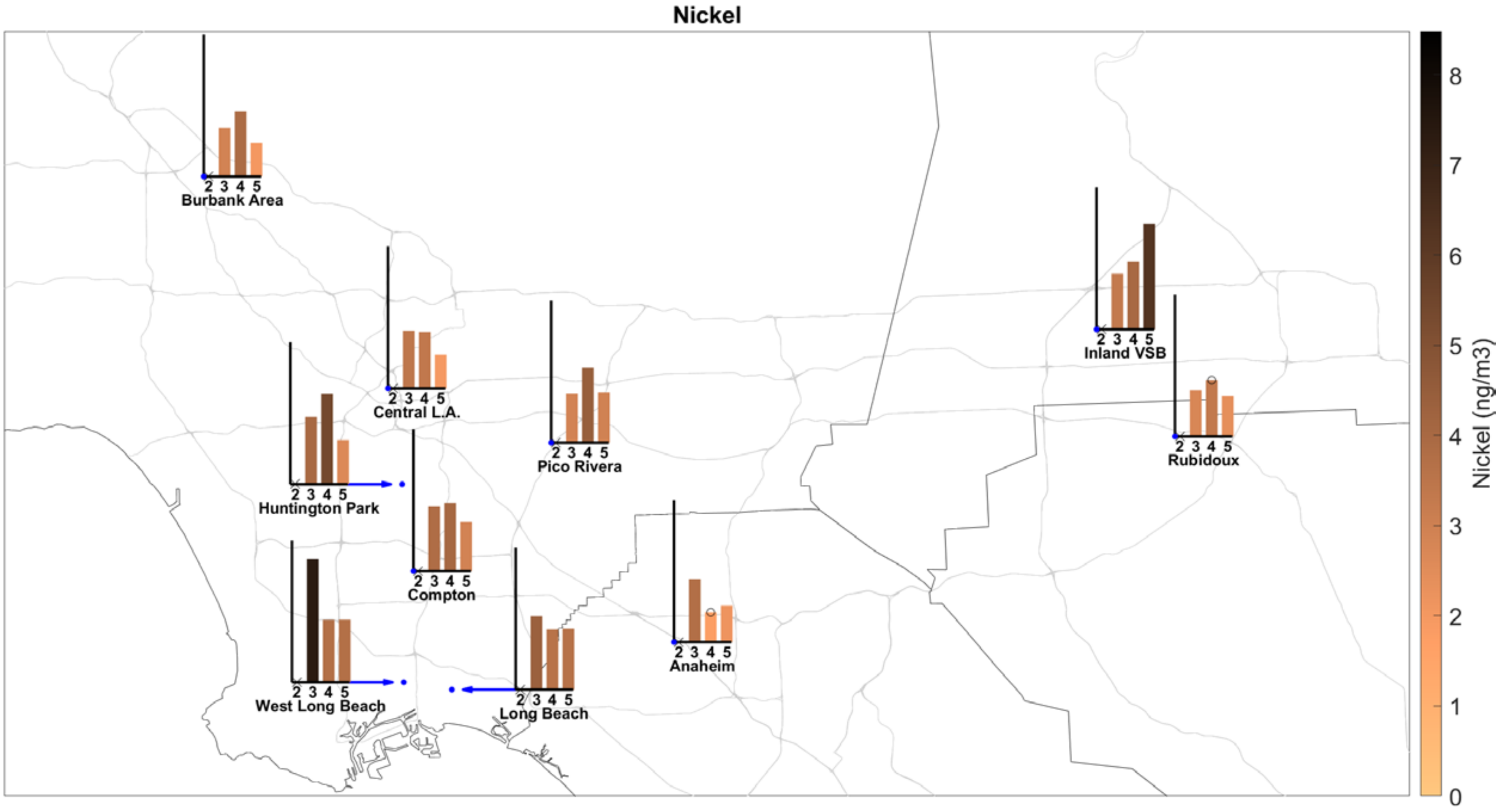


Figure IV-267. Geographic distribution of Nickel from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Palladium

Table IV-136. Ambient Concentrations (ng/m^3) of Palladium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	0.799, 2.04[a]	0.616, 1.85[a]	0.682, 1.92[a]	0.624, 1.88[a]	0.603, 1.85[a]	0.618, 1.9[a]	1.85	0.523, 1.8[a]	0.854, 2.09[a]	0.673, 1.92[a]
95% CI LB	0.557[a]	0.44[a]	0.481[a]	0.432[a]	0.349[a]	0.417[a]	1.75	0.288[a]	0.613[a]	0.467[a]
95% CI UB	2.24[a]	1.98[a]	2.08[a]	2.04[a]	2.05[a]	2.06[a]	1.97	1.98[a]	2.28[a]	2.07[a]
N	240[a]	239[a]	234[a]	238[a]	117[a]	228[a]	237	116[a]	236[a]	228[a]
% < MDL	82.9[a]	82.4[a]	82.5[a]	83.6[a]	82.9[a]	85.5[a]	77.6	85.3[a]	82.2[a]	83.3[a]
Max	13.6[a]	9.91[a]	8.66[a]	12.4[a]	8.65[a]	9.87[a]	8.66	7.42[a]	8.68[a]	7.43[a]
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

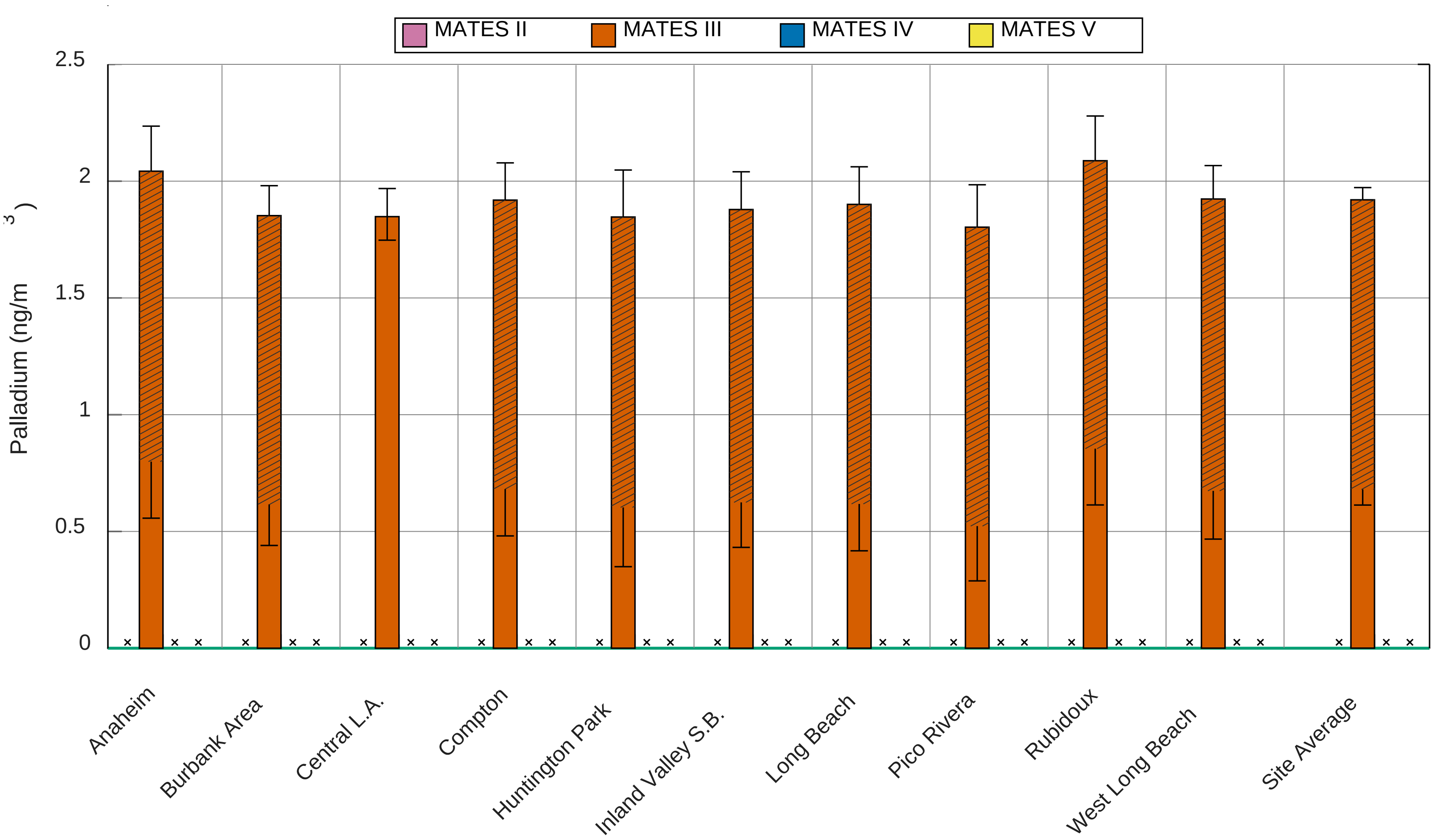


Figure IV-268. Annual Average Concentrations of Palladium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

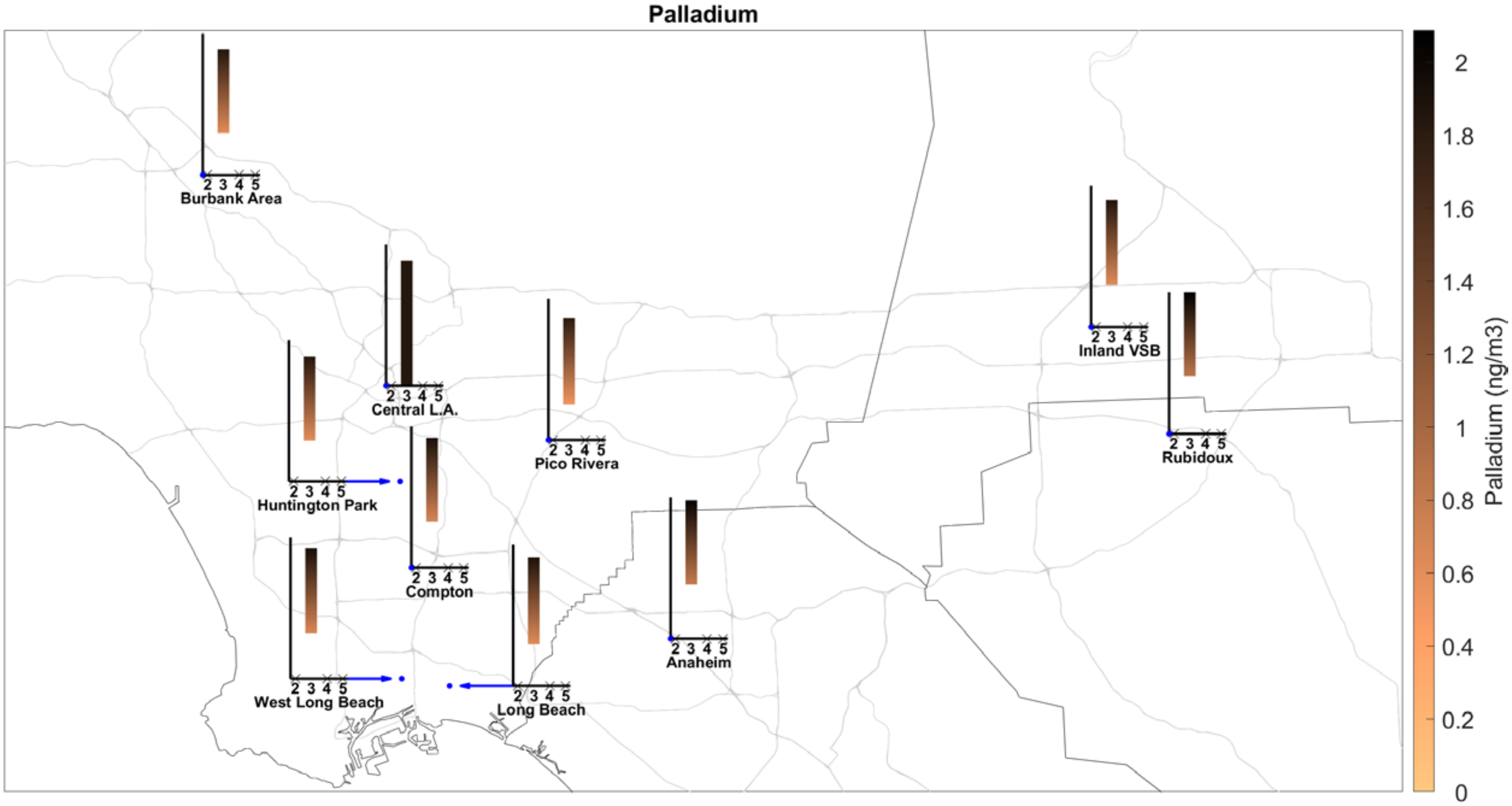


Figure IV-269. Geographic distribution of Palladium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Phosphorus

Table IV-137. Ambient Concentrations (ng/m^3) of Phosphorus from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	25.6	27.4	32.3	28.6	35.3	34.6	28.3	32.8	25.6	36.8
95% CI LB	22.6	23.6	28	24.6	29	29.8	24.9	26.4	22.5	31.8
95% CI UB	28.9	31.6	37.6	32.8	42.3	39.7	32.1	39.7	28.9	42.7
N	240	239	234	238	117	228	237	116	236	228
% < MDL	59.6	62.8	56.8	58	46.2	54.8	51.5	48.3	63.6	49.6
Max	152	214	217	236	184	204	186	222	164	315
MATES IV										
Average	20.6	22.8	22.2	23.4	24	21.3	23.5	22.2	22.1	20.9
95% CI LB	18.5	19.9	19.6	20.9	20.9	19	20.3	19.7	19.7	18.7
95% CI UB	22.8	25.9	24.9	26.2	27.4	23.9	26.6	24.6	24.6	23.2
N	59	59	61	60	59	61	60	59	61	61
% < MDL	61	57.6	52.5	51.7	49.2	55.7	53.3	50.8	52.5	52.5
Max	48	64	54	55	74	60	69	46	52	49
MATES V										
Average	16	16.4	16.9	16.7	17.7	16.5	17.8	16.7	16.6	16.5
95% CI LB	15.4	15.7	15.8	16	16.2	15.6	16.5	15.9	15.9	15.6
95% CI UB	16.6	17.3	18.1	17.5	19.4	17.5	19.4	17.6	17.4	17.6
N	54	59	61	60	60	61	61	59	56	57
% < MDL	77.8	79.7	73.8	66.7	70	73.8	67.2	72.9	67.9	75.4
Max	25	28	35	27	40	32	37.5	28	25	33

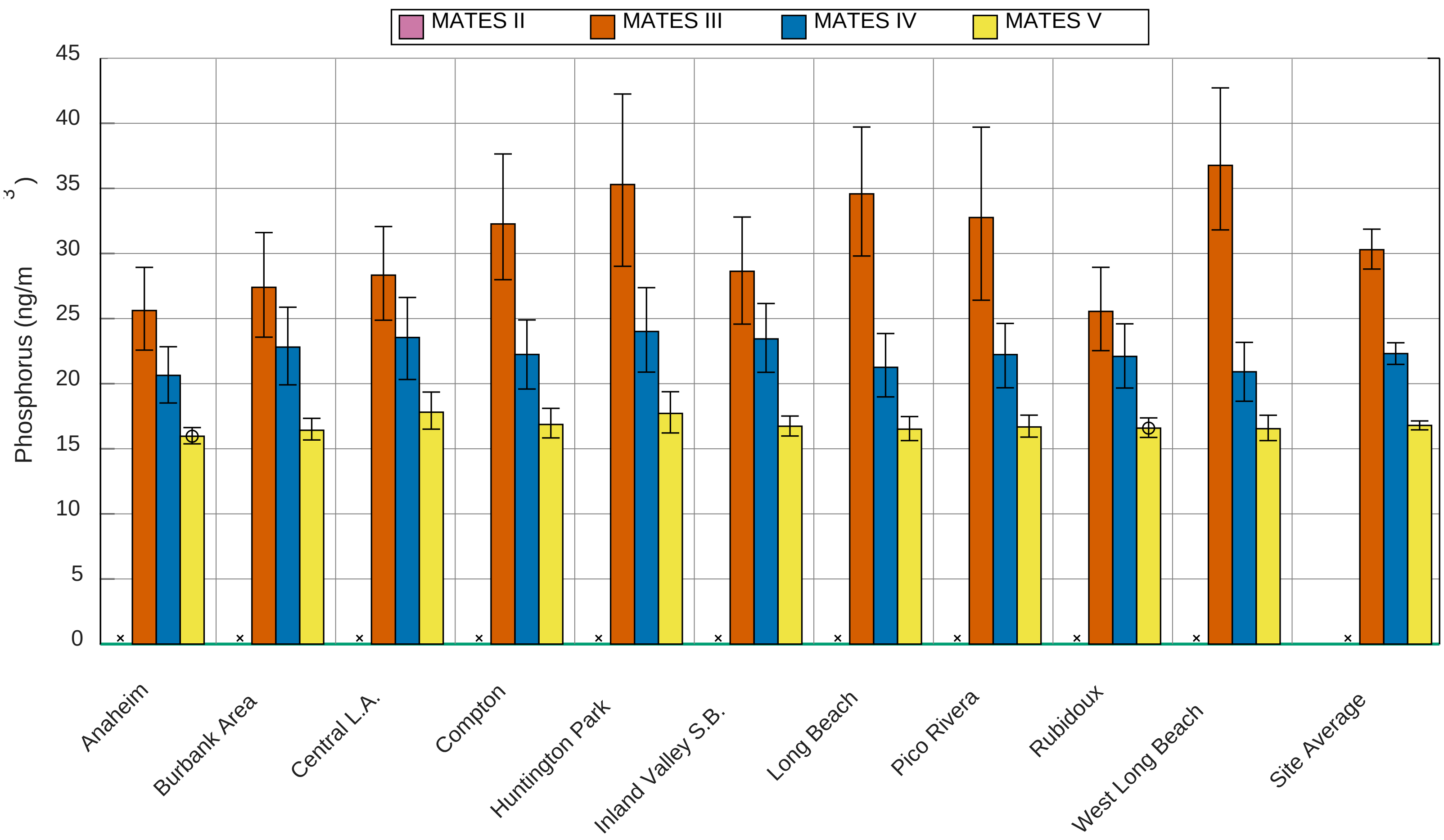


Figure IV-270. Annual Average Concentrations of Phosphorus in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

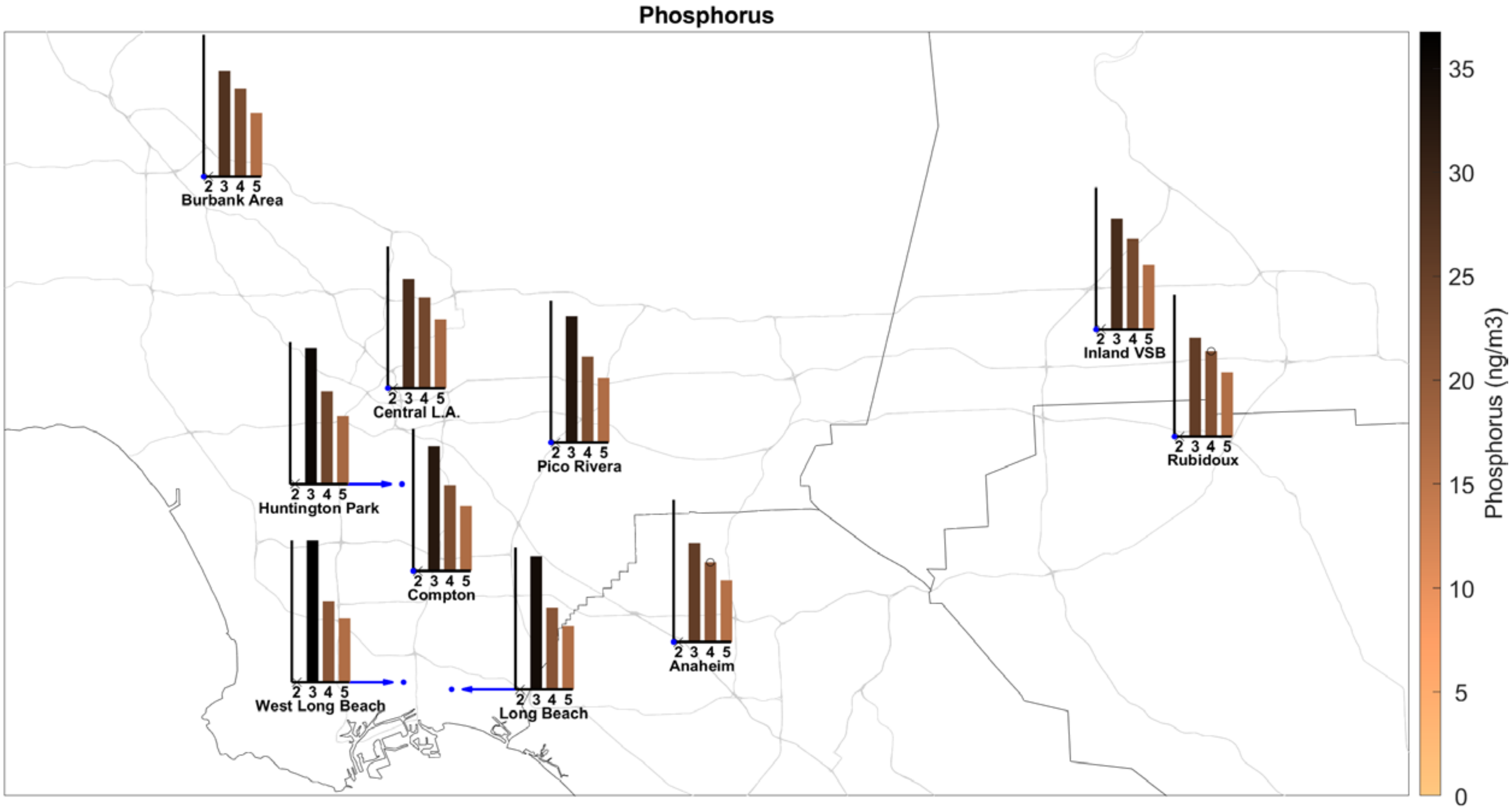


Figure IV-271. Geographic distribution of Phosphorus from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Potassium

Table IV-138. Ambient Concentrations (ng/m^3) of Potassium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	81.6	97.1	84	167	122	62.5	73.4	136	136	59.4
95% CI LB	51.3	68.3	58.4	70.4	77	46.2	48.9	57.9	61.5	45.5
95% CI UB	134	144	120	353	190	83.2	114	279	275	77.8
N	240	239	234	238	117	228	237	116	236	228
% < MDL	3.3	1.7	3.4	2.9	2.6	4.4	1.7	1.7	3.4	6.1
Max	5530	4770	2990	21500	2980	1600	4080	7850	14900	1550
MATES IV										
Average	68.5	73.9	71.1	74.4	68.2	61.2	69	72.6	73.7	71.8
95% CI LB	58.3	64.5	59.2	64.5	58.4	53.1	60.5	63.8	65.3	61.7
95% CI UB	80.5	83.7	83.9	84.8	78.8	69.8	79.4	81.7	82.5	82.9
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	1.7	0	0	3.4	0	1.7	1.7	1.6	0
Max	290	191	229	187	203	152	213	176	183	245
MATES V										
Average	64.6	53.2	74.3	73.9	63.5	52.3	60.5	67.4	85.4	59.7
95% CI LB	48.7	41.9	59.1	61.5	52.1	43.2	47.8	55.6	68.6	48.6
95% CI UB	84.2	66.5	91.7	87.8	76.6	62.6	76.4	82.3	105	72.8
N	54	59	61	60	60	61	61	59	56	57
% < MDL	1.9	0	0	0	0	0	0	0	0	1.8
Max	399	304	335	267	269	209	375	385	383	272

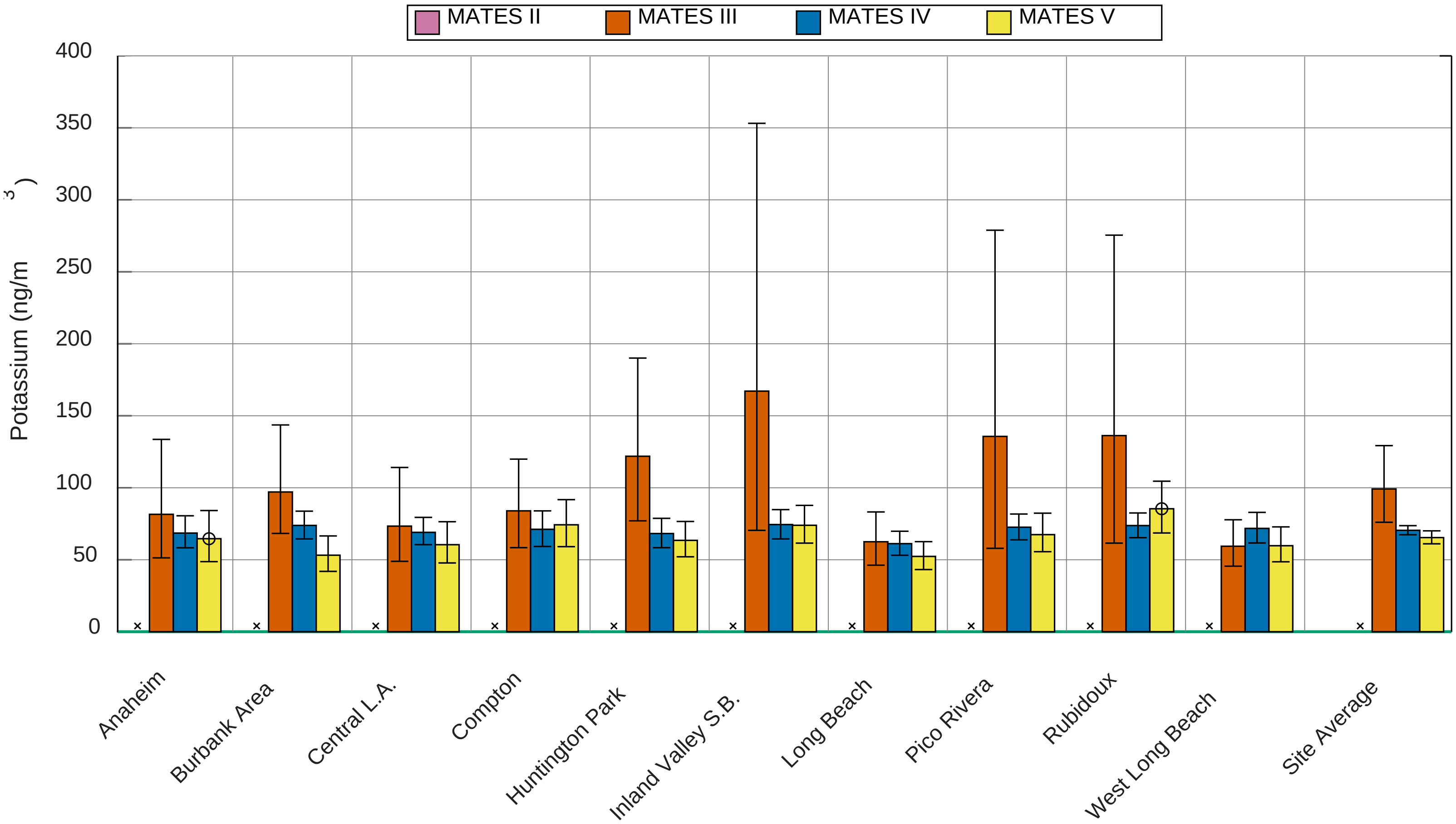


Figure IV-272. Annual Average Concentrations of Potassium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

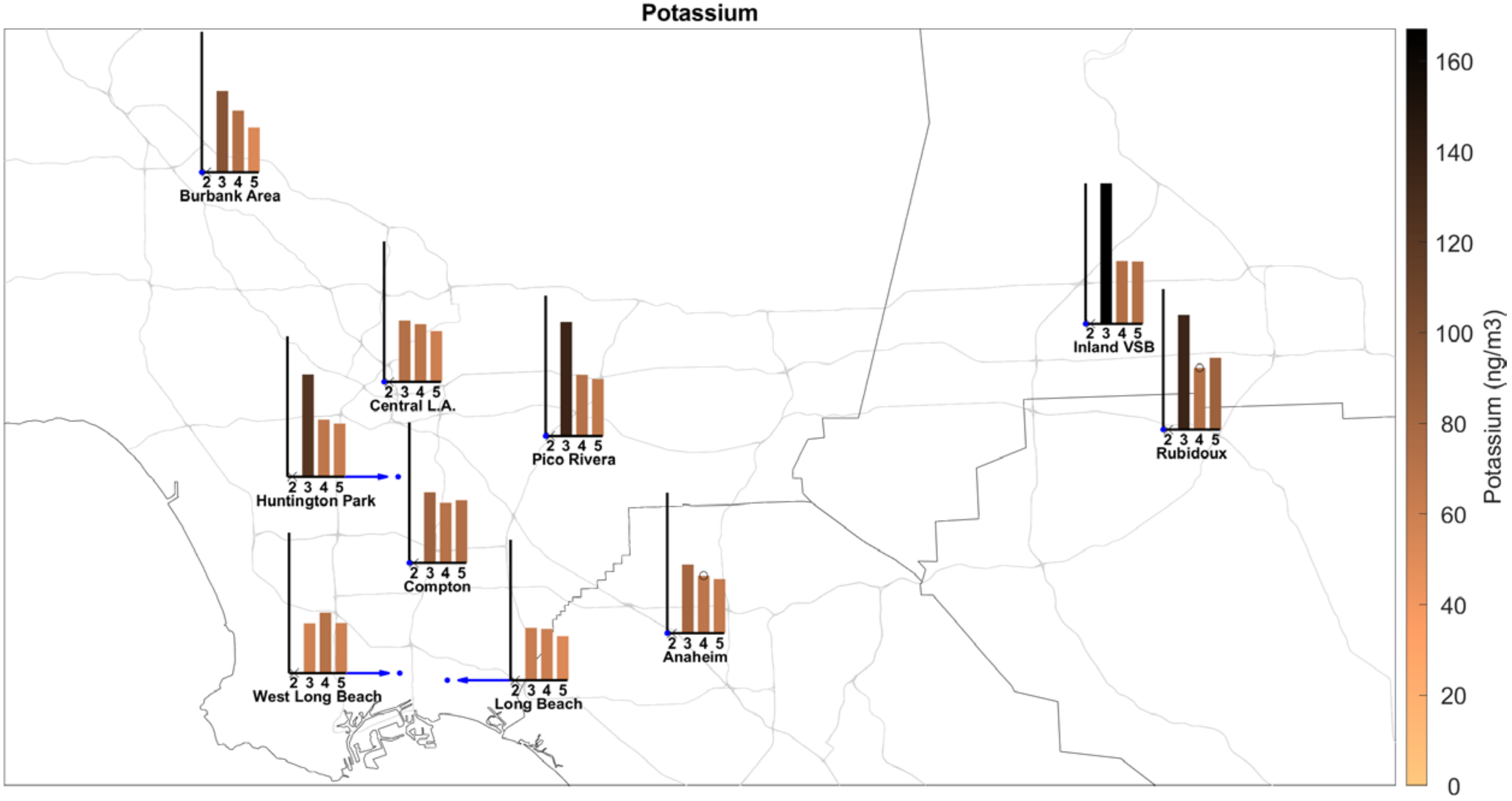


Figure IV-273. Geographic distribution of Potassium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Rubidium

Table IV-139. Ambient Concentrations (ng/m^3) of Rubidium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	0.575	0.572	0.586	0.569	0.737	0.58	0.564	0.74	0.588	0.591
95% CI LB	0.533	0.53	0.54	0.527	0.665	0.536	0.524	0.667	0.546	0.547
95% CI UB	0.618	0.616	0.633	0.615	0.808	0.627	0.607	0.812	0.631	0.639
N	240	239	234	238	117	228	237	116	236	228
% < MDL	79.2	79.5	77.8	79.8	59.8	78.5	79.3	59.5	77.5	77.2
Max	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.25	1.24	1.27
MATES IV										
Average	0, 0.643[b]	0, 1.14[b]	0, 1.17[b]	0, 2.24[b]	0, 1.14[b]	0, 0.948[b]	0, 1.12[b]	0, 1.25[b]	0, 2.18[b]	0, 1.45[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.758[b]	1.36[b]	1.39[b]	2.68[b]	1.36[b]	1.12[b]	1.31[b]	1.46[b]	2.61[b]	1.78[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]
MATES V										
Average	0, 1.33[b]	0, 1.53[b]	0, 1.38[b]	0, 3.01[b]	0, 1.1[b]	0, 1.18[b]	0, 1.18[b]	0, 2.38[b]	0, 3.16[b]	0, 1.58[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	1.57[b]	1.78[b]	1.68[b]	3.67[b]	1.3[b]	1.53[b]	1.36[b]	2.75[b]	3.63[b]	2.03[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

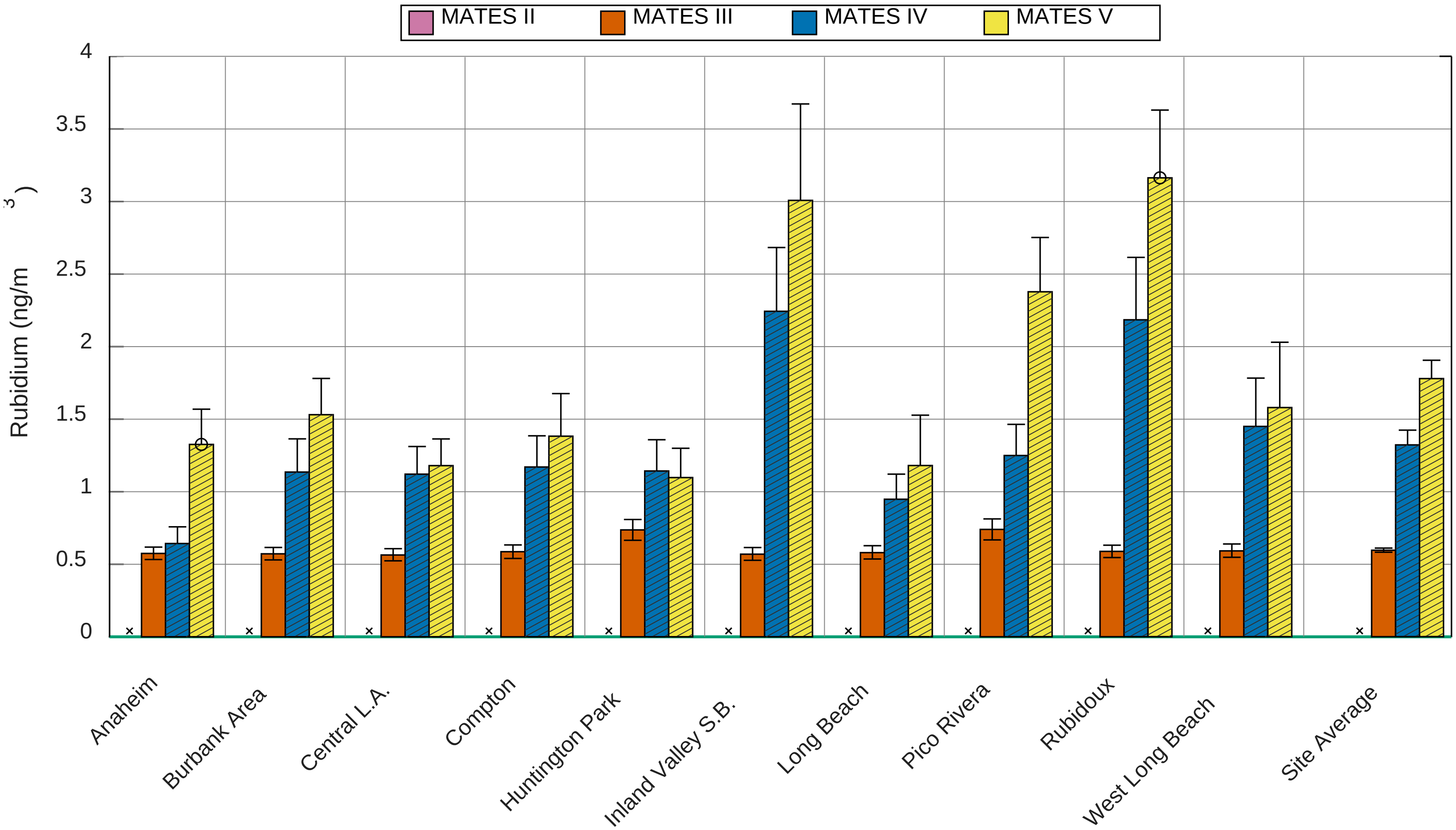


Figure IV-274. Annual Average Concentrations of Rubidium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

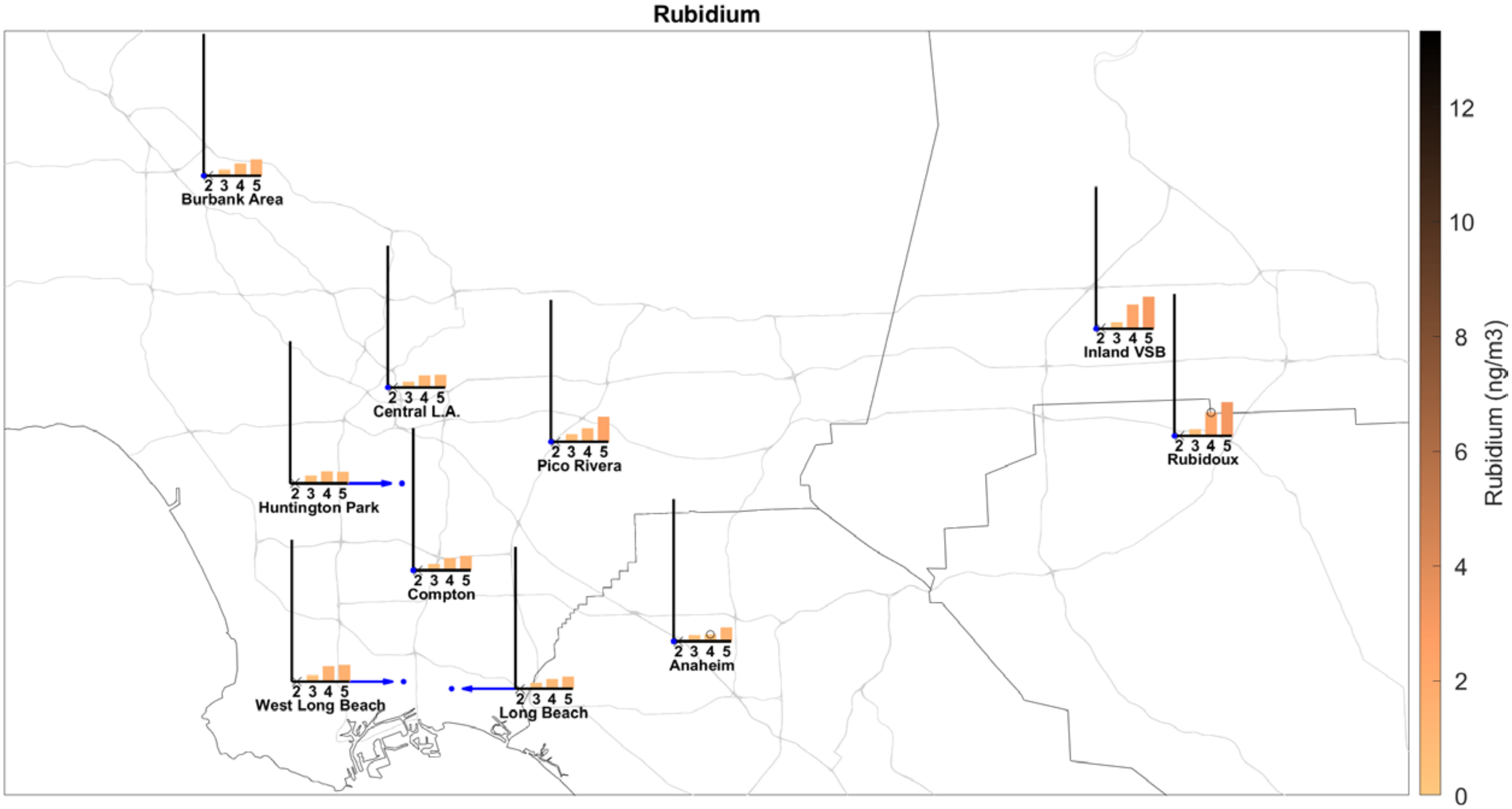


Figure IV-275. Geographic distribution of Rubidium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Samarium

Table IV-140. Ambient Concentrations (ng/m^3) of Samarium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	0, 124[a]	0, 124[a]	0, 124[a]	0, 124[a]	0, 124[a]	0, 124[a]	0, 124[a]	0, 124[a]	0, 124[a]	0, 124[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	124[a]	124[a]	124[a]	124[a]	124[a]	124[a]	124[a]	124[a]	124[a]	124[a]
N	54[a]	59[a]	61[a]	60[a]	60[a]	61[a]	61[a]	59[a]	56[a]	57[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

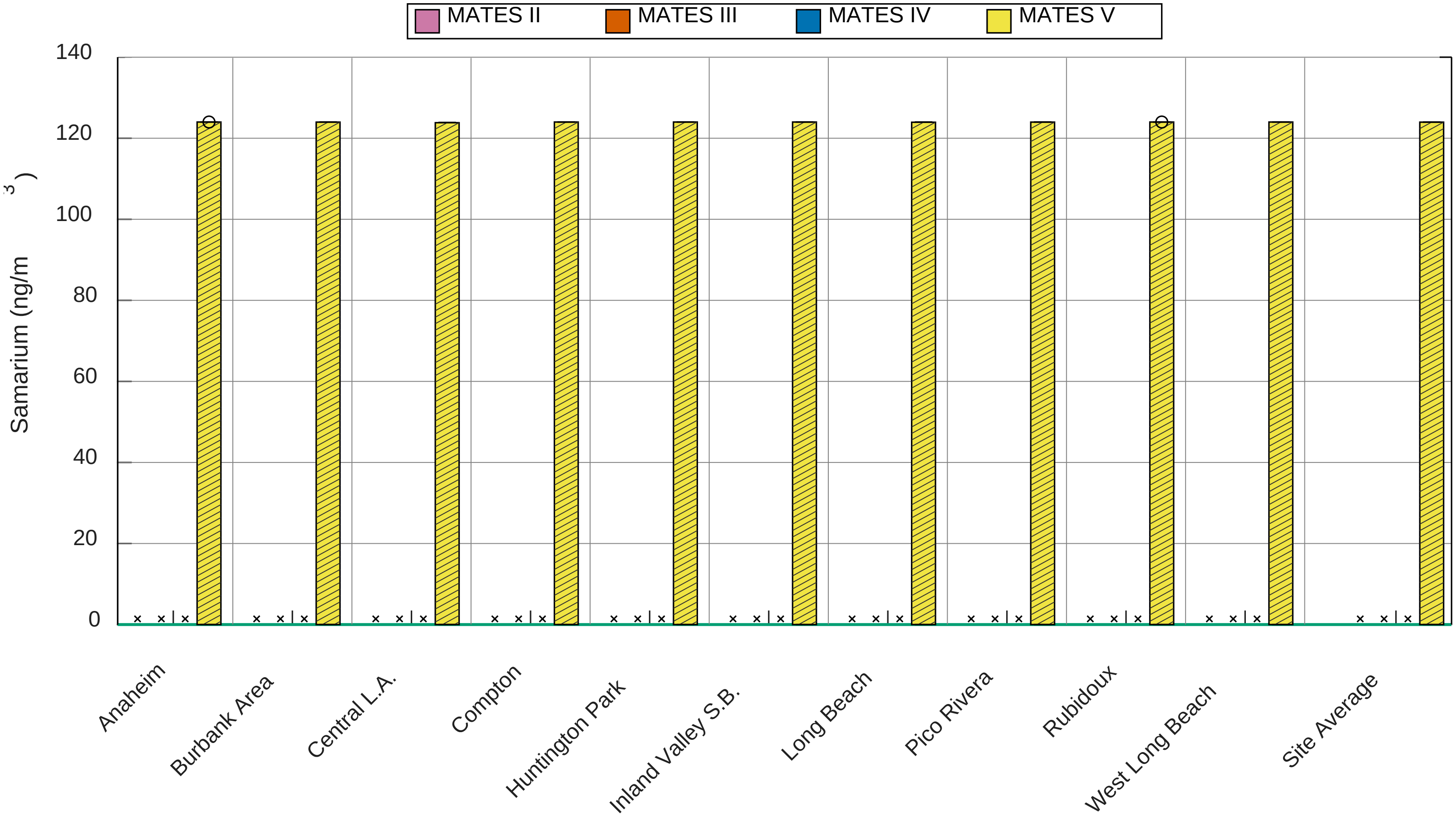


Figure IV-276. Annual Average Concentrations of Samarium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

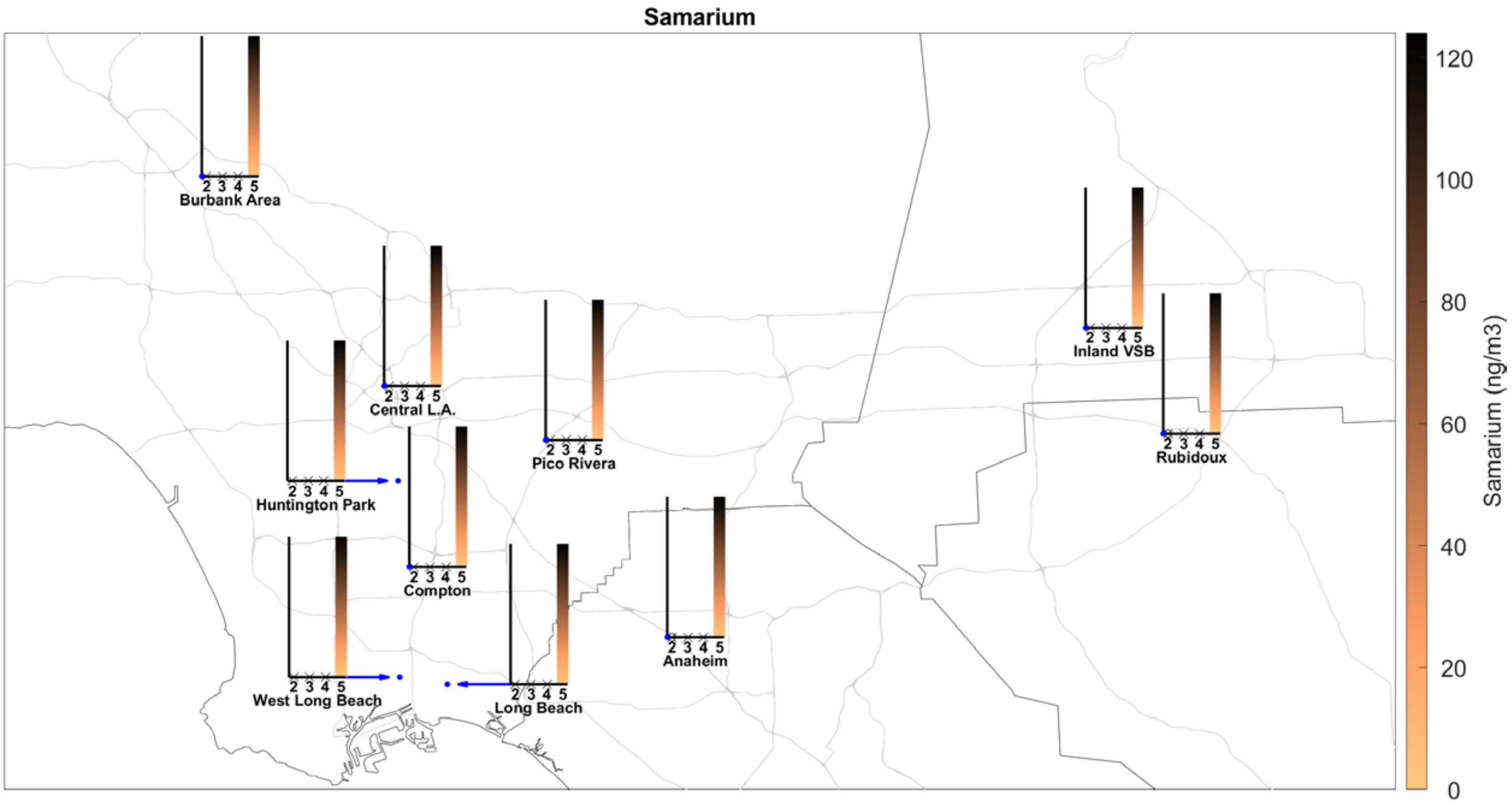


Figure IV-277. Geographic distribution of Samarium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Selenium

Table IV-141. Ambient Concentrations (ng/m^3) of Selenium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	1.05	1.05	1.05	1.05	1.1	1.05	0.235, 1.05[a]	1.09	1.05	1.05
95% CI LB	1.04	1.04	1.04	1.04	1.08	1.04	0.178[a]	1.07	1.04	1.04
95% CI UB	1.06	1.06	1.07	1.06	1.12	1.06	1.06[a]	1.12	1.06	1.07
N	240	239	234	238	117	228	237[a]	116	236	228
% < MDL	79.2	79.5	77.8	79.8	59.8	78.9	81[a]	60.3	78.8	77.2
Max	1.24	1.24	1.24	1.24	1.24	1.24	1.24[a]	1.25	1.24	1.27
MATES IV										
Average	0, 25.6[a]	0, 25.6[a]	0, 1.04[b]	0, 1[b]	0, 1.79[b]	0, 1.08[b]	0, 1.17[b]	0, 1.17[b]	0, 1.02[b]	0, 25.6[a]
95% CI LB	0[a]	0[a]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[a]
95% CI UB	25.6[a]	25.6[a]	1.24[b]	1.07[b]	2.33[b]	1.4[b]	1.3[b]	1.3[b]	1.17[b]	25.6[a]
N	59[a]	59[a]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[a]
% < MDL	100[a]	100[a]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[a]
MATES V										
Average	0, 25[a]	0, 25[a]	0, 0.614[b]	0, 0.681[b]	0, 0.697[b]	0, 25[a]	0, 0.637[b]	0, 0.691[b]	0, 25[a]	0, 0.591[b]
95% CI LB	0[a]	0[a]	0[b]	0[b]	0[b]	0[a]	0[b]	0[b]	0[a]	0[b]
95% CI UB	25[a]	25[a]	0.638[b]	0.723[b]	0.817[b]	25[a]	0.681[b]	0.771[b]	25[a]	0.608[b]
N	54[a]	59[a]	61[b]	60[b]	60[b]	61[a]	61[b]	59[b]	56[a]	57[b]
% < MDL	100[a]	100[a]	100[b]	100[b]	100[b]	100[a]	100[b]	100[b]	100[a]	100[b]
Max	< MDL[a]	< MDL[a]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[a]	< MDL[b]	< MDL[b]	< MDL[a]	< MDL[b]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

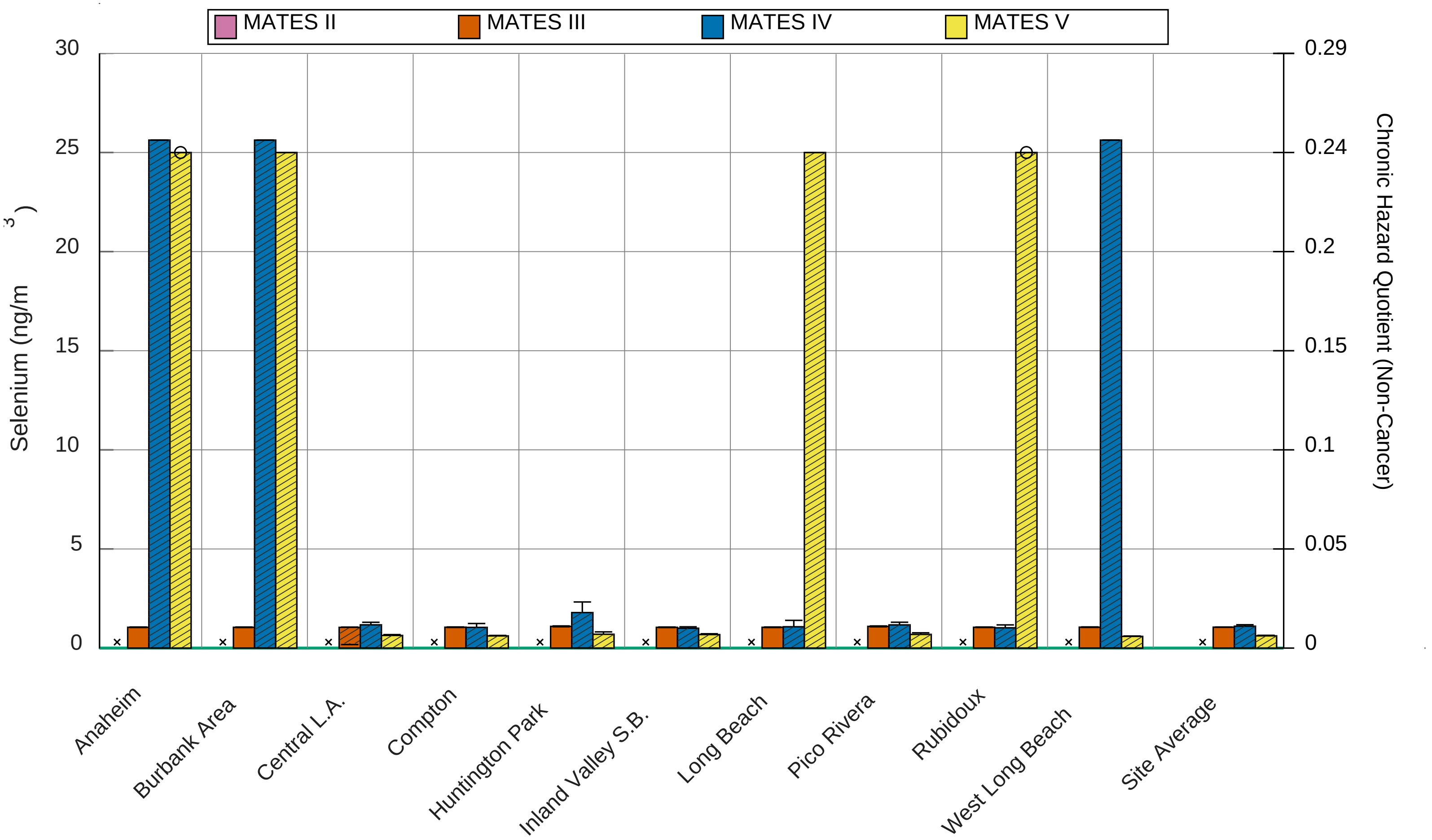


Figure IV-278. Annual Average Concentrations of Selenium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

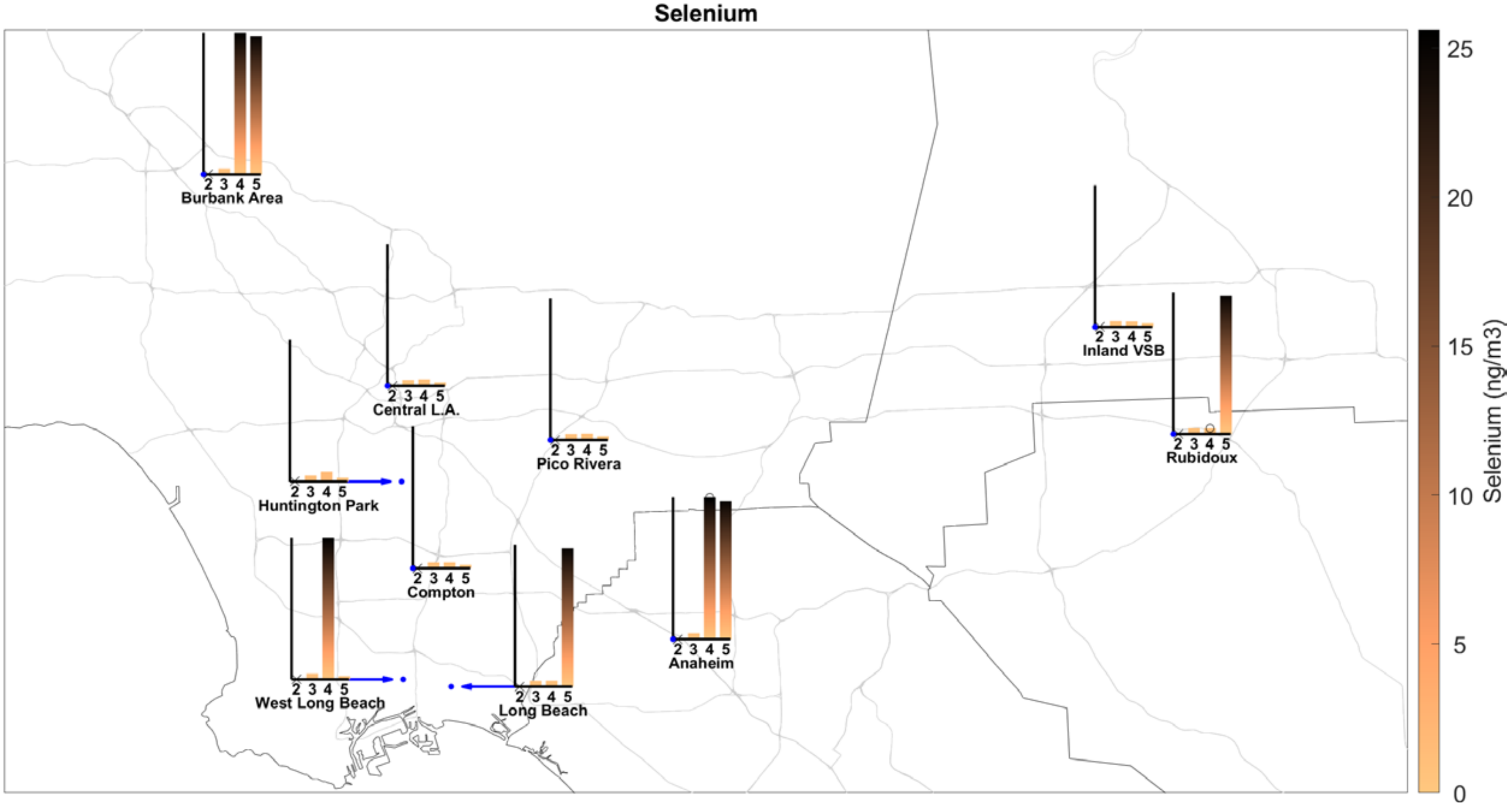


Figure IV-279. Geographic distribution of Selenium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Silicon

Table IV-142. Ambient Concentrations (ng/m^3) of Silicon from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	55.6, 5130[b]	244	56.1, 5790[b]	271	223	211	74.4, 5870[b]	236	206	236
95% CI LB	36.5[b]	210	37.3[b]	244	195	195	50.8[b]	202	193	213
95% CI UB	5550[b]	290	6170[b]	300	256	229	6200[b]	275	222	260
N	240[b]	239	234[b]	238	117	228	237[b]	116	236	228
% < MDL	86.7[b]	76.2	85[b]	65.1	78.6	79.8	83.1[b]	73.3	79.7	75.9
Max	1120[b]	4300	1120[b]	1720	1620	1010	1430[b]	1440	924	1800
MATES IV										
Average	82.5	102	82	162	101	83.8	101	94.8	129	135
95% CI LB	66.5	86.9	61.1	135	81.8	64.4	83.1	79.8	110	107
95% CI UB	100	118	109	191	123	108	122	110	149	165
N	59	59	61	60	59	61	60	59	61	61
% < MDL	10.2	10.2	19.7	5	8.5	13.1	15	11.9	11.5	4.9
Max	300	268	664	615	398	552	399	223	352	567
MATES V										
Average	97.3	116	114	167	114	94.6	104	142	171	134
95% CI LB	82.8	103	99	143	99.1	81	92.9	124	142	114
95% CI UB	113	130	131	193	130	111	116	163	205	156
N	54	59	61	60	60	61	61	59	56	57
% < MDL	0	0	0	0	0	0	0	0	1.8	0
Max	285	321	369	583	360	435	259	458	819	411

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

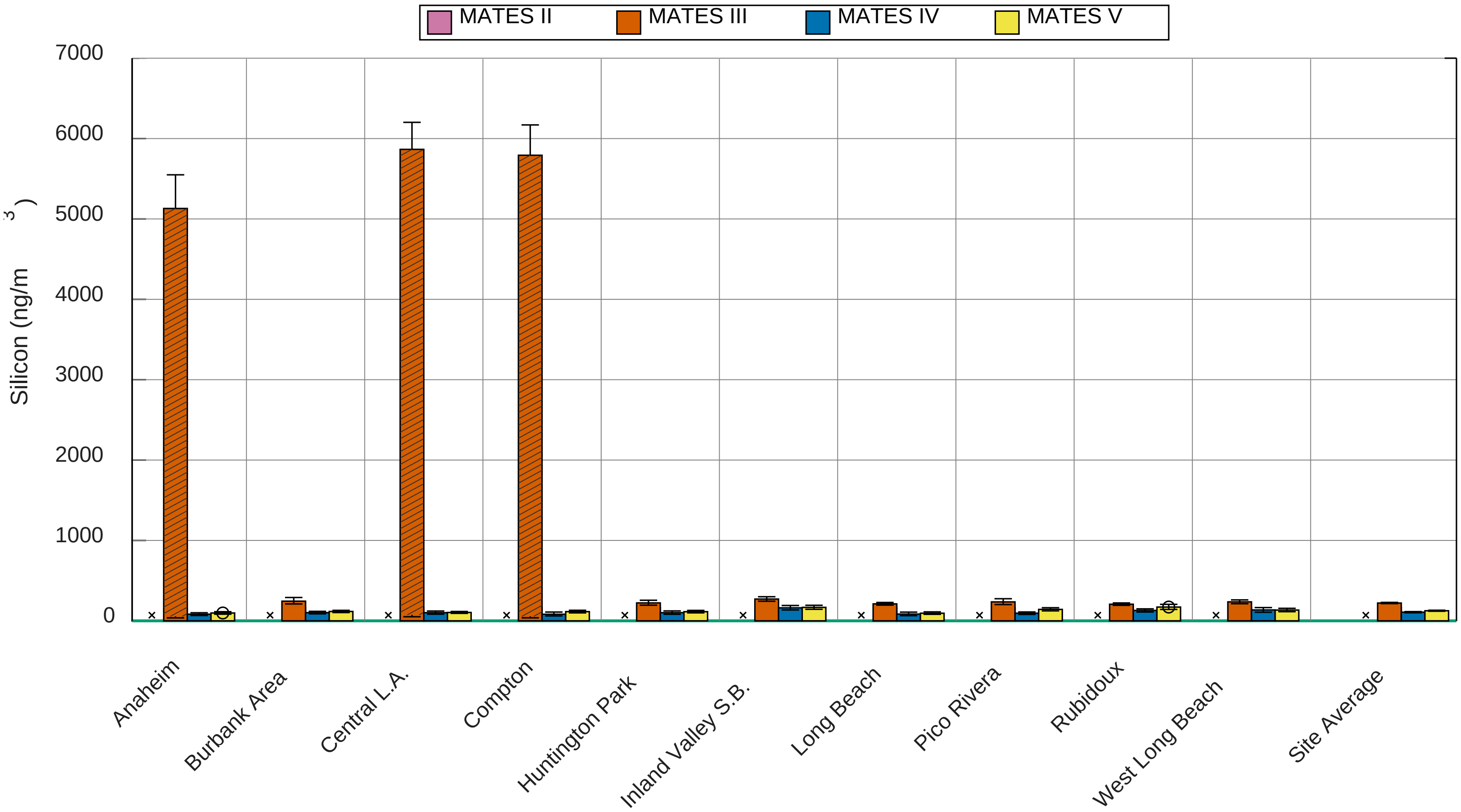


Figure IV-280. Annual Average Concentrations of Silicon in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

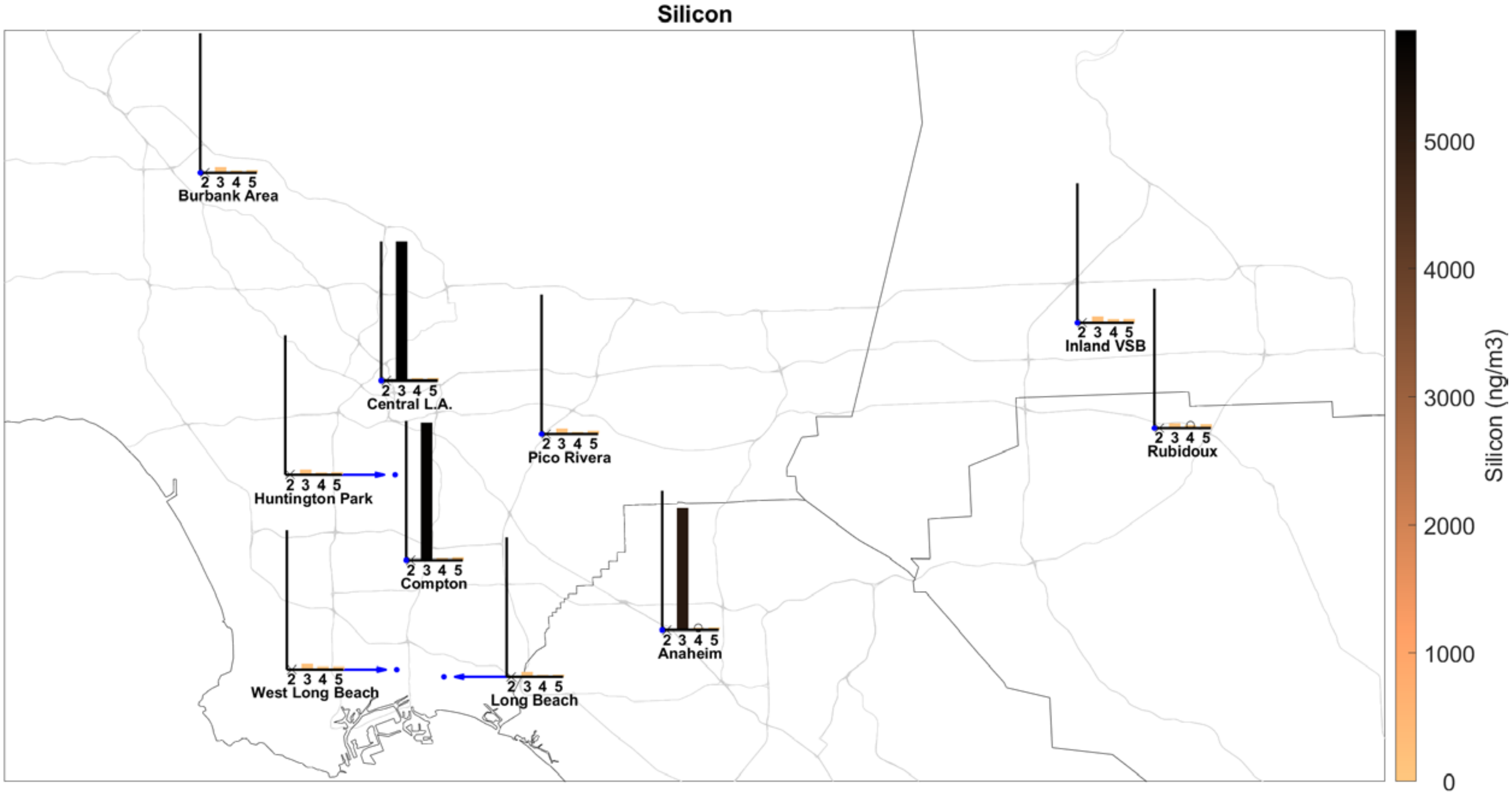


Figure IV-281. Geographic distribution of Silicon from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Silver

Table IV-143. Ambient Concentrations (ng/m^3) of Silver from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	1.44	1.33	1.39	2.25	1.37	1.32	1.28	1.38	1.36	1.37
95% CI LB	1.33	1.25	1.3	1.27	1.26	1.26	1.24	1.28	1.29	1.29
95% CI UB	1.57	1.41	1.5	4.15	1.53	1.42	1.34	1.5	1.45	1.46
N	240	239	234	238	117	228	237	116	236	228
% < MDL	67.9	69.9	64.5	68.5	51.3	68.9	71.7	50	69.5	68
Max	8.65	7.43	8.67	222	7.42	7.42	6.18	6.18	6.17	7.43
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										

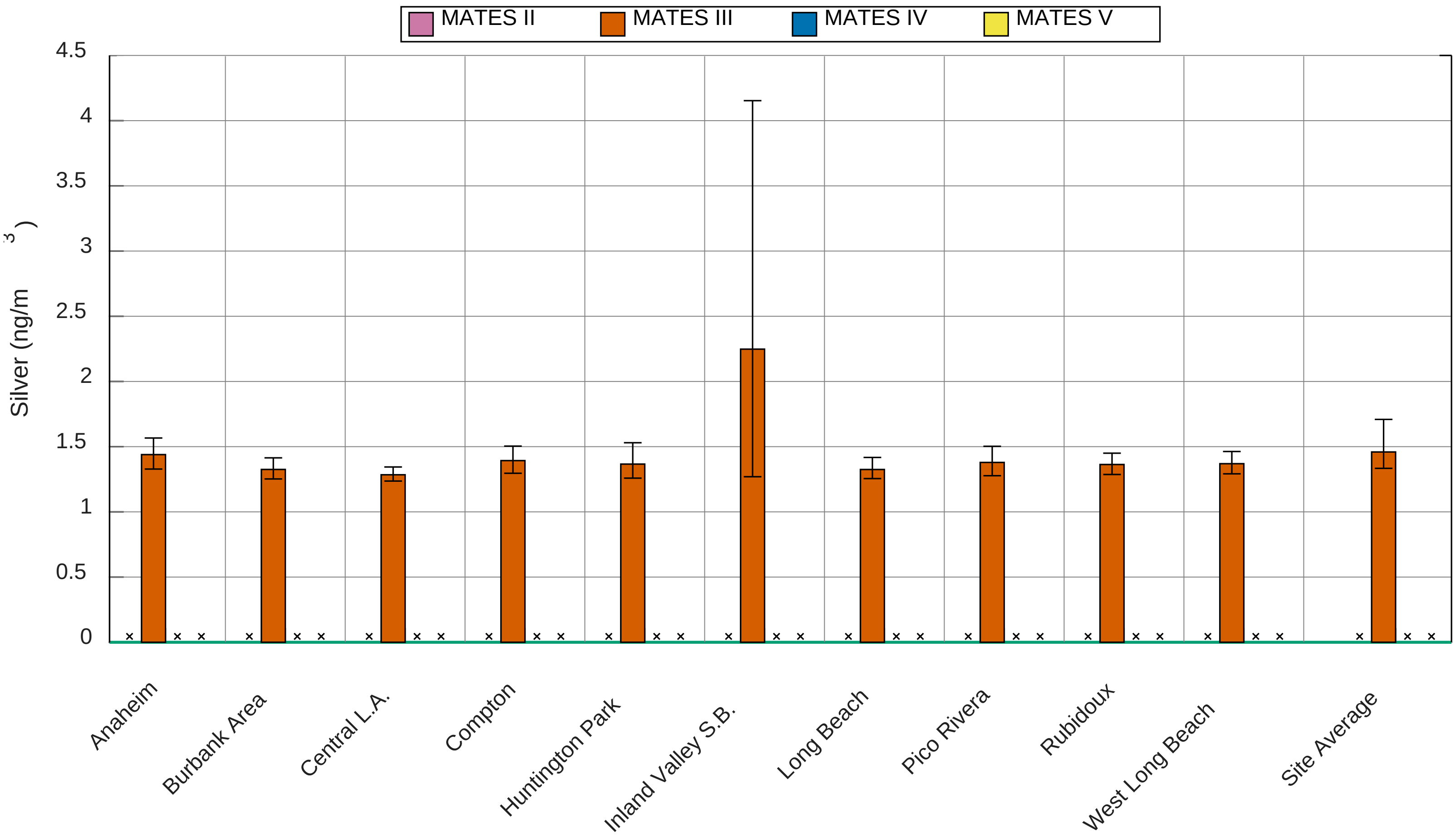


Figure IV-282. Annual Average Concentrations of Silver in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

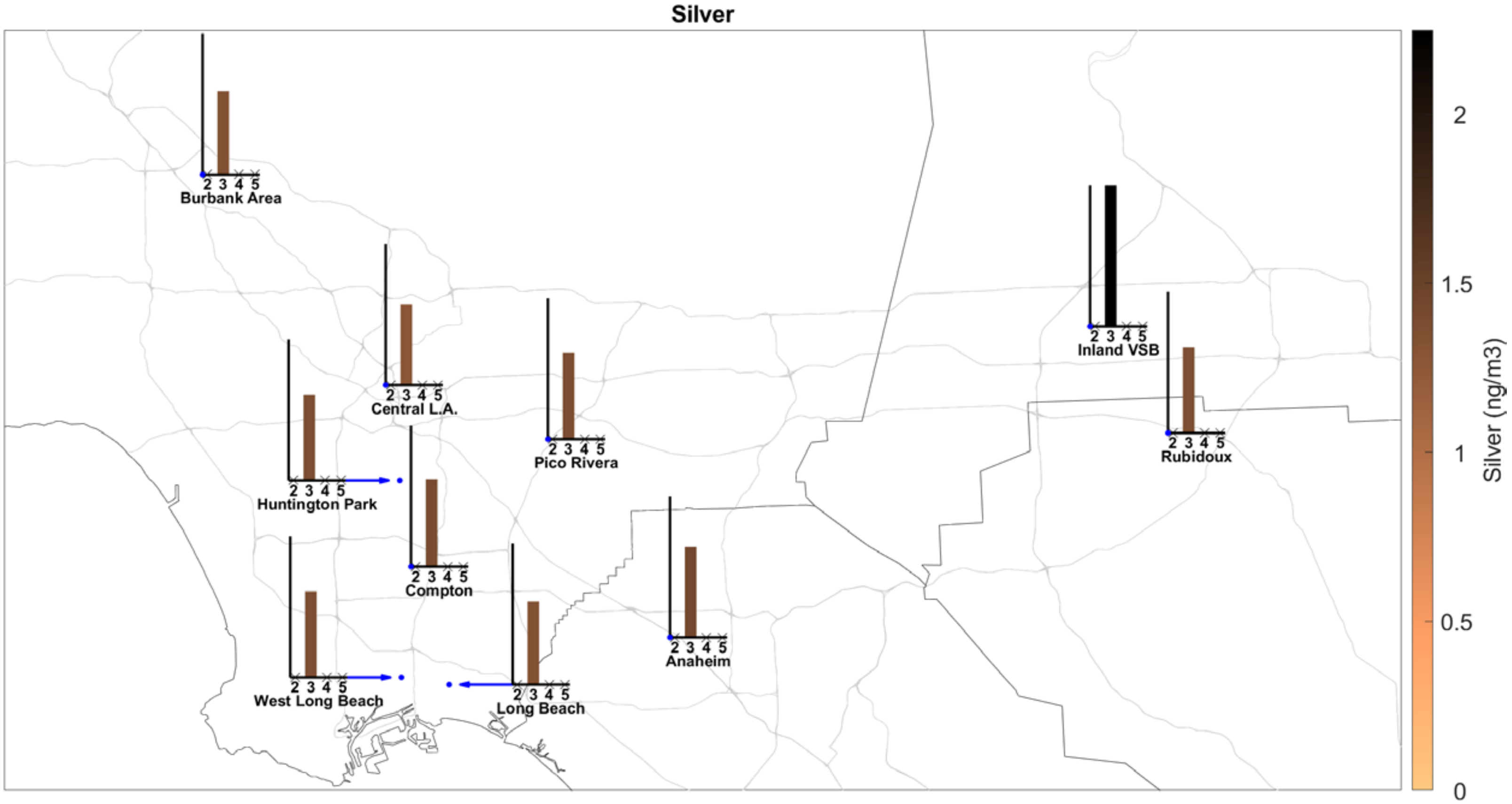


Figure IV-283. Geographic distribution of Silver from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Strontium

Table IV-144. Ambient Concentrations (ng/m^3) of Strontium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	2.34	1.97	1.68	3.16	1.96	1.56	1.94	2.89	2.48	1.61
95% CI LB	1.44	1.48	1.32	1.33	1.36	1.32	1.47	1.38	1.25	1.38
95% CI UB	3.56	2.79	2.25	6.71	3.09	1.84	2.7	5.66	4.86	1.88
N	240	239	234	238	117	228	237	116	236	228
% < MDL	57.1	52.3	53	53.8	41	58.8	55.3	41.4	56.4	48.2
Max	101	82.9	54.5	414	52	19.8	74.2	148	276	21.1
MATES IV										
Average	0.407, 7.27[b]	0, 10.9[b]	0, 10.9[b]	0, 17.8[b]	0, 11.9[b]	0, 9.6[b]	0.417, 16.1[b]	0, 12.7[b]	0, 20.1[b]	0.574, 15.6[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	9.01[b]	12.7[b]	12.5[b]	22.2[b]	13.9[b]	11.3[b]	19.2[b]	14.8[b]	24.7[b]	18.8[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	98.3[b]	100[b]	100[b]	100[b]	100[b]	100[b]	98.3[b]	100[b]	100[b]	98.4[b]
Max	24[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	25[b]	< MDL[b]	< MDL[b]	35[b]
MATES V										
Average	0.704, 9.54[b]	0, 10.2[b]	0.213, 11.1[b]	0, 16.1[b]	0, 10.4[b]	0, 8.22[b]	0.205, 12.5[b]	0, 14.6[b]	0, 17.6[b]	0, 11.9[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	11.3[b]	11.8[b]	13.2[b]	19.3[b]	12.2[b]	10.2[b]	14.5[b]	17[b]	20.4[b]	14.7[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	94.4[b]	100[b]	98.4[b]	100[b]	100[b]	100[b]	98.4[b]	100[b]	100[b]	100[b]
Max	16[b]	< MDL[b]	13[b]	< MDL[b]	< MDL[b]	< MDL[b]	12.5[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

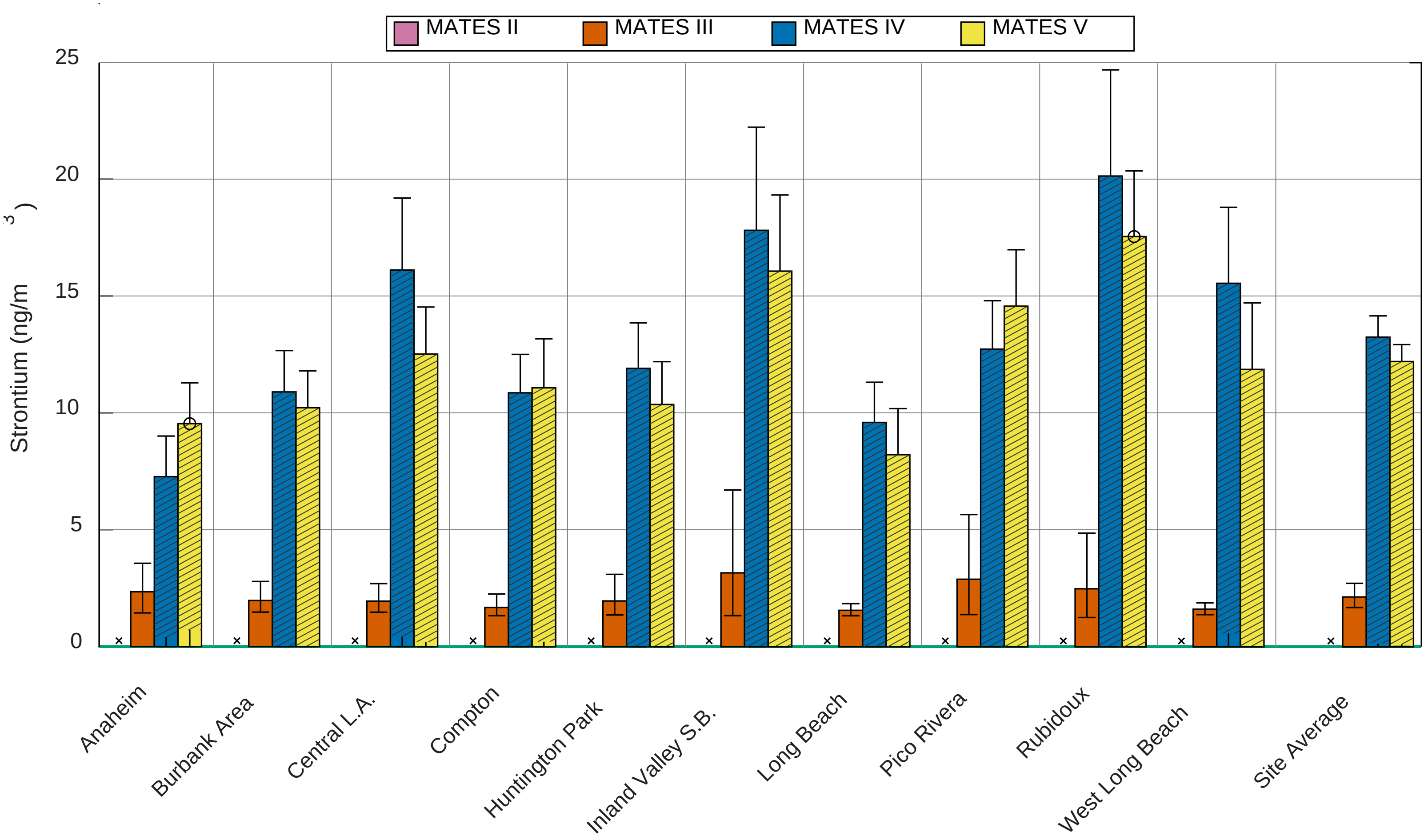


Figure IV-284. Annual Average Concentrations of Strontium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

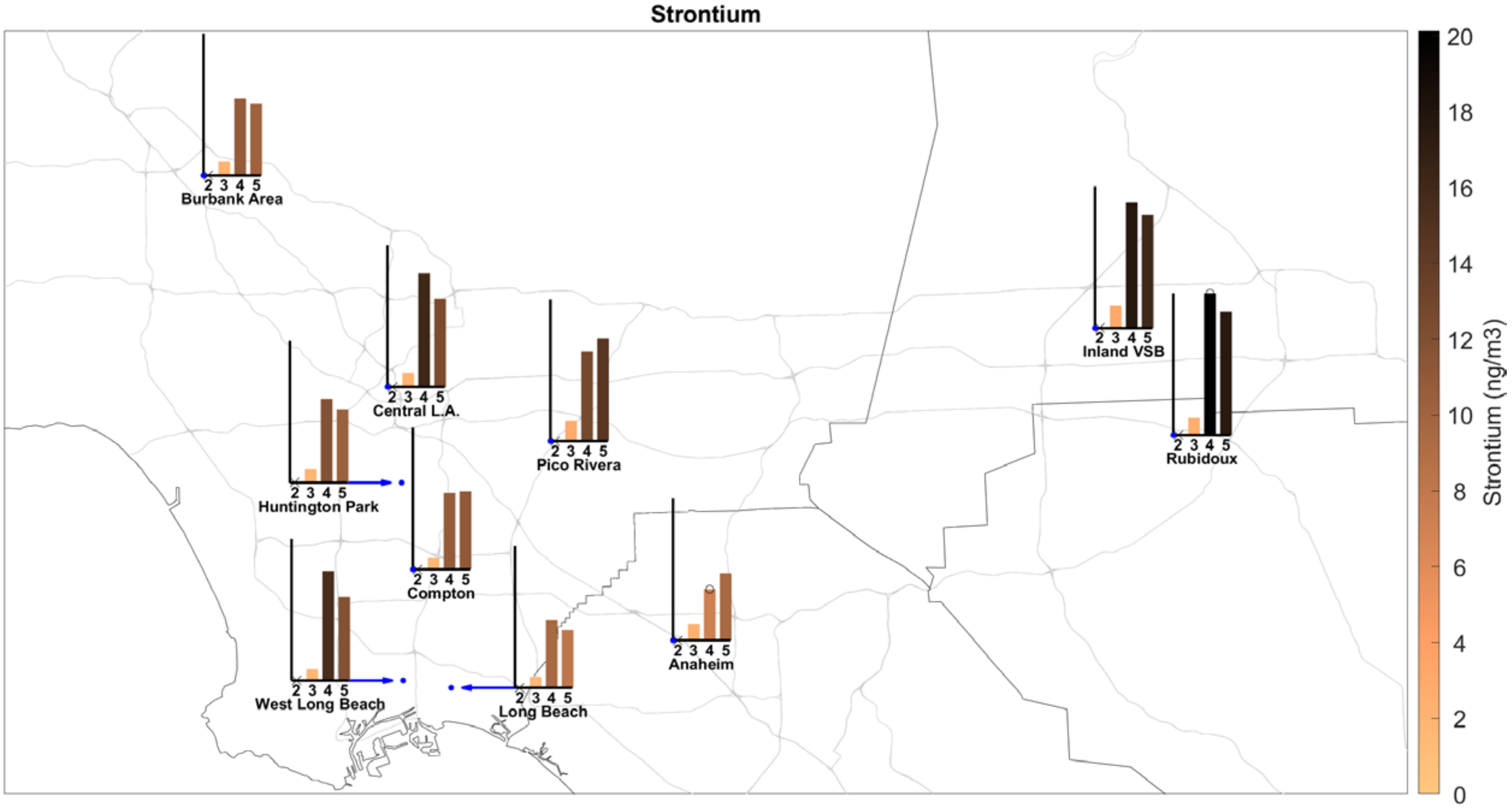


Figure IV-285. Geographic distribution of Strontium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Sulfur

Table IV-145. Ambient Concentrations (ng/m^3) of Sulfur from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	1410	1430	1530	1240	1710	1700	1450	1580	1190	1780
95% CI LB	1260	1260	1360	1080	1420	1510	1250	1310	1060	1590
95% CI UB	1580	1600	1730	1410	2020	1900	1640	1860	1330	1990
N	240	239	234	238	117	228	237	116	236	228
% < MDL	0.8	1.3	0.9	2.5	2.6	0.4	1.3	0.9	5.5	0
Max	6090	5810	6340	10500	6930	7920	7680	6860	8480	9070
MATES IV										
Average	520	510	547	501	572	558	545	537	467	595
95% CI LB	440	426	464	416	475	472	458	451	392	510
95% CI UB	602	594	639	587	669	646	644	625	548	682
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	1.7	0	0	3.4	0	1.7	1.7	1.6	0
Max	1320	1260	1480	1350	1640	1470	1720	1510	1100	1670
MATES V										
Average	238	247	288	246	300	279	279	278	231	293
95% CI LB	188	197	234	198	236	228	222	226	185	241
95% CI UB	285	303	343	292	360	328	338	331	277	348
N	54	59	61	60	60	61	61	59	56	57
% < MDL	11.1	15.3	3.3	11.7	8.3	8.2	13.1	6.8	10.7	5.3
Max	649	766	858	641	928	759	841	731	649	812

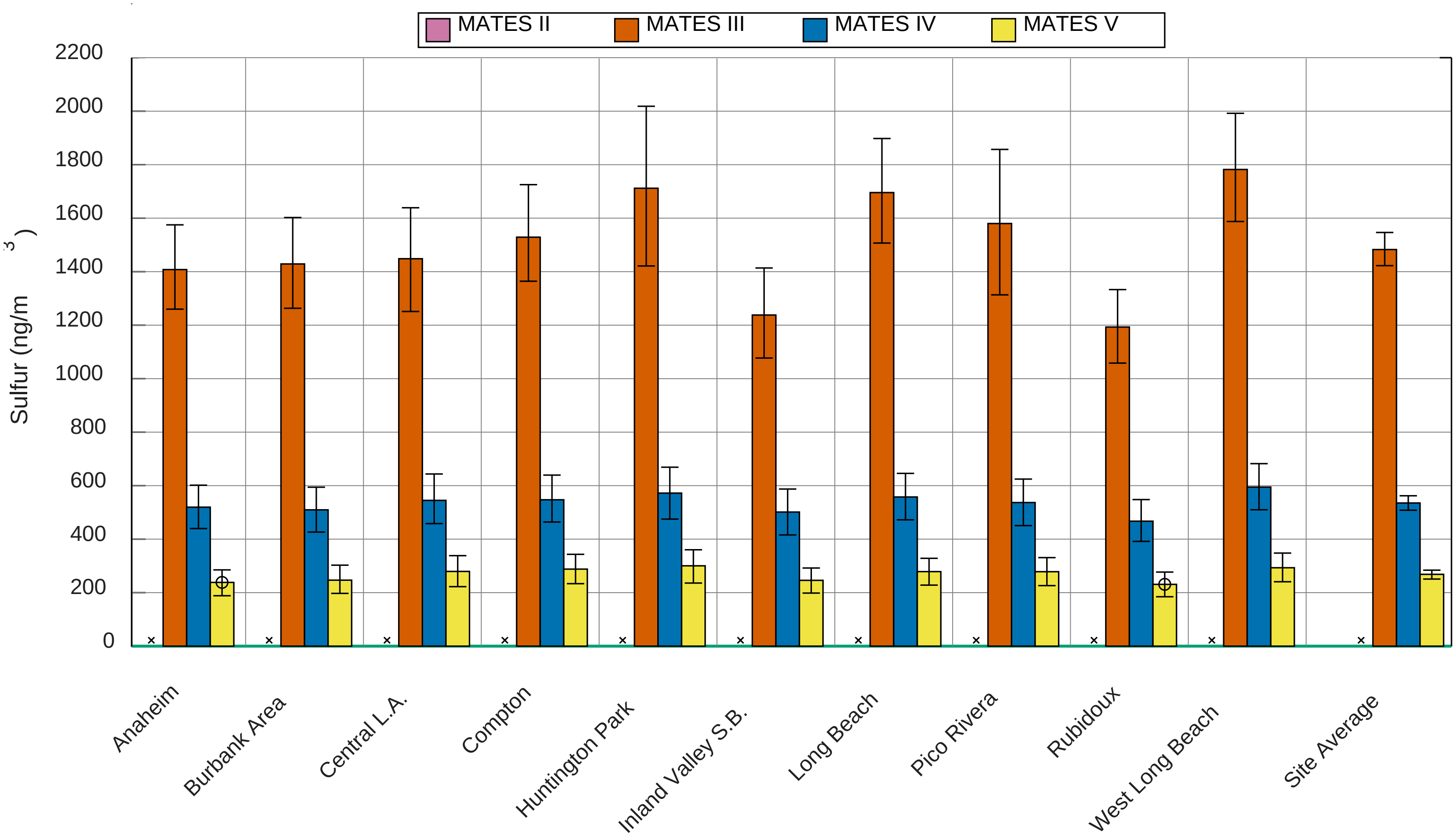


Figure IV-286. Annual Average Concentrations of Sulfur in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

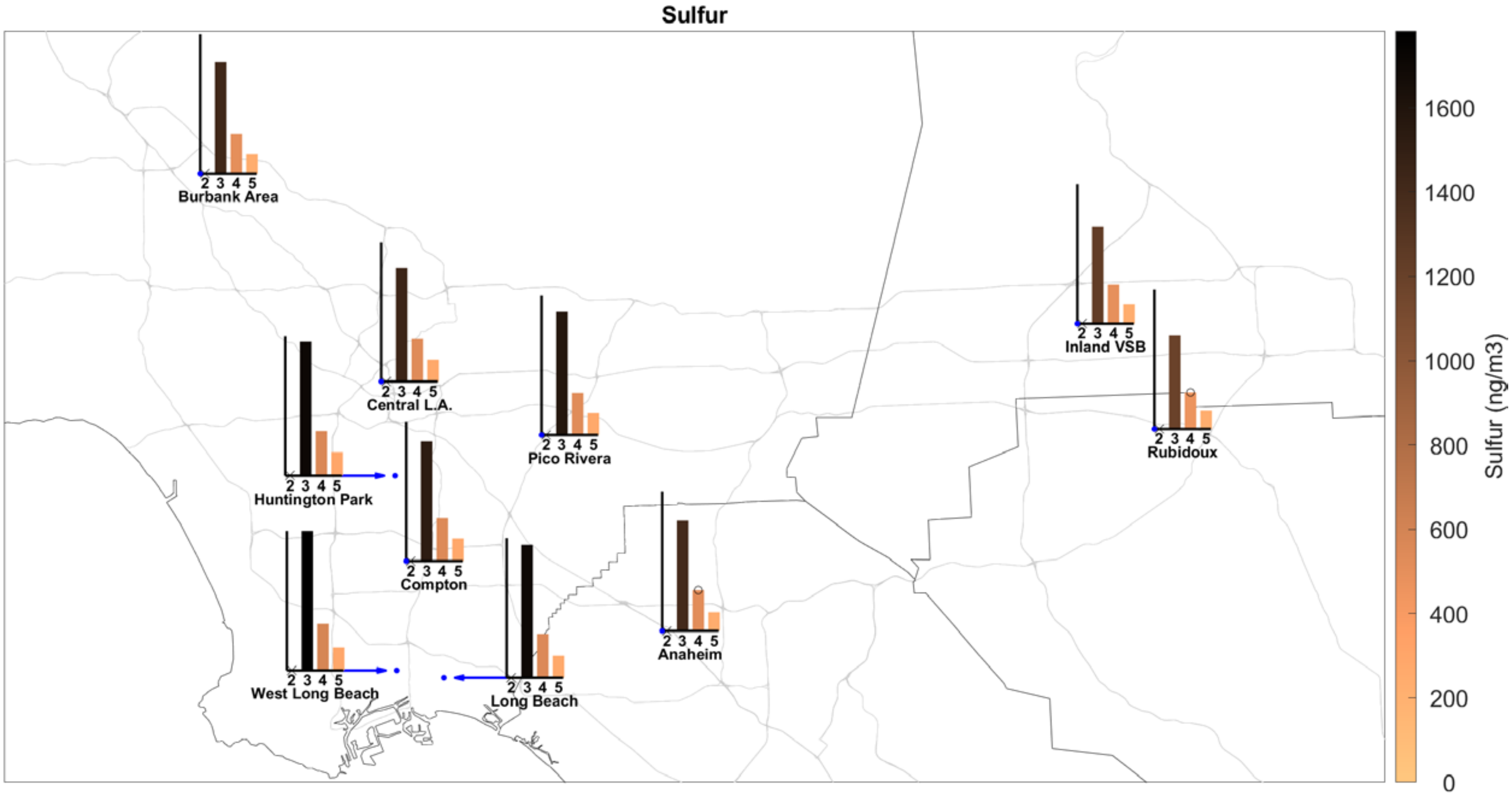


Figure IV-287. Geographic distribution of Sulfur from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Thallium

Table IV-146. Ambient Concentrations (ng/m^3) of Thallium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	0, 25[a]	0, 25[a]	0, 25[a]	0, 25[a]	0, 25[a]	0, 25[a]	0, 25[a]	0, 25[a]	0, 25[a]	0, 25[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	25[a]	25[a]	25[a]	25[a]	25[a]	25[a]	25[a]	25[a]	25[a]	25[a]
N	54[a]	59[a]	61[a]	60[a]	60[a]	61[a]	61[a]	59[a]	56[a]	57[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

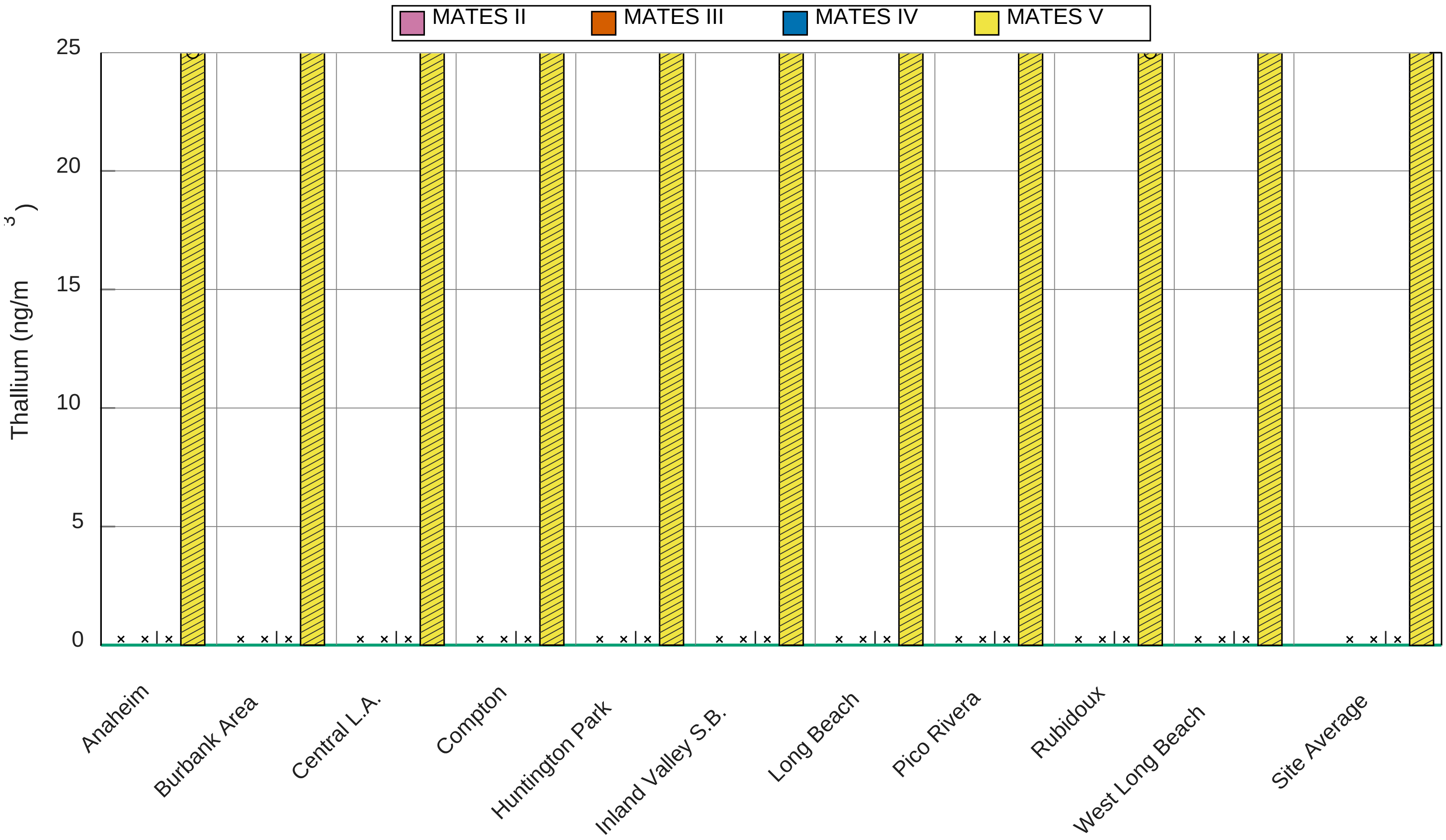


Figure IV-288. Annual Average Concentrations of Thallium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

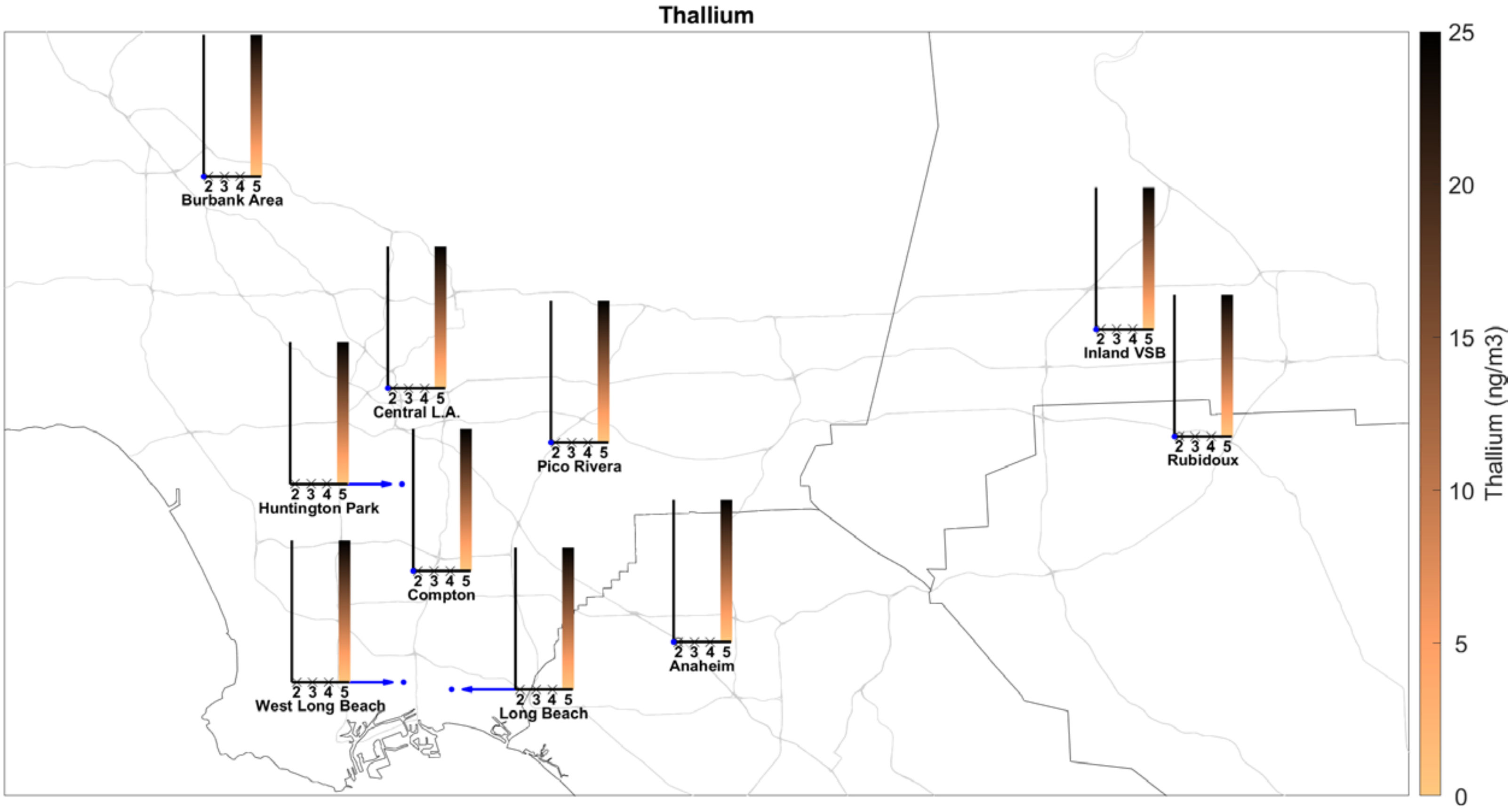


Figure IV-289. Geographic distribution of Thallium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Tin

Table IV-147. Ambient Concentrations (ng/m^3) of Tin from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	1.3, 3.51[b]	1.63, 4.75[b]	1.42, 4.18[b]	1.46, 3.58[b]	0.793, 5.47[b]	1.02, 4.31[b]	2.61	8.47	0.963, 3.31[b]	1.57, 4.16[b]
95% CI LB	0.777[b]	1.04[b]	0.846[b]	0.899[b]	0.444[b]	0.558[b]	2.18	5.23	0.518[b]	0.935[b]
95% CI UB	3.67[b]	5.1[b]	4.52[b]	3.76[b]	6.23[b]	4.7[b]	3.09	12.6	3.41[b]	4.56[b]
N	240[b]	239[b]	234[b]	238[b]	117[b]	228[b]	237	116	236[b]	228[b]
% < MDL	88.3[b]	84.5[b]	86.3[b]	85.3[b]	84.6[b]	89.5[b]	78.9	71.6	90.7[b]	86.4[b]
Max	27.1[b]	29.6[b]	36.9[b]	29.6[b]	9.9[b]	27.1[b]	25.2	116	26[b]	33.3[b]
MATES IV										
Average	1.03, 1.9[b]	2.03, 5.26[b]	6.48, 2.86[b]	0.967, 3.98[b]	5.07, 5.83[b]	0.852, 3.25[b]	2.75, 6.5[b]	26, 20[b]	0.869, 2.89[b]	2.59, 2.55[b]
95% CI LB	0[b]	0[b]	2[b]	0[b]	1.14[b]	0[b]	0[b]	4.76[b]	0[b]	0[b]
95% CI UB	2.27[b]	6.17[b]	3.38[b]	4.87[b]	7.62[b]	4.55[b]	7.95[b]	40.3[b]	3.55[b]	3.07[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	98.3[b]	96.6[b]	90.2[b]	98.3[b]	91.5[b]	98.4[b]	95[b]	86.4[b]	98.4[b]	95.1[b]
Max	61[b]	63[b]	81[b]	58[b]	77[b]	52[b]	59[b]	966[b]	53[b]	55[b]
MATES V										
Average	0, 2.92[b]	0.576, 3.5[b]	0.41, 3.25[b]	0.467, 4.17[b]	2.15, 3.72[b]	0.82, 2.44[b]	0, 5.16[b]	0.915, 4.63[b]	0, 2.69[b]	0, 2.54[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0.45[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	3.68[b]	3.99[b]	4.12[b]	4.73[b]	4.78[b]	3.07[b]	6.05[b]	5.45[b]	3.13[b]	3.23[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	98.3[b]	98.4[b]	98.3[b]	93.3[b]	96.7[b]	100[b]	96.6[b]	100[b]	100[b]
Max	< MDL[b]	34[b]	25[b]	28[b]	42[b]	25[b]	< MDL[b]	28[b]	< MDL[b]	< MDL[b]

^{b}More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

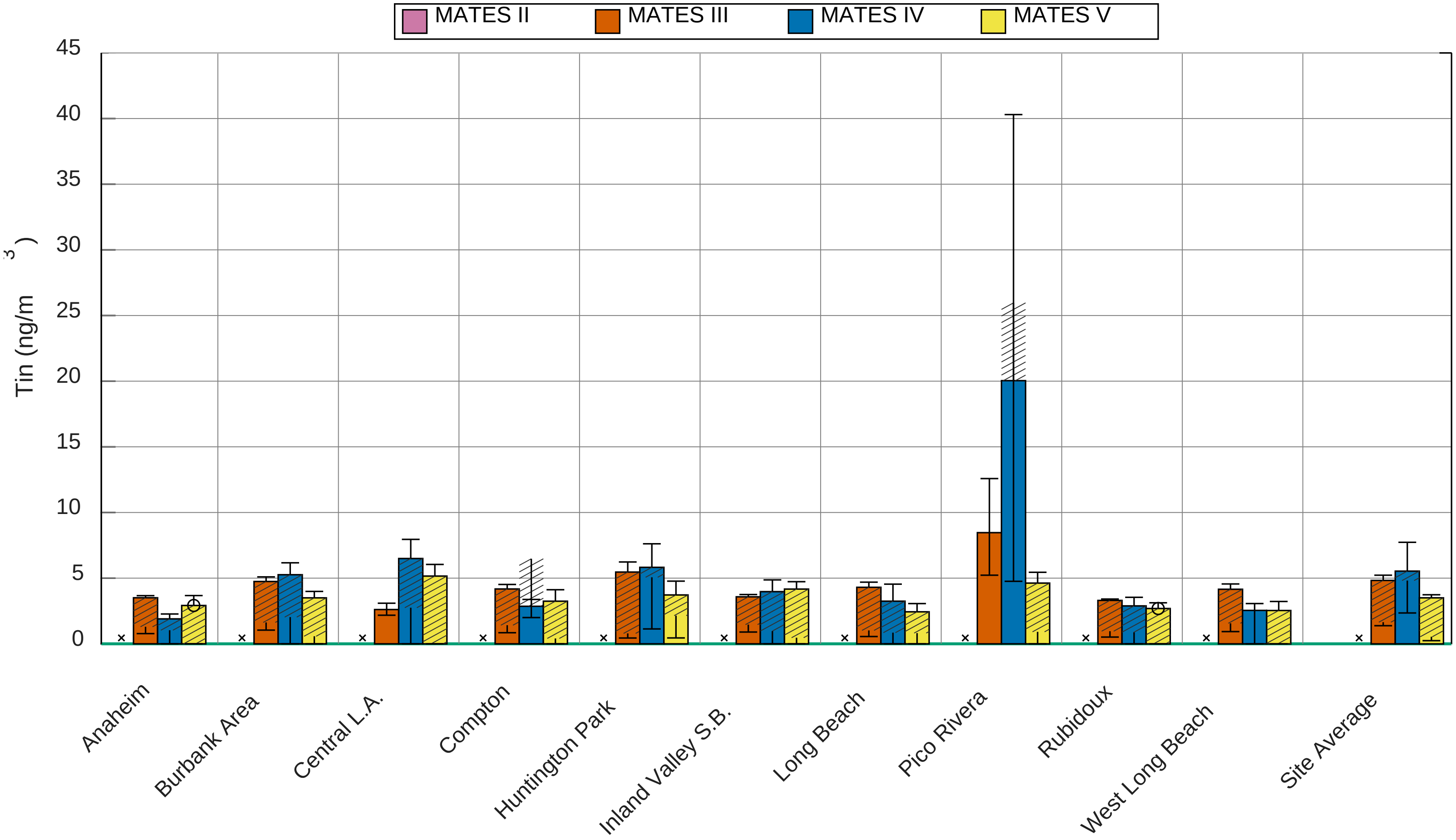


Figure IV-290. Annual Average Concentrations of Tin in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

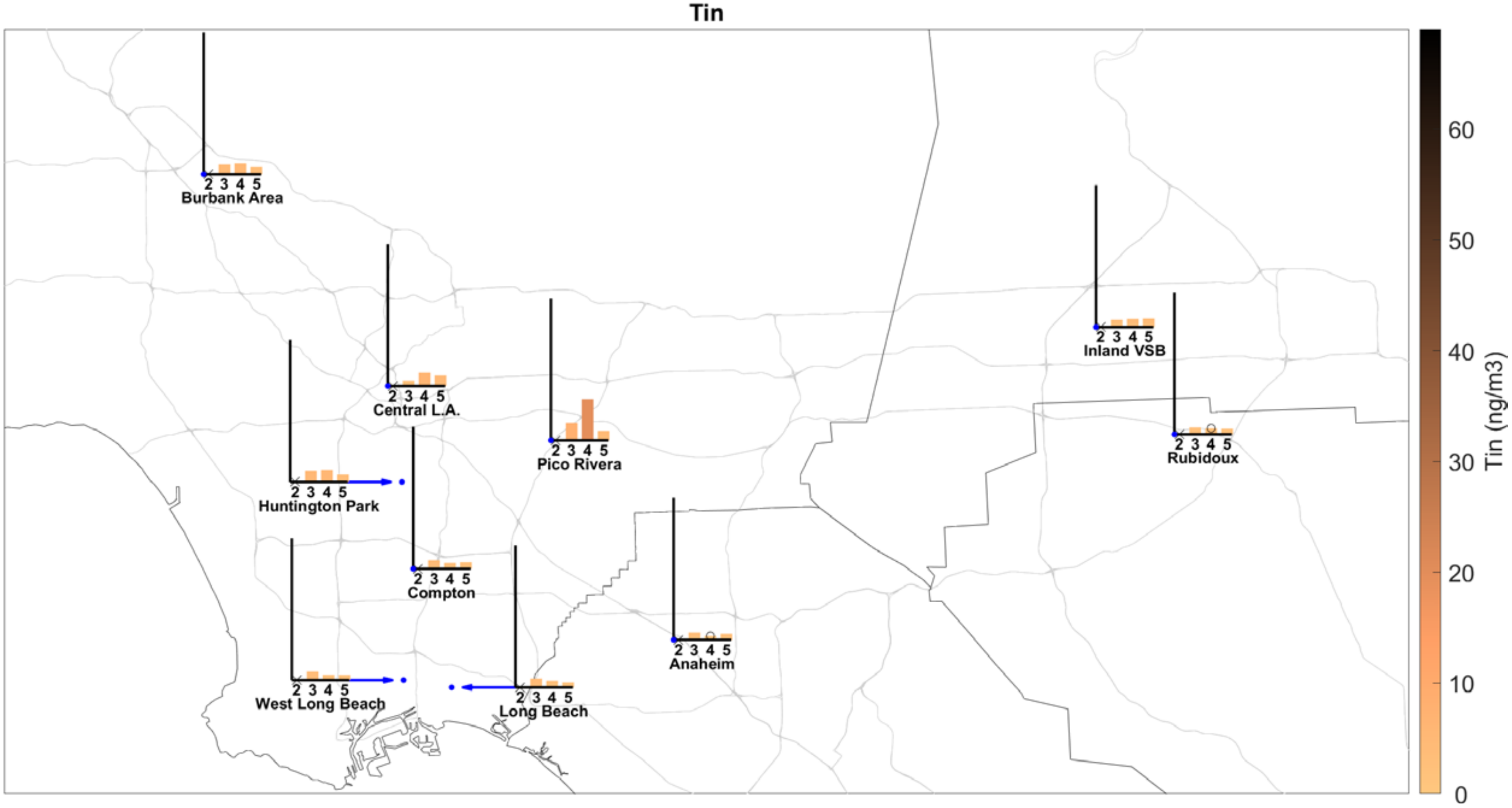


Figure IV-291. Geographic distribution of Tin from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Titanium

Table IV-148. Ambient Concentrations (ng/m^3) of Titanium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	18.2	24.2	25.5	24.6	19	22.9	21.6	20.8	18.4	20.3
95% CI LB	16.9	20	23.2	22.9	17.4	20	20.2	18.9	17.2	17.7
95% CI UB	19.5	30.7	28.1	26.4	20.6	26.1	23.1	22.9	19.8	23
N	240	239	234	238	117	228	237	116	236	228
% < MDL	0.4	0.4	0	0	0.9	0.4	0	0	0	0.4
Max	57	629	175	136	49.3	120	87.9	63.1	96.9	148
MATES IV										
Average	0.898, 30[b]	1.07, 53.9[b]	1.87, 58.8[b]	1.8, 146[b]	1.69, 56.2[b]	4.82, 51.6[b]	2.02, 59.7[b]	2.34, 71.5[b]	0.426, 133[b]	5.21, 73.1[b]
95% CI LB	0[b]	0[b]	0[b]	0.367[b]	0.339[b]	1.62[b]	0.483[b]	0.678[b]	0[b]	1.84[b]
95% CI UB	38[b]	62.4[b]	67.8[b]	183[b]	65.7[b]	63.2[b]	71.3[b]	84.5[b]	165[b]	89.6[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	96.6[b]	94.9[b]	95.1[b]	93.3[b]	93.2[b]	88.5[b]	91.7[b]	89.8[b]	98.4[b]	86.9[b]
Max	32[b]	24[b]	45[b]	34[b]	29[b]	55[b]	30[b]	30[b]	26[b]	77[b]
MATES V										
Average	1.61, 52.5[b]	0, 66.3[b]	1.02, 62[b]	0.733, 134[b]	0, 49.7[b]	0, 49[b]	0, 54.8[b]	1.47, 103[b]	1.04, 112[b]	0, 65.2[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0.339[b]	0[b]	0[b]
95% CI UB	61.3[b]	76.7[b]	75.2[b]	163[b]	58.2[b]	64.3[b]	62.1[b]	119[b]	127[b]	84.5[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	94.4[b]	100[b]	95.1[b]	96.7[b]	100[b]	100[b]	100[b]	93.2[b]	96.4[b]	100[b]
Max	37[b]	< MDL[b]	22[b]	24[b]	< MDL[b]	< MDL[b]	< MDL[b]	25[b]	36[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

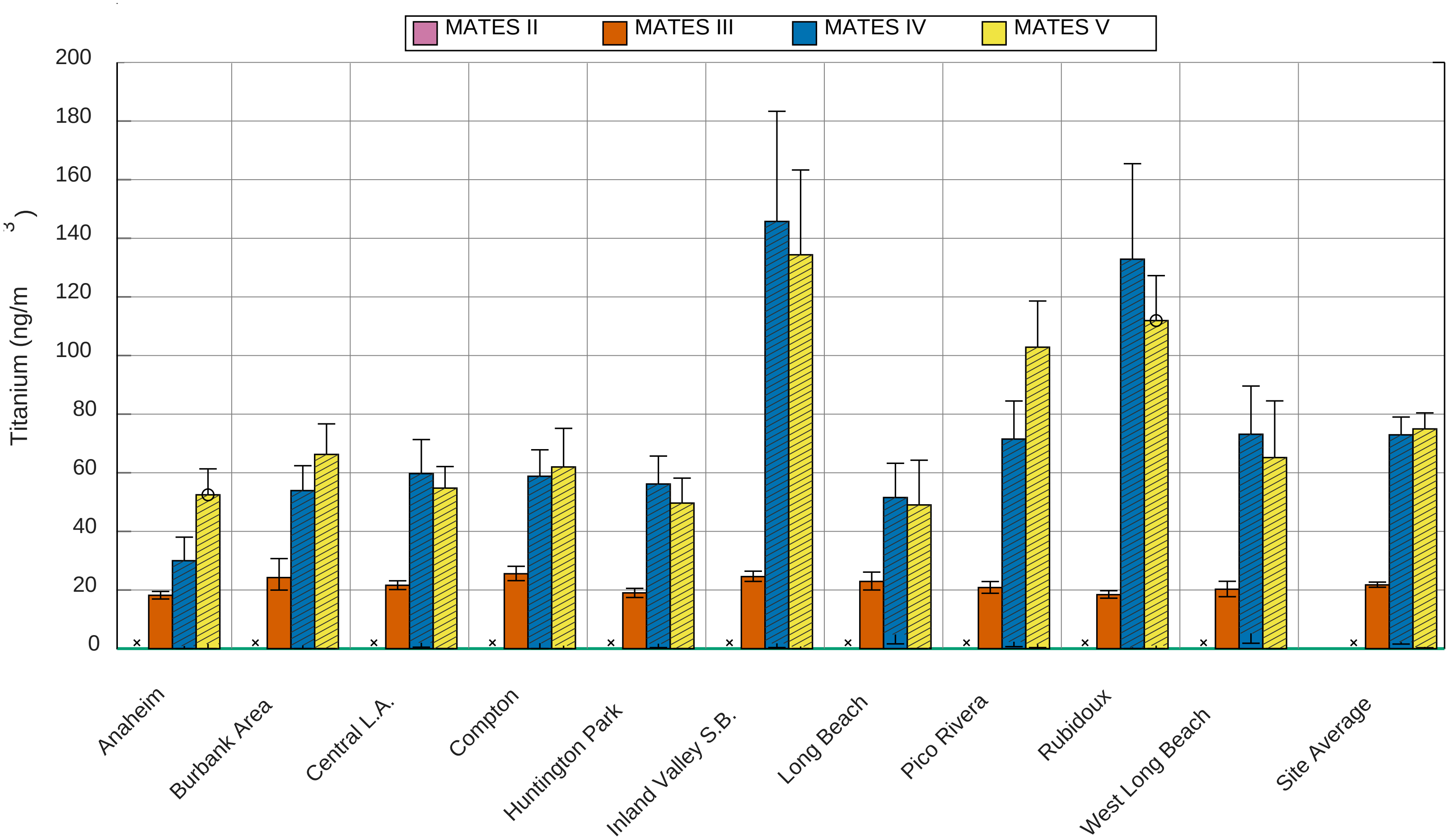


Figure IV-292. Annual Average Concentrations of Titanium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

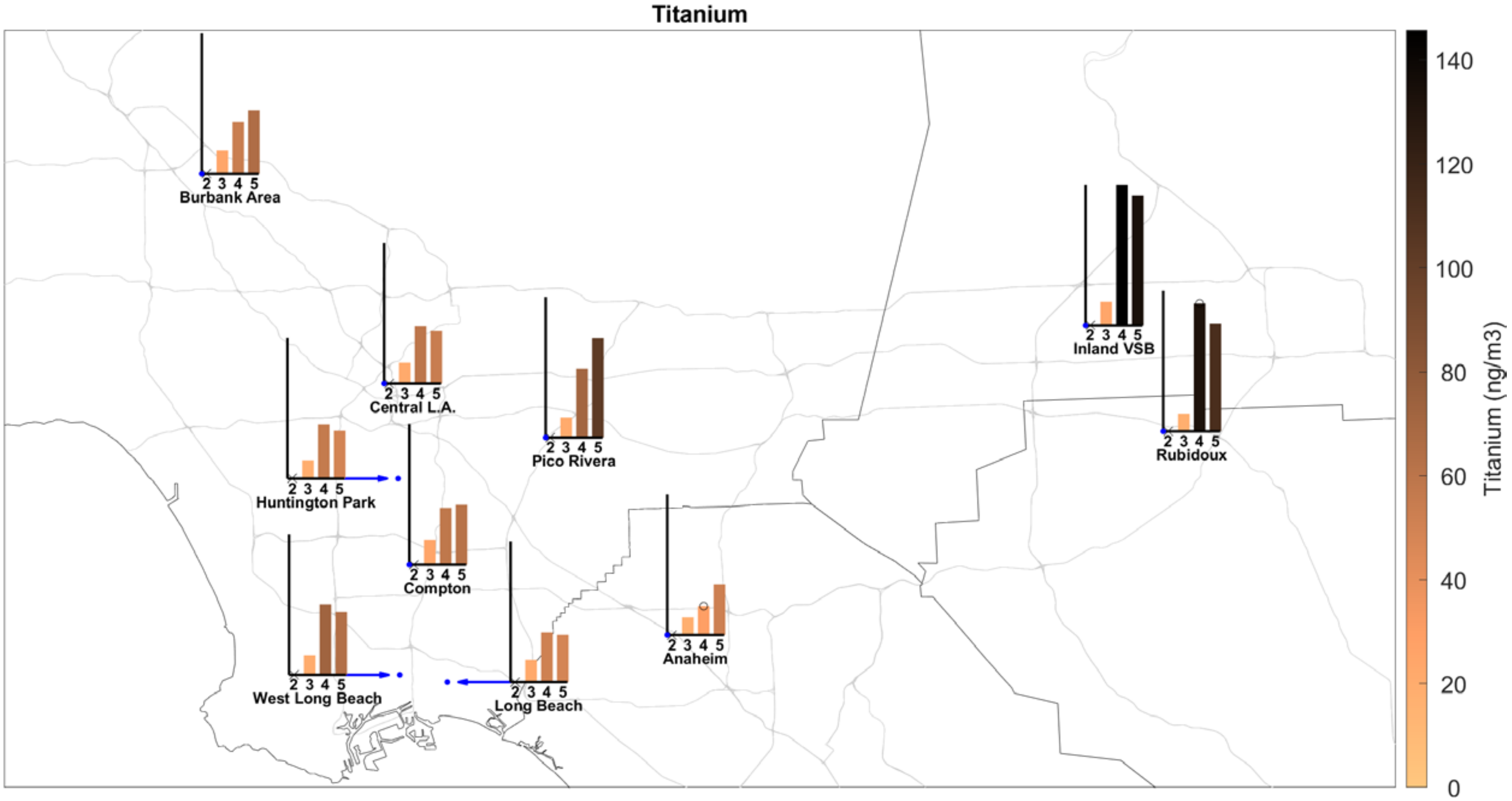


Figure IV-293. Geographic distribution of Titanium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Uranium

Table IV-149. Ambient Concentrations (ng/m^3) of Uranium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average	1.41, 23.6[a]	1, 23.6[a]	1.9, 23.8[a]	1.85, 0.122[b]	1.71, 23.5[a]	3.03, 23.8[a]	1.7, 23.5[a]	2.76, 23.8[a]	2.26, 0.123[b]	1.92, 23.8[a]
95% CI LB	0[a]	0[a]	0.393[a]	0.4[b]	0.407[a]	0.918[a]	0.4[a]	0.864[a]	0.492[b]	0.459[a]
95% CI UB	24[a]	24[a]	24.3[a]	0.145[b]	23.7[a]	24.1[a]	23.7[a]	24.2[a]	0.147[b]	24.2[a]
N	59[a]	59[a]	61[a]	60[b]	59[a]	61[a]	60[a]	59[a]	61[b]	61[a]
% < MDL	94.9[a]	96.6[a]	93.4[a]	93.3[b]	93.2[a]	88.5[a]	93.3[a]	89.8[a]	91.8[b]	93.4[a]
Max	32[a]	31[a]	33[a]	34[b]	29[a]	31[a]	27[a]	32[a]	33[b]	31[a]
MATES V										
Average	0, 0.0561[b]	0, 0.0577[b]	0, 0.0453[b]	0, 0.0944[b]	0, 0.0376[b]	0, 0.036[b]	0, 0.0465[b]	0, 0.0664[b]	0, 0.0908[b]	0, 0.0475[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	0.0658[b]	0.0675[b]	0.0571[b]	0.114[b]	0.0459[b]	0.0472[b]	0.0542[b]	0.0781[b]	0.105[b]	0.0647[b]
N	54[b]	55[b]	56[b]	60[b]	56[b]	61[b]	61[b]	54[b]	56[b]	52[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

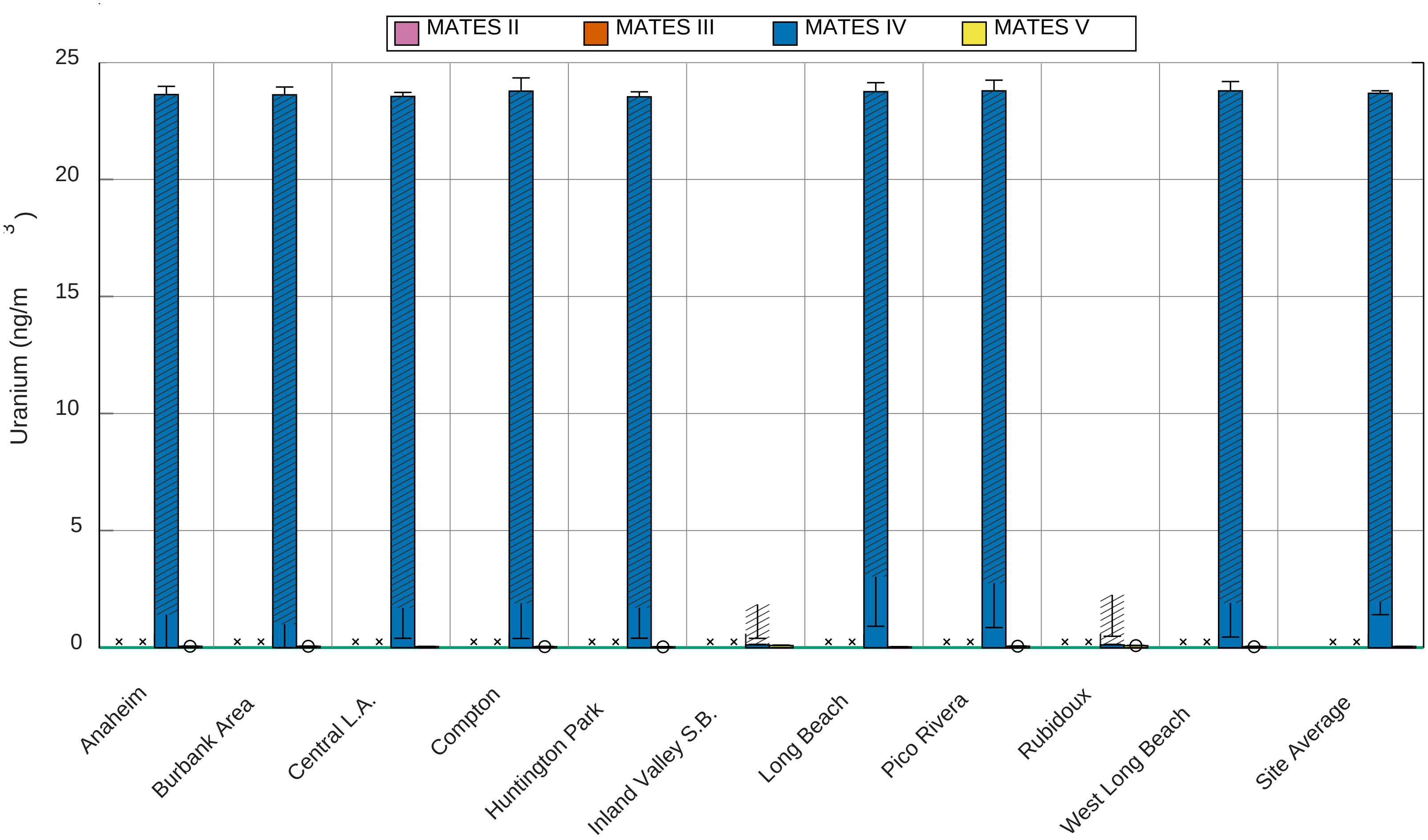


Figure IV-294. Annual Average Concentrations of Uranium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

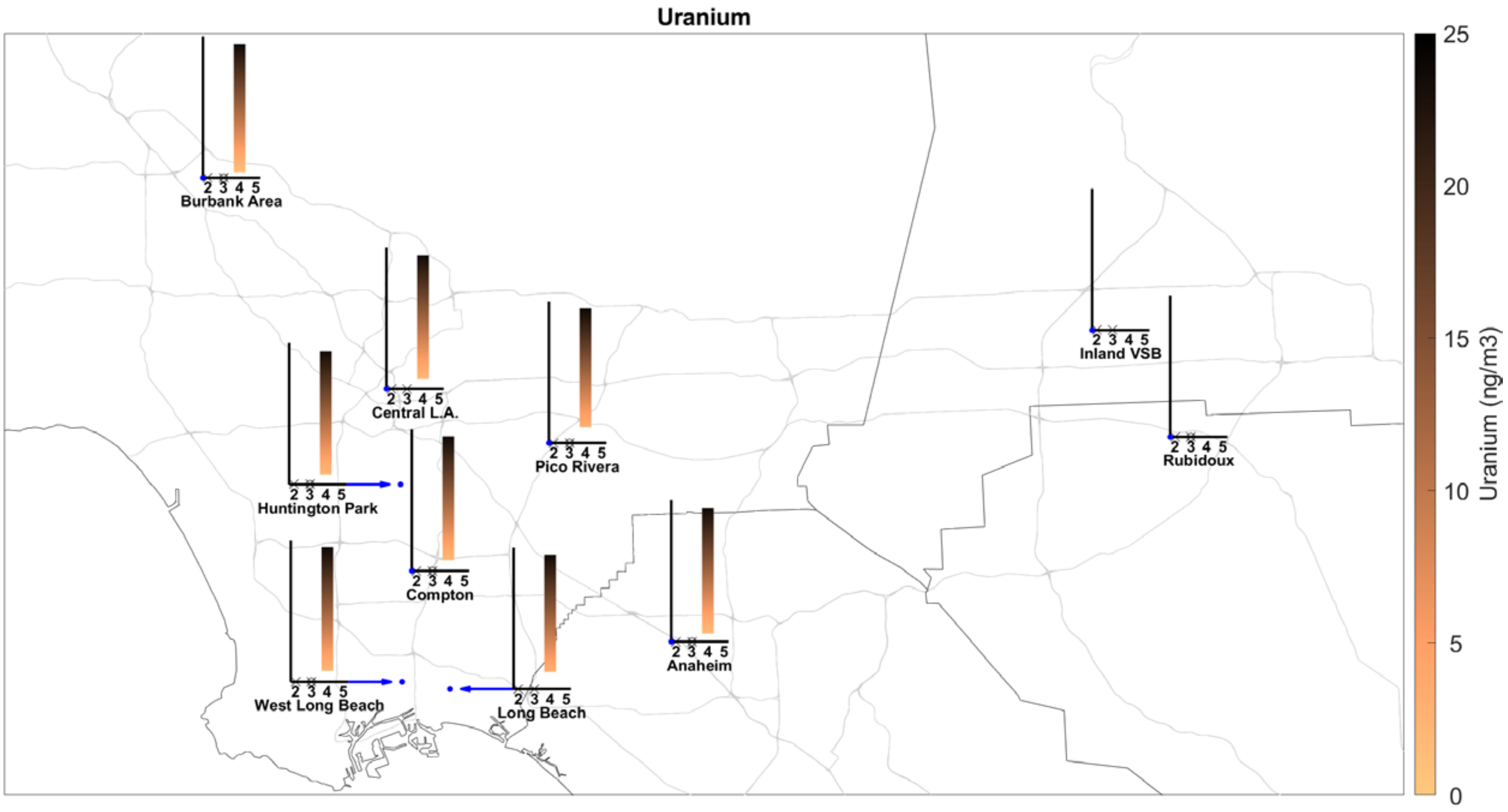


Figure IV-295. Geographic distribution of Uranium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Vanadium

Table IV-150. Ambient Concentrations (ng/m^3) of Vanadium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	6.9	4.34	7.54	3.89	6.03	11.5	4.83	5.65	4.03	19.5
95% CI LB	6.17	3.88	6.81	3.48	5.09	10.4	4.31	4.83	3.61	17.6
95% CI UB	7.66	4.83	8.31	4.34	7.03	12.6	5.38	6.53	4.48	21.5
N	240	239	234	238	117	228	237	116	236	228
% < MDL	7.1	18.4	6.4	20.2	5.1	4.4	17.7	8.6	18.2	2.6
Max	28.5	22.3	34.6	19.8	28.5	50.7	22.9	26	23.5	87.5
MATES IV										
Average	0, 1.82[b]	0, 2.1[b]	0, 3.14[b]	0, 5.63[b]	0, 2.67[b]	0, 3.53[b]	0, 2.64[b]	0, 3.11[b]	0, 4.72[b]	0, 4.58[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	2.64[b]	2.43[b]	3.59[b]	7.16[b]	3.08[b]	4.34[b]	3.16[b]	3.73[b]	5.94[b]	5.49[b]
N	59[b]	59[b]	61[b]	60[b]	59[b]	61[b]	60[b]	59[b]	61[b]	61[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]
MATES V										
Average	0, 1.94[b]	0, 2.22[b]	0, 2.4[b]	0, 4.78[b]	0, 1.85[b]	0, 2.21[b]	0, 1.9[b]	0, 3.41[b]	0, 3.66[b]	0, 3.06[b]
95% CI LB	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
95% CI UB	2.19[b]	2.57[b]	2.78[b]	5.83[b]	2.16[b]	2.54[b]	2.16[b]	4.04[b]	4.24[b]	3.55[b]
N	54[b]	59[b]	61[b]	60[b]	60[b]	61[b]	61[b]	59[b]	56[b]	57[b]
% < MDL	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]	100[b]
Max	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]	< MDL[b]

---

[b] More than 80% of data are < MDL. Values based on zero substitutions and TSP KM mean.

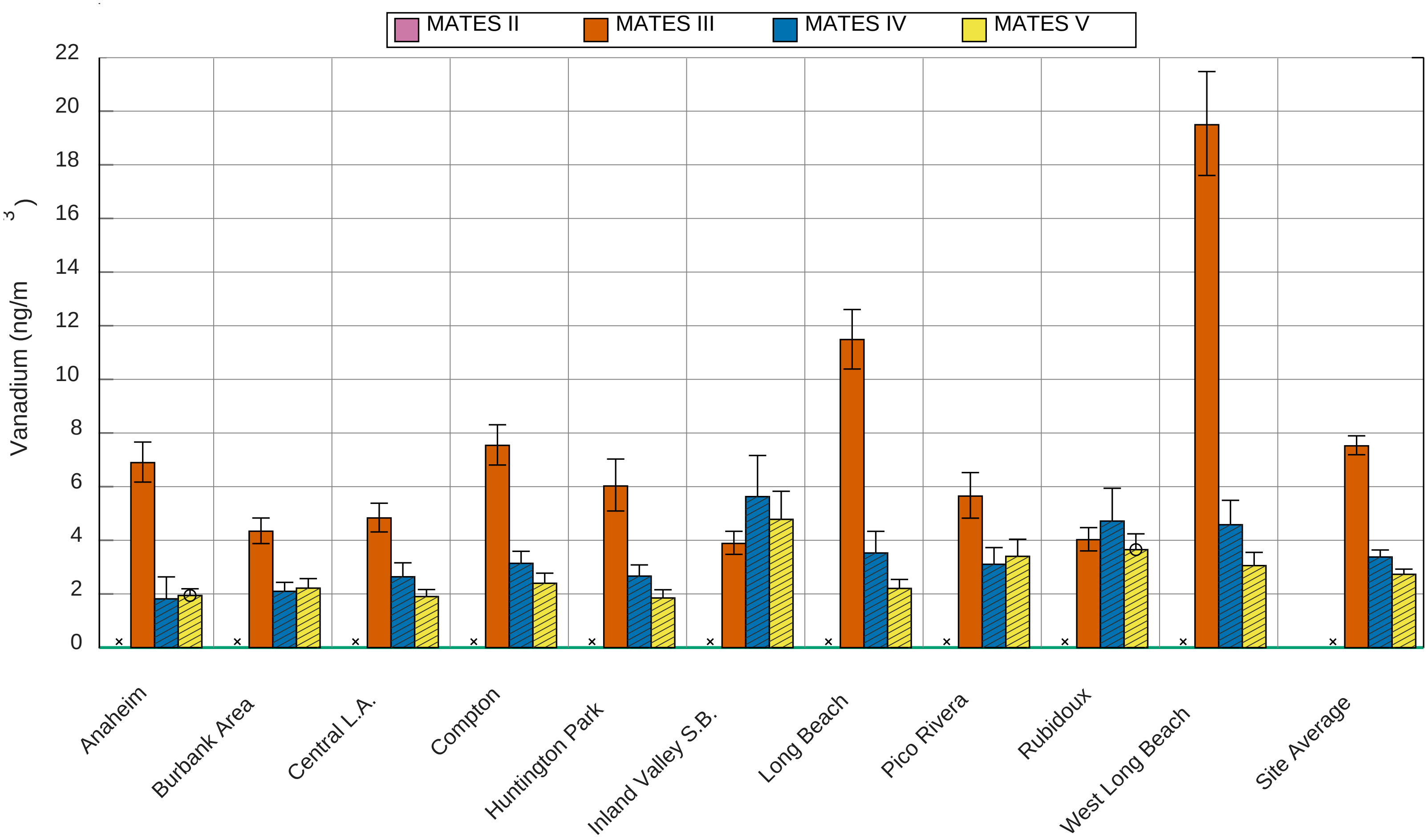


Figure IV-296. Annual Average Concentrations of Vanadium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

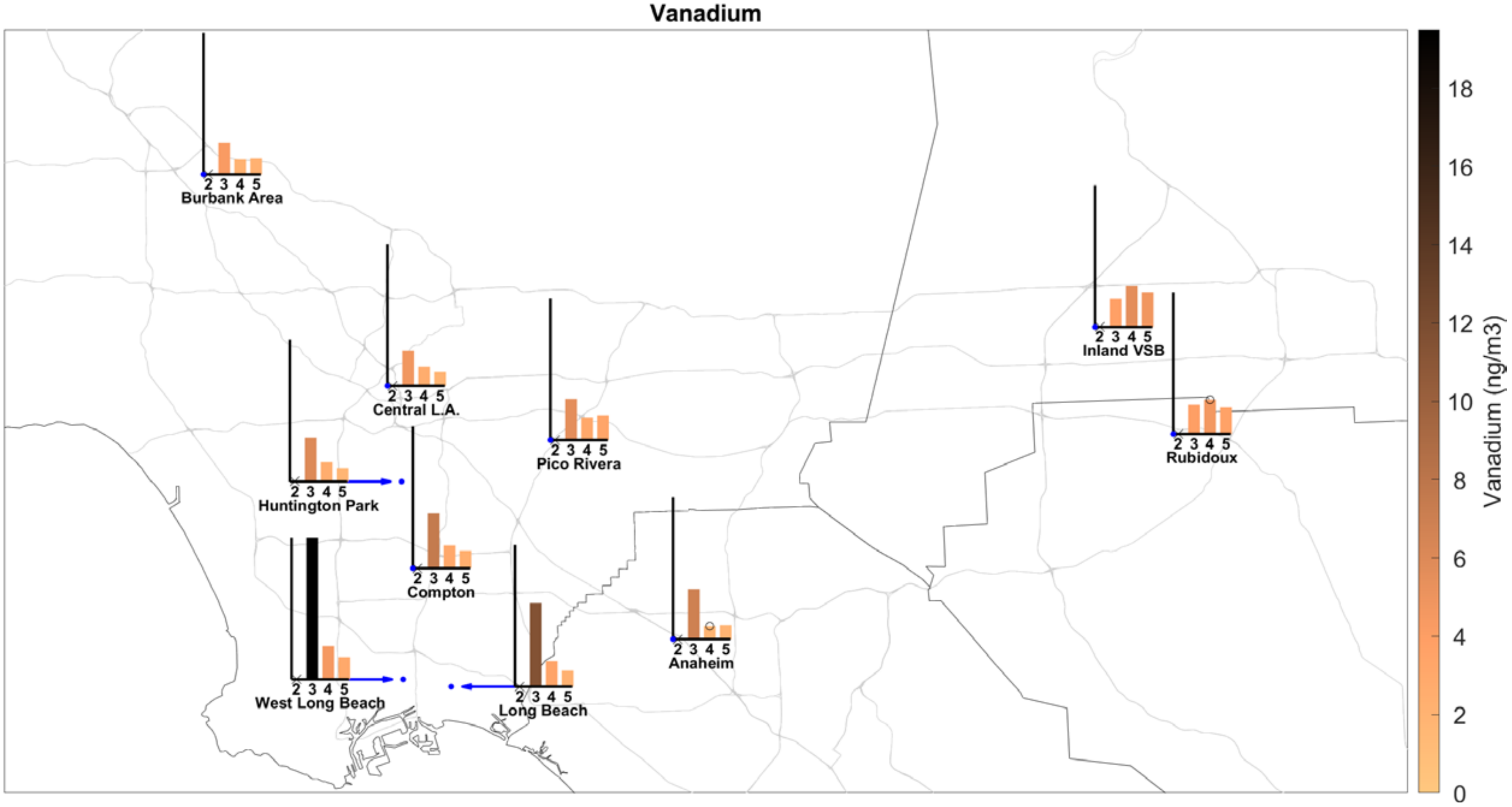


Figure IV-297. Geographic distribution of Vanadium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Yttrium

Table IV-151. Ambient Concentrations (ng/m^3) of Yttrium from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	1.1	1.12	1.18	0.947	1.32	1.21	1.04	1.23	1.07	1.19
95% CI LB	0.989	0.99	1.06	0.843	1.17	1.08	0.947	1.1	0.946	1.08
95% CI UB	1.21	1.25	1.31	1.05	1.47	1.34	1.15	1.36	1.19	1.3
N	240	239	234	238	117	228	237	116	236	228
% < MDL	37.1	41	34.6	44.5	21.4	32.5	32.1	21.6	41.5	30.3
Max	4.95	3.72	4.95	4.93	3.72	6.17	3.1	3.72	6.16	3.72
MATES IV										
Average	0, 15.7[a]	0, 15.7[a]	0, 15.7[a]	0, 15.7[a]	0, 15.7[a]	0, 15.7[a]	0, 15.7[a]	0, 15.7[a]	0, 15.7[a]	0, 15.7[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	15.7[a]	15.7[a]	15.7[a]	15.7[a]	15.7[a]	15.7[a]	15.7[a]	15.7[a]	15.7[a]	15.7[a]
N	59[a]	59[a]	61[a]	60[a]	59[a]	61[a]	60[a]	59[a]	61[a]	61[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]
MATES V										
Average	0, 12[a]	0, 12[a]	0, 12[a]	0, 12[a]	0, 12[a]	0, 12[a]	0, 12[a]	0, 12[a]	0, 12[a]	0, 12[a]
95% CI LB	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
95% CI UB	12[a]	12[a]	12[a]	12[a]	12[a]	12[a]	12[a]	12[a]	12[a]	12[a]
N	54[a]	59[a]	61[a]	60[a]	60[a]	61[a]	61[a]	59[a]	56[a]	57[a]
% < MDL	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
Max	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]	< MDL[a]

---

[a] More than 80% of data are < MDL. Values based on zero and MDL substitutions.

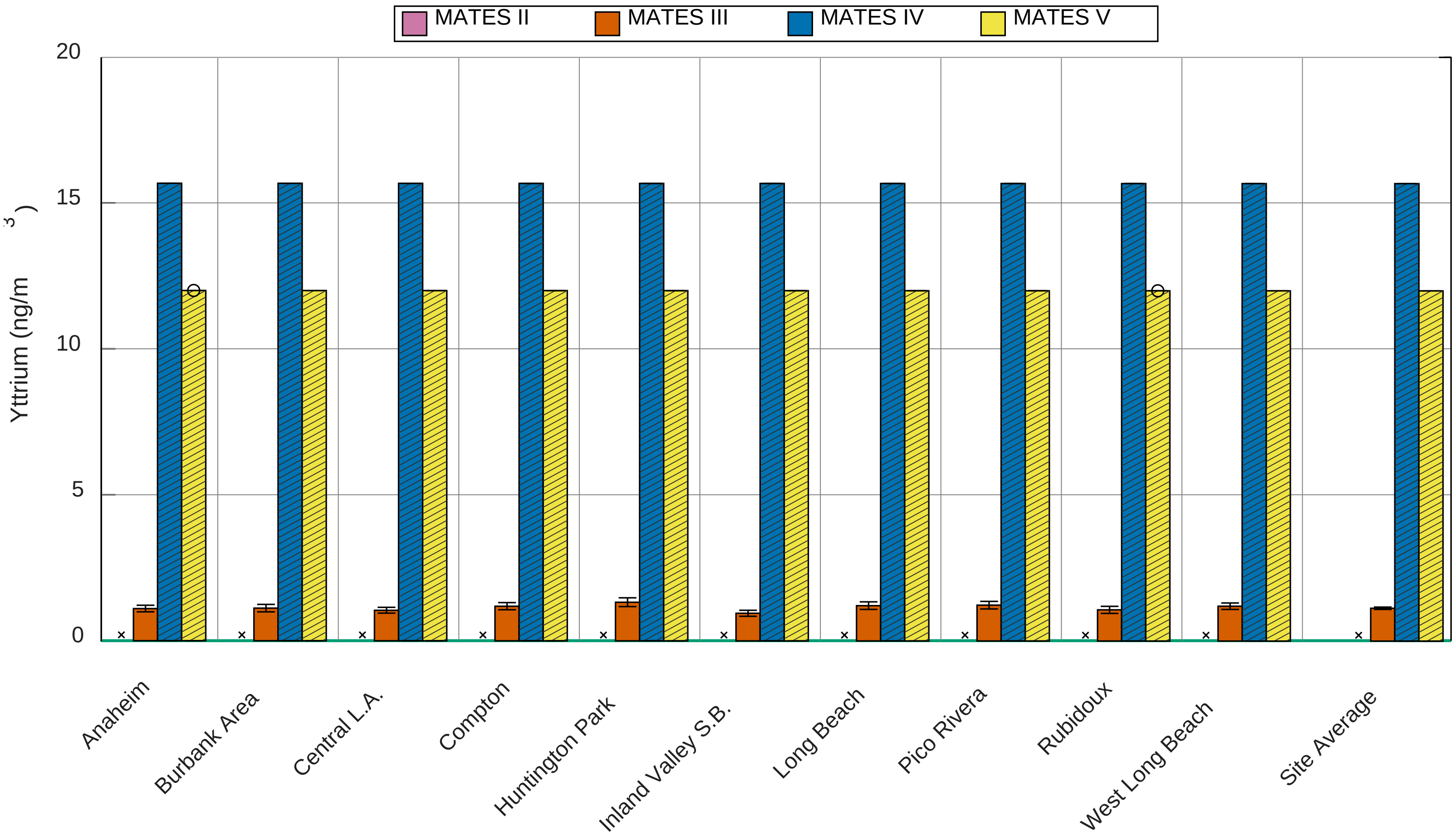


Figure IV-298. Annual Average Concentrations of Yttrium in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

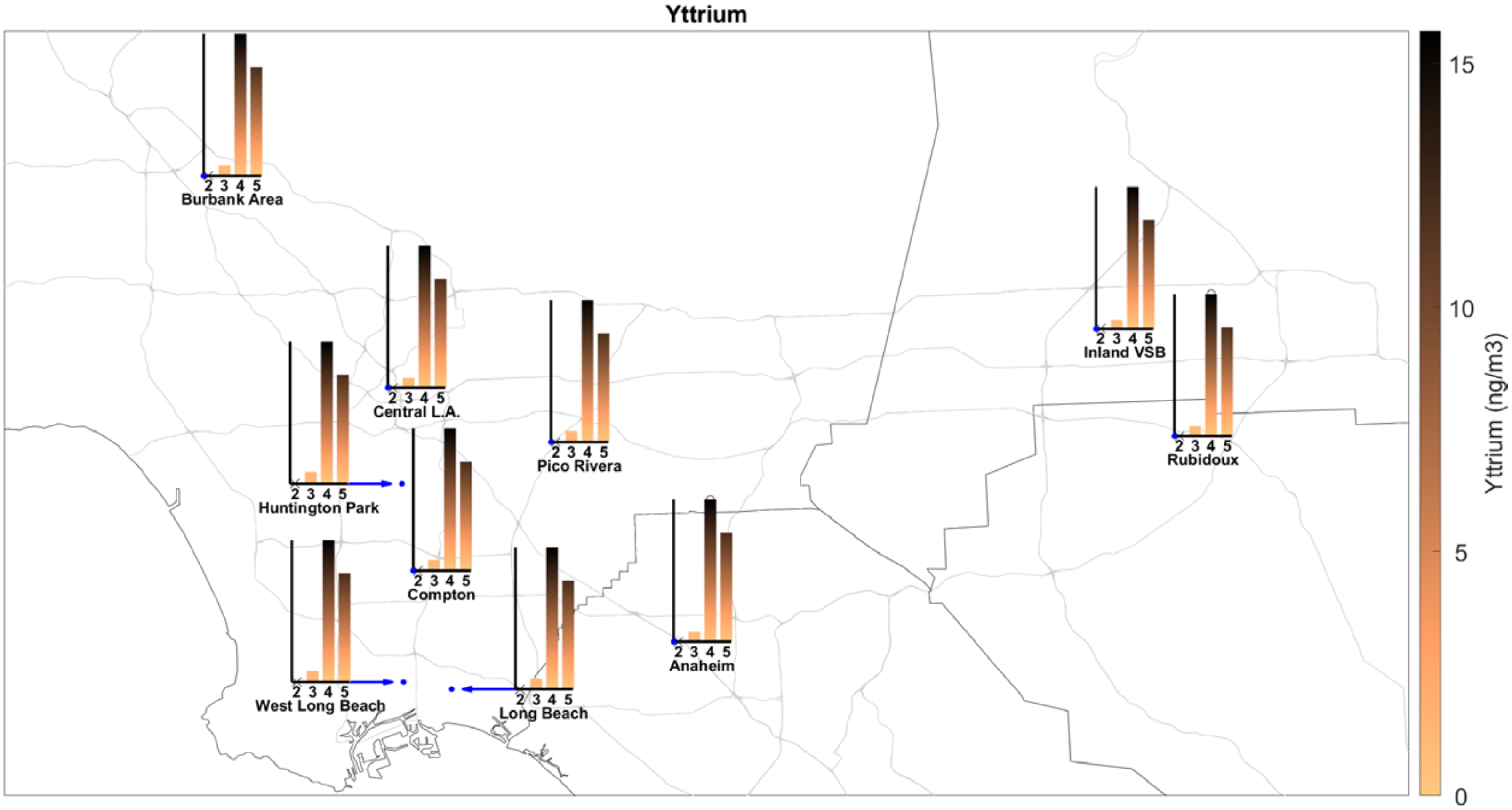


Figure IV-299. Geographic distribution of Yttrium from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Zinc

Table IV-152. Ambient Concentrations (ng/m^3) of Zinc from the PM2.5 Metals analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average	21	21.4	29.2	56.7	36.5	26.8	36.2	40.7	31.9	27.1
95% CI LB	19.2	19.8	25.5	49.2	30.3	23.9	23.3	31.6	27.6	23.5
95% CI UB	22.8	23	33.5	67.6	43.6	29.9	60	51.5	36.5	31.1
N	240	239	234	238	117	228	237	116	236	228
% < MDL	0	0	0	0	0	0	0	0	0	0
Max	75.5	79.3	237	1050	224	181	2620	362	262	189
MATES IV										
Average	24.4	11.5	13.2	25	21.1	16.2	13.4	19.8	12.6	15.2
95% CI LB	15.1	10.1	10.7	20.9	14.5	12.9	11.2	12	10.4	12
95% CI UB	35.3	13.1	16.3	29.3	29.6	19.8	16	32.4	15.2	18.7
N	59	59	61	60	59	61	60	59	61	61
% < MDL	59.3	59.3	67.2	16.7	50.8	50.8	53.3	49.2	60.7	50.8
Max	210	36	61	72	189	72	58	332	56	64
MATES V										
Average	39.1	10.7	14.7	25.4	15.9	13	12.3	15	12.3	18
95% CI LB	18.6	9.22	12.4	22.1	12.7	11	10.4	12.6	10.4	13.8
95% CI UB	66.9	12.6	17.2	28.8	19.4	15.2	15.1	17.7	14.3	23
N	54	59	61	60	60	61	61	59	56	57
% < MDL	33.3	33.9	21.3	1.7	16.7	39.3	19.7	13.6	21.4	15.8
Max	525	55	45	71	88	51	79	69	43	97

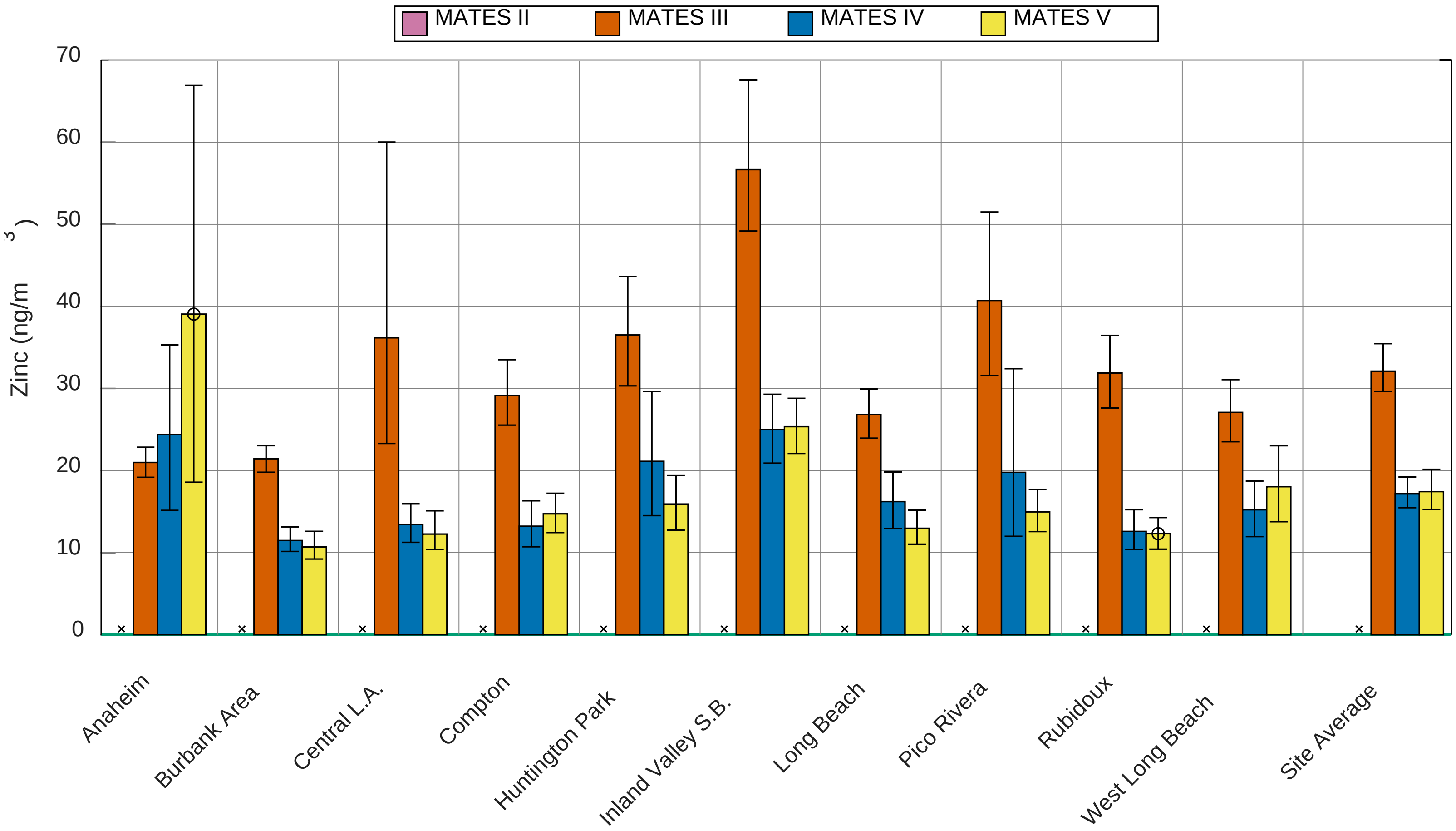


Figure IV-300. Annual Average Concentrations of Zinc in the PM2.5 Metals Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

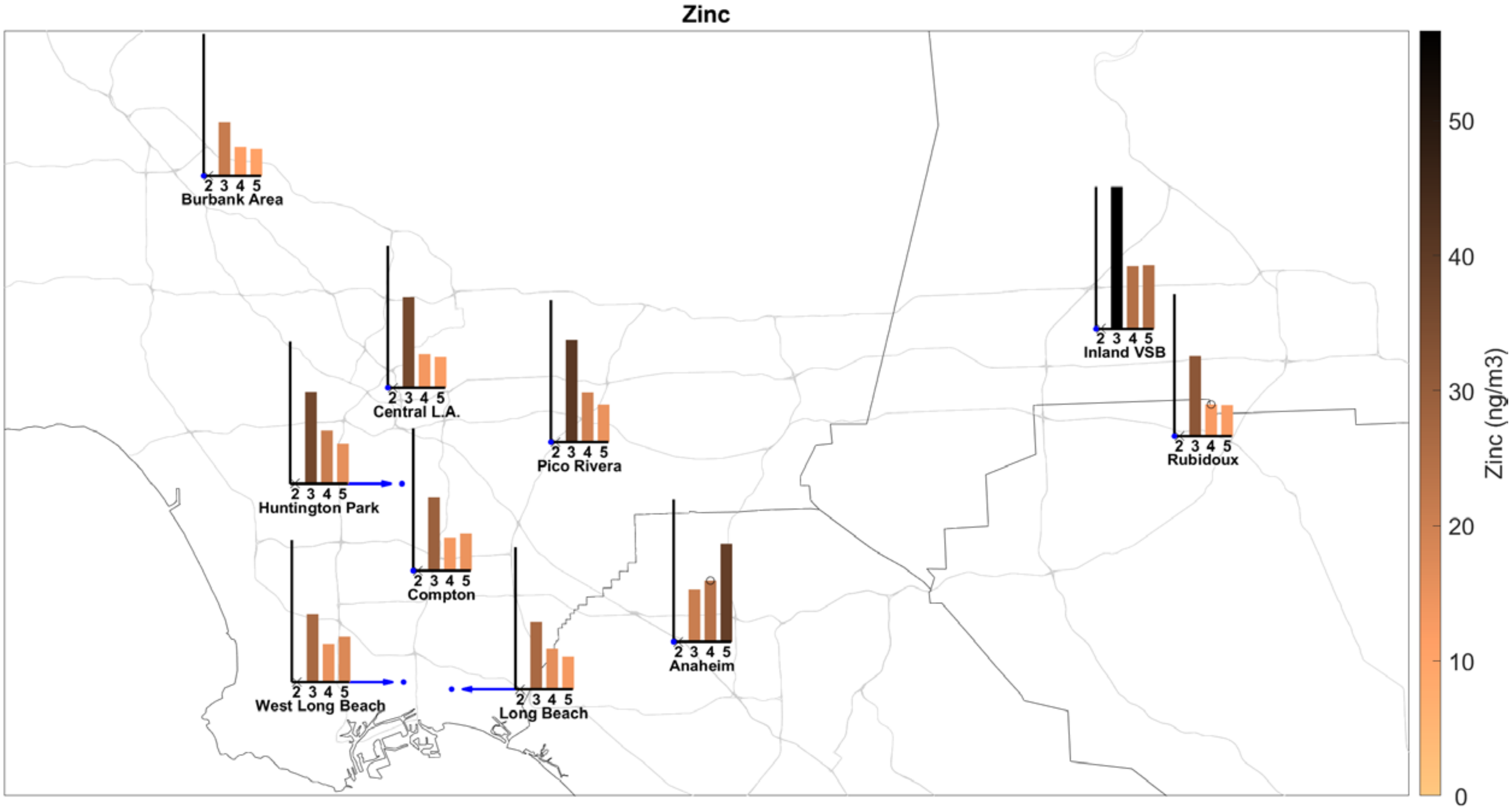


Figure IV-301. Geographic distribution of Zinc from the PM2.5 Metals Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

PM2.5 Levoglucosan Analysis

Galactosan

Table IV-153. Ambient Concentrations (ng/m^3) of Galactosan from the PM2.5 Levoglucosan analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	4.25	3.17	7.03	3.48	4.03	3.85	3.65	4.67	5.11	4.3
95% CI LB	3.04	2.4	4.47	2.74	3.03	2.87	3.02	3.36	3.96	2.97
95% CI UB	5.71	4.15	10.3	4.43	5.24	5.08	4.37	6.26	6.42	6.1
N	56	58	60	61	59	61	110	58	113	56
% < MDL	30.4	37.9	45	31.1	44.1	49.2	35.5	34.5	31.9	57.1
Max	24	25	75	22	21	28	23.5	32	40	42

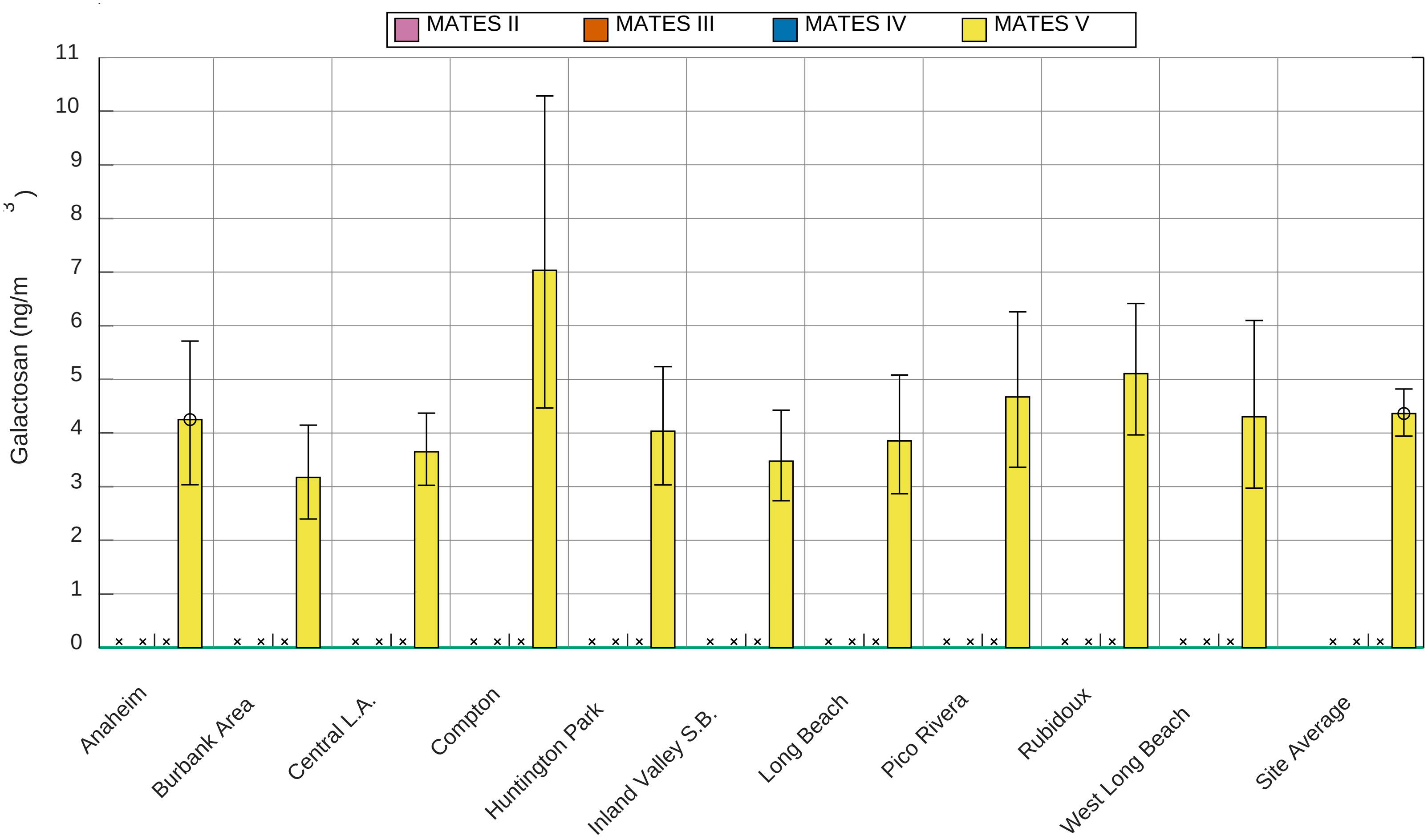


Figure IV-302. Annual Average Concentrations of Galactosan in the PM2.5 Levoglucosan Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

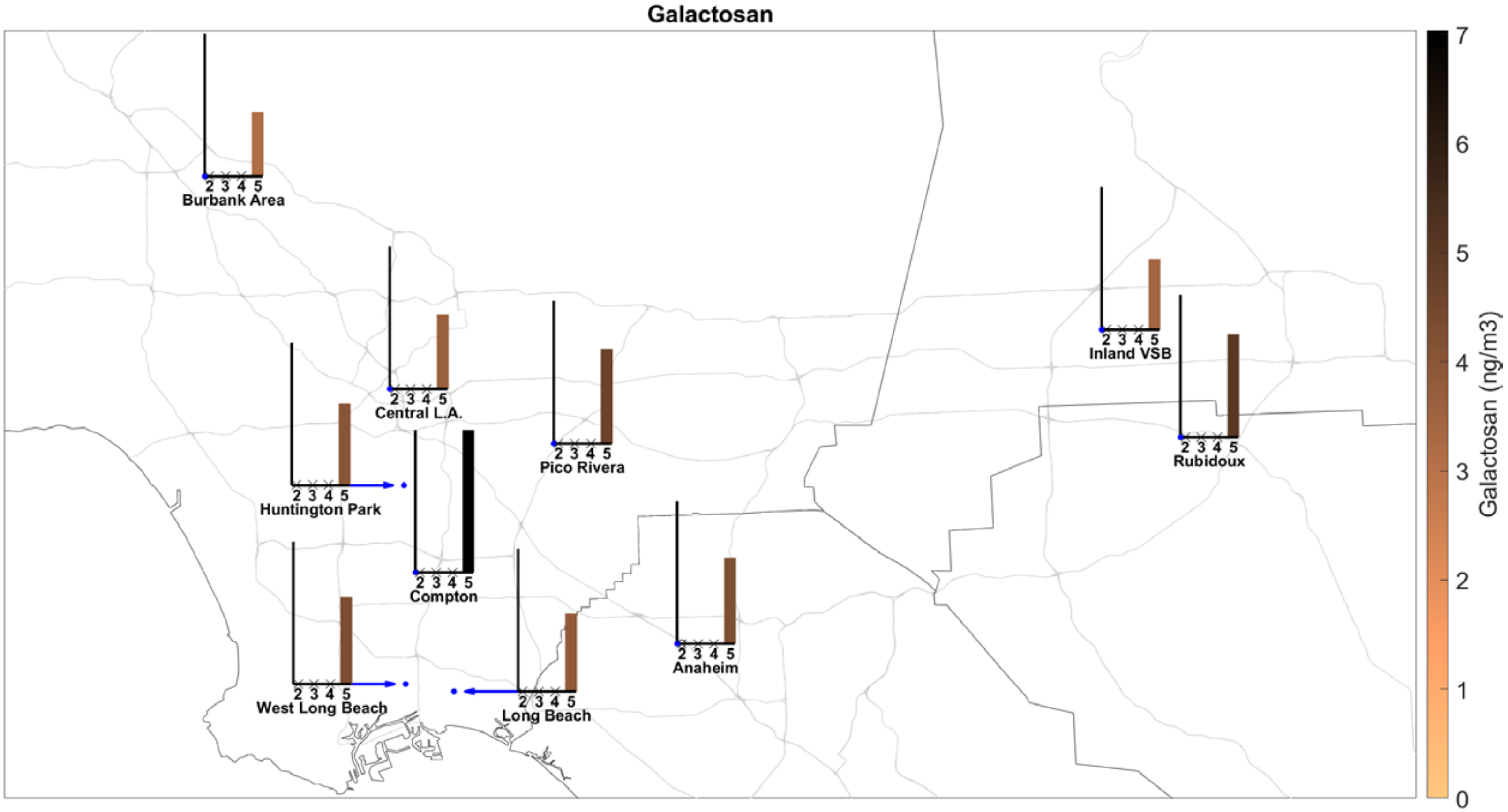


Figure IV-303. Geographic distribution of Galactosan from the PM2.5 Levoglucosan Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. "x" indicates that there is no data for a given station/MATES iteration.

Levoglucosan

Table IV-154. Ambient Concentrations (ng/m^3) of Levoglucosan from the PM2.5 Levoglucosan analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	56.3	36.8	113	49	58.2	52.7	53.2	73.6	76.2	62.8
95% CI LB	36.6	24.7	65.6	34.8	39.3	32.9	41.2	49	57.8	35.3
95% CI UB	80.1	52.8	171	65.8	80.2	76.6	67.4	102	97.3	96.7
N	56	58	60	60	59	60	109	58	112	55
% < MDL	0	1.7	0	0	0	0	0	1.7	0	3.6
Max	400	370	1220	348	389	491	434	480	646	635

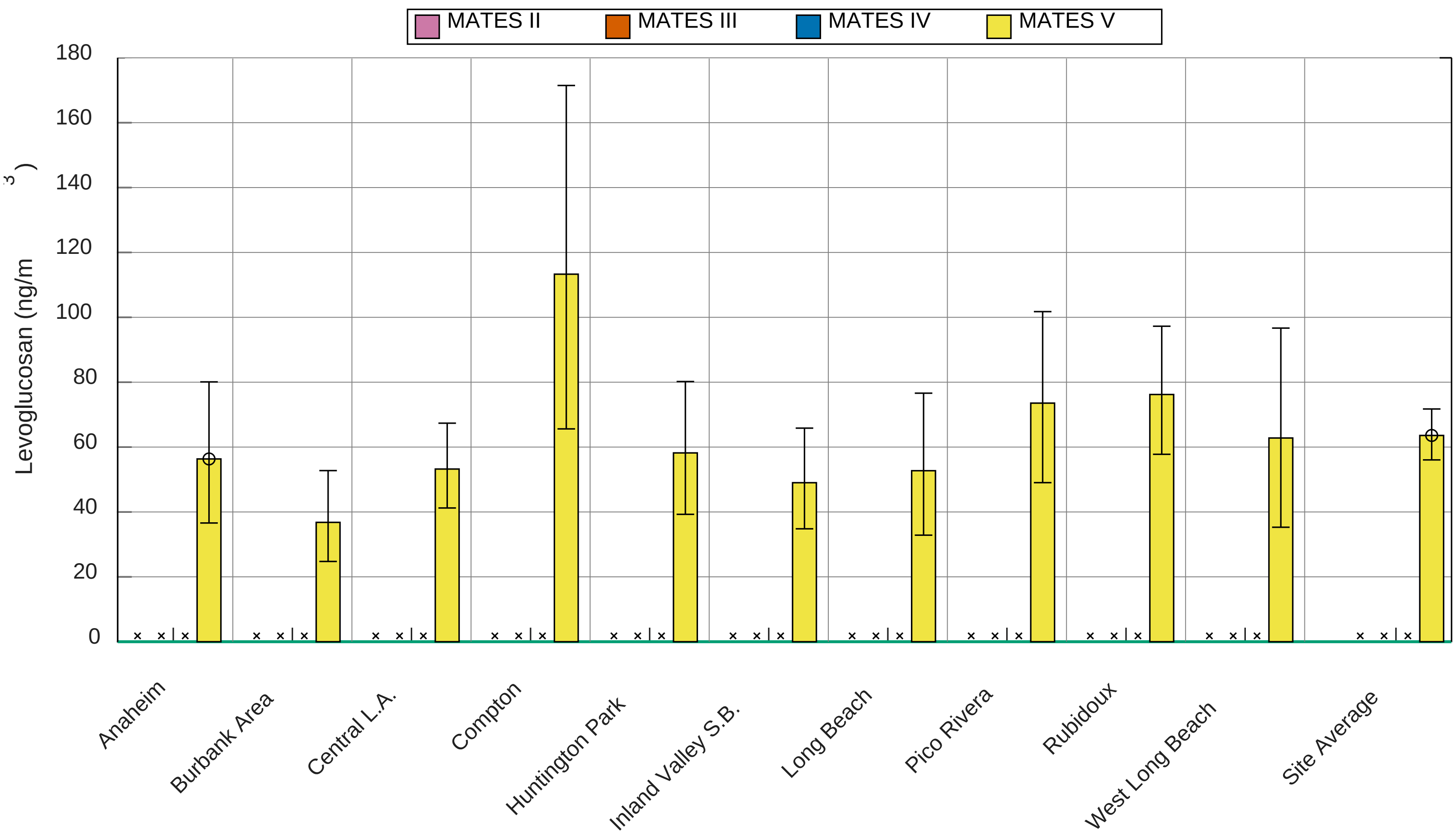


Figure IV-304. Annual Average Concentrations of Levoglucosan in the PM2.5 Levoglucosan Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with 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.

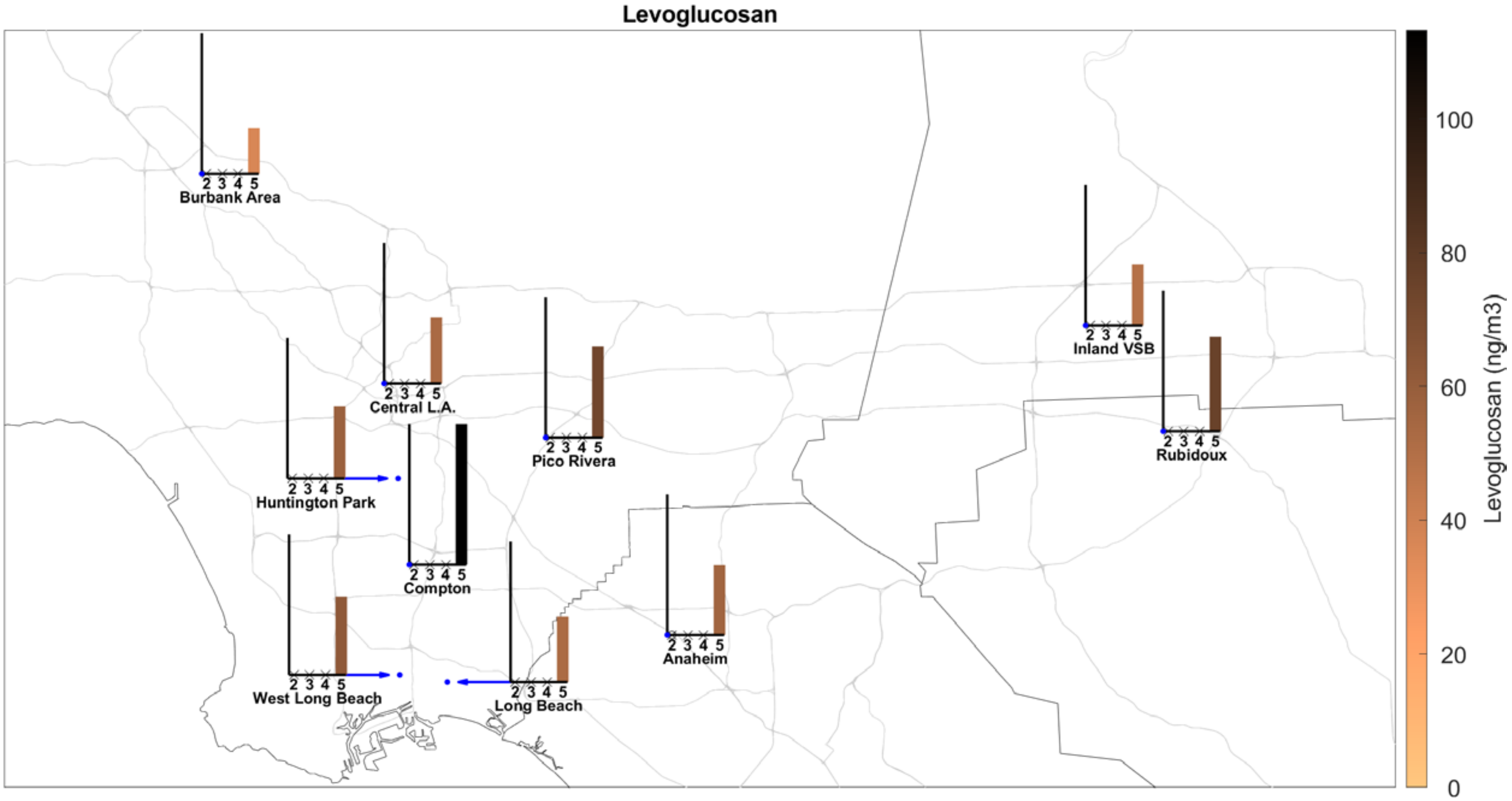


Figure IV-305. Geographic distribution of Levoglucosan from the PM2.5 Levoglucosan Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Mannosan

Table IV-155. Ambient Concentrations (ng/m^3) of Mannosan from the PM2.5 Levoglucosan analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES III										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES IV										
Average										
95% CI LB										
95% CI UB										
N	0	0	0	0	0	0	0	0	0	0
% < MDL										
Max										
MATES V										
Average	10.8	6.93	21.7	8.48	11.3	10.5	9.32	13.1	13	11.7
95% CI LB	7.32	4.97	13.3	6.03	7.58	7.04	7.39	9.06	10.1	7.18
95% CI UB	14.6	9.36	31.7	11.5	16.1	14.8	11.5	17.9	16.4	17.5
N	55	58	60	60	59	60	110	58	113	55
% < MDL	7.3	10.3	6.7	13.3	6.8	15	10.9	6.9	0.9	25.5
Max	67	45	210	64	76	95	56.5	78	101	122

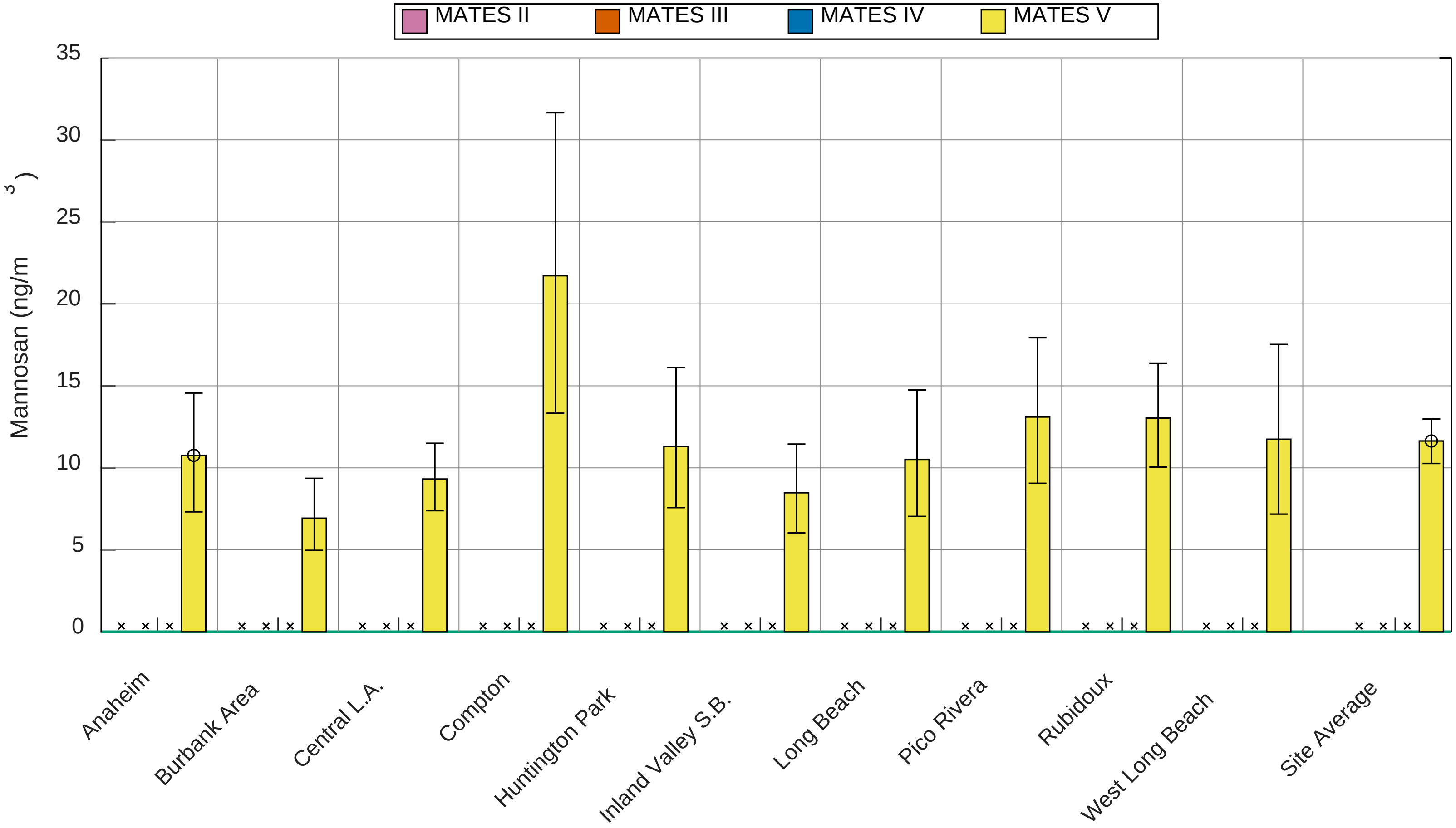


Figure IV-306. Annual Average Concentrations of Mannosan in the PM2.5 Levoglucosan Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero 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.

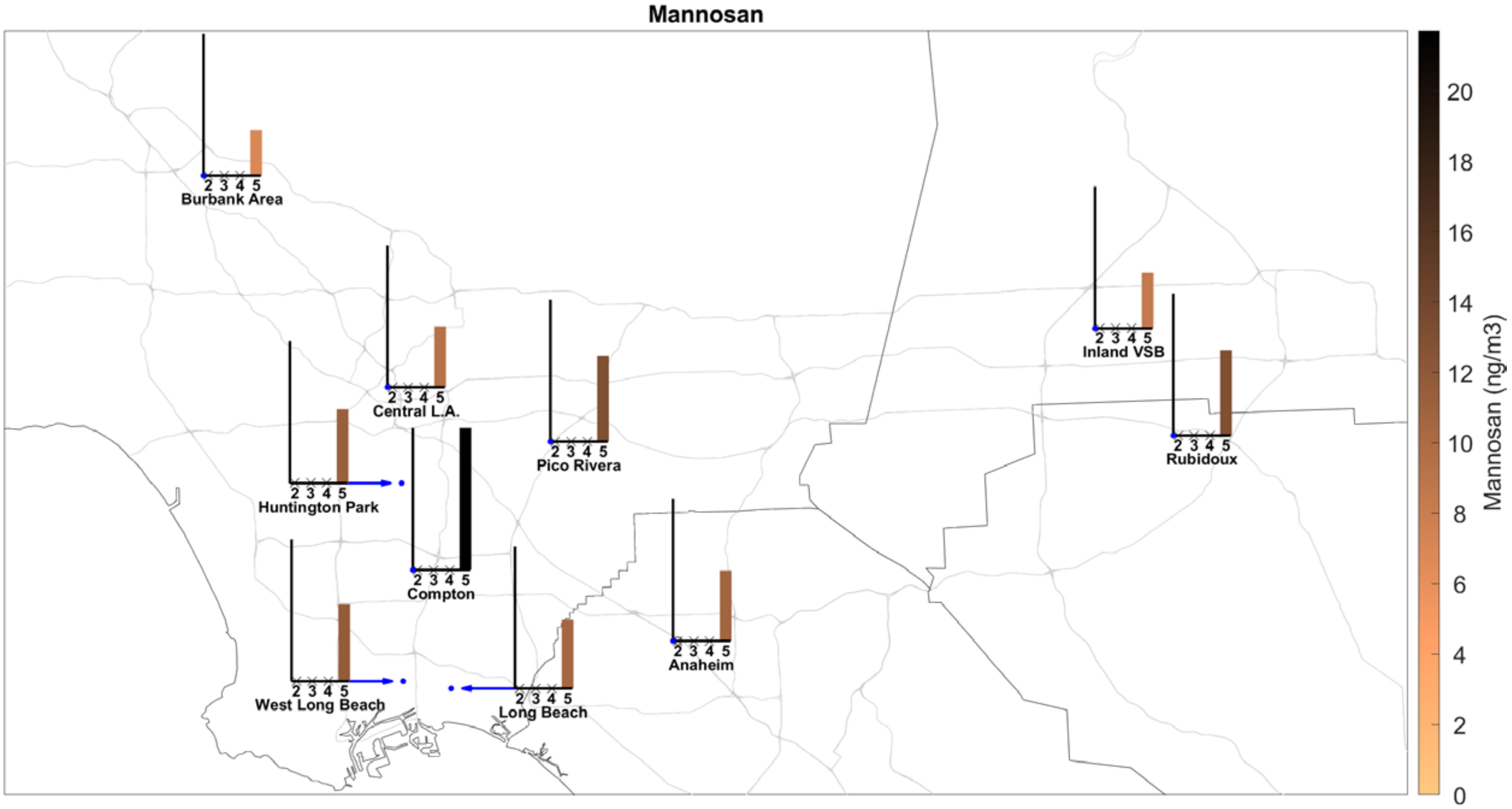


Figure IV-307. Geographic distribution of Mannosan from the PM2.5 Levoglucosan Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

Diesel PM Analysis

Diesel PM

Table IV-156. Ambient Concentrations (ng/m^3) of Diesel PM from the Diesel PM analysis at the Fixed Sites.

	Measurement Site									
Statistic	**AN**	**BU**	**CP**	**SB**	**HP**	**LB**	**LA**	**PR**	**RU**	**WLB**
MATES II										
Average	2420	3310		3230	4720	2680	3670	4530	3560	
95% CI LB										
95% CI UB										
N	58	53	0	59	46	58	59	38	62	0
% < MDL	12.1	3.8		5.1	0	20.7	1.7	0	12.9	
Max										
MATES III										
Average	2640	3810	3320	3980	4280	2870	3600	3840	3230	4060
95% CI LB										
95% CI UB										
N	242	241	235	236	118	228	240	116	235	228
% < MDL	0.4	0	0.4	0.8	0.8	0.4	0	0	0.4	0.4
Max										
MATES IV										
Average	774	1120	878	1120	957	777	1080	1230	1060	1070
95% CI LB	591	901	649	947	771	578	904	1020	903	803
95% CI UB	982	1360	1130	1310	1170	998	1290	1470	1230	1380
N	59	59	61	60	59	61	60	59	61	61
% < MDL	0	1.7	0	1.7	0	1.6	0	0	0	0
Max										
MATES V										
Average	327	352	518	574	498	338	529	524	579	543
95% CI LB	238	280	367	473	383	241	412	407	430	398
95% CI UB	431	430	689	679	625	448	664	656	753	710
N	56	59	61	60	60	61	61	59	59	55
% < MDL	3.6	6.8	6.6	5	0	8.2	1.6	1.7	3.4	1.8
Max										

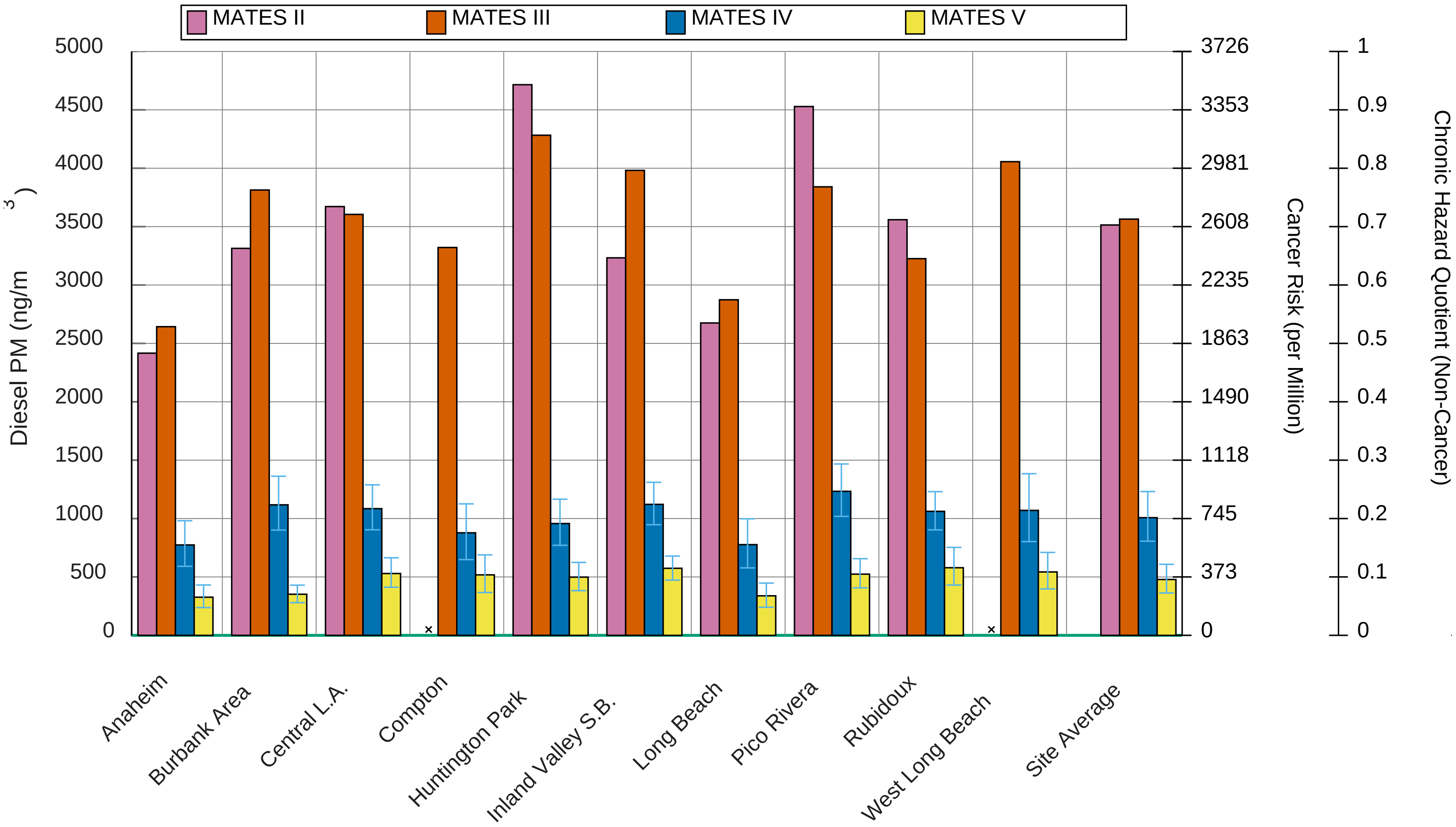


Figure IV-308. Annual Average Concentrations of Diesel PM in the Diesel PM Analysis. The diagonal lines (shading) on the bars indicate that more than 80% of the measurements for those stations were below the method detection limits (MDLs). The lower edge of the shading shows the mean with zero substituted 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.

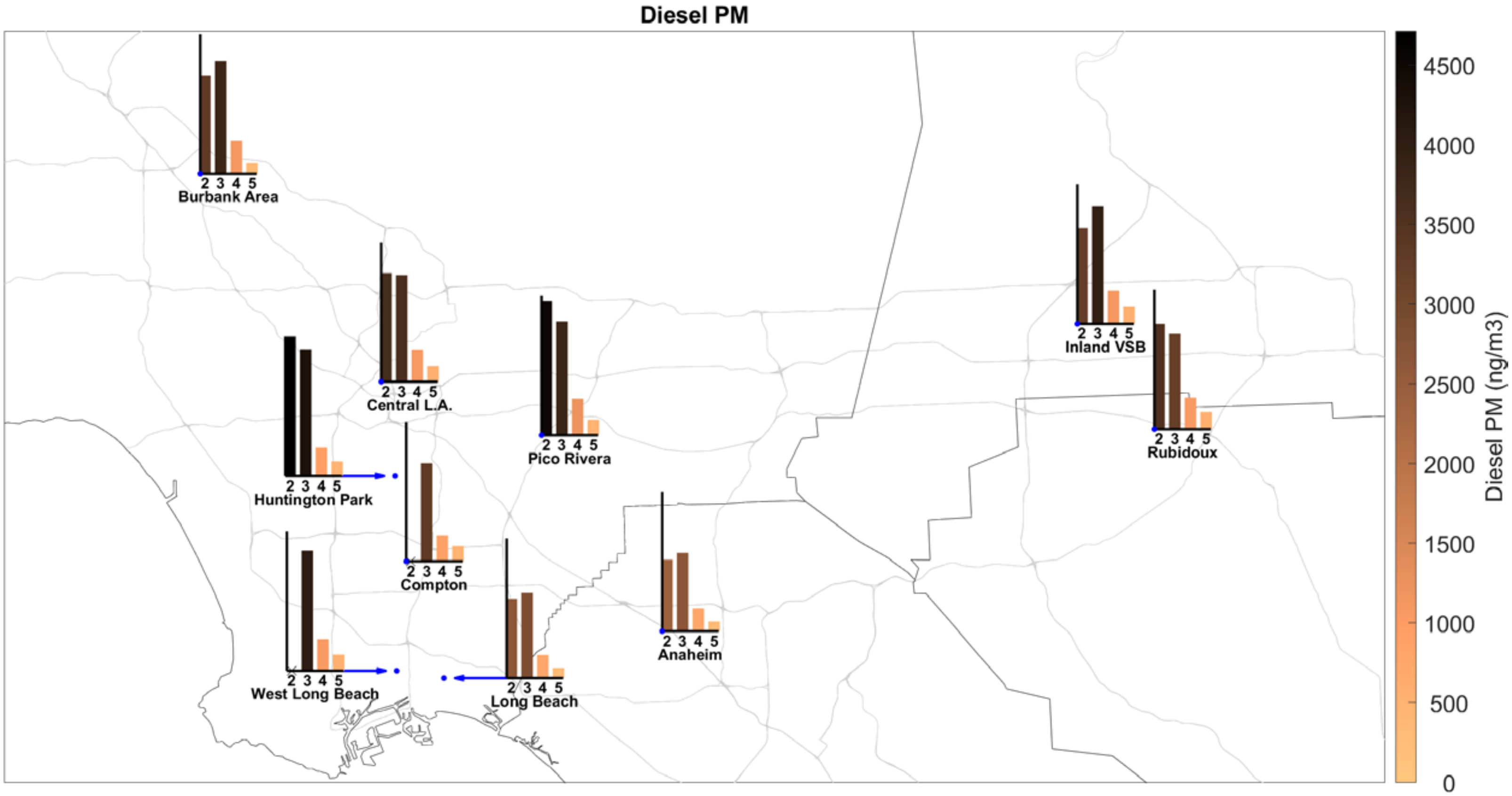


Figure IV-309. Geographic distribution of Diesel PM from the Diesel PM Analysis. The blue dots represent the locations of the MATES V stations. A circle at the top of a bar indicates that at least one quarter has less than 75% data completeness. “x” indicates that there is no data for a given station/MATES iteration.

IV.2 Methods for Aggregate Risk Calculations

As mentioned in Chapter 2, calculated cumulative risks would be artificially low if some analytes are missing, which would lead to inaccurate comparisons between stations or across MATES studies. To address this issue, missing analytes were substituted to fill in gaps. The method used for substituting data creates additional uncertainty. To address this uncertainty, five different methods were used to calculate cumulative risks to determine if the results are sensitive to the method chosen. For descriptive purposes, these methods are called: Missing Data, Interpolate Trends, Adjacent MATES, Min MATES, and Max MATES. These substitutions are only used for discussions and figures related to aggregate risk, e.g., Figure ES-2 through Figure ES-5 in the Executive Summary and Figure 2-44 through Figure 2-55 in Chapter 2, and not elsewhere in the MATES V report. The results from all five methods are shown in Figure IV-298 through Figure IV-301.

The Missing Data method simply ignores any data that is missing. In other words, this method it does not make any estimates to fill in any missing data, and therefore shows unrealistically low cumulative risks. As a result, we do not rely on this method, and it is shown for comparison purposes only.

The Interpolate Trends, Adjacent MATES, Min MATES, and Max MATES methods all substitute the basin wide average from the same MATES study if it is available. For example, as discussed in Chapter 2, carbonyl and VOC pollutant data were not available due to equipment issues at Anaheim for MATES V. Since these pollutants were measured at other stations during MATES V, the basin-wide averages from MATES V are substituted for the missing carbonyl and VOC data. The results presented in Figure ES-2 through Figure ES-5 in the Executive Summary and Figure 2-44 through Figure 2-55 in Chapter 2 use the Interpolate Trends method.

The Interpolate Trends, Adjacent MATES, Min MATES, and Max MATES methods differ in how they handle missing data when a pollutant is not available for any stations in a given MATES study. For example, as shown in Figure 2-33 in Chapter 2, Total Suspended Particle (TSP) Beryllium was only measured during MATES IV and MATES V. In order to make a fair comparison of trends over time, some substitution of beryllium data needs to be made for MATES II and MATES III. The Missing Data method shows artificially low risks in MATES II and MATES III due to the lack of beryllium data.

For the Interpolate Trends method, if a pollutant has no data for one or more MATES studies, the percent change in basin-wide concentration for that pollutant is calculated for the MATES studies that are available, and then the largest percent change is applied to the highest of any available basin average. For example, if the basin-wide average for a pollutant decreased 83% from MATES III to MATES IV and 34% from MATES IV to MATES V, and the pollutant was not measured in MATES II, the highest basin wide average (i.e., the MATES III basin-wide average in this example) would be multiplied by 1.83. This value would be used for all stations for the MATES study missing that pollutant. These numbers were only provided as an example. The calculations are done separately for each pollutant. The Interpolate Trends method estimates the higher concentrations we would expect in older MATES projects based on observed trends.

For the Adjacent MATES method, if a pollutant has no data for one or more MATES studies, the basin-wide average from the preceding MATES study is used for substitution, if available (e.g., MATES II data would be used for MATES III data if possible). If data for the preceding MATES study are not available (or MATES II is the study missing data), the basin-wide average from the subsequent MATES study is used, if available. If no data is available from an adjacent MATES study, then data is substituted from the remaining MATES study.

For the Min MATES method, if a pollutant has no data for one or more MATES studies, the minimum value of the basin-wide values from the MATES studies that do have data is used to substitute for the missing data. This method is likely to be an underestimate, particularly if the missing data is from earlier MATES studies, when concentrations were likely higher. In contrast, for the Max MATES method, the maximum value of the basin-wide values from the MATES studies that do have data is used to substitute for the missing data.

Figure IV-298 shows the results for all five methods used to calculate the aggregate cancer risk for the MATES V data. From left to right for each station, the results are shown for the Missing Data, Adjacent MATES, Min MATES, Max MATES, and Interpolate Trends methods. This order is the same for Figure IV-298 through Figure IV-301. The left-most bar for each station is for the Missing Data method and shows the artificially low aggregate risk estimates if no substitutions are made for missing data, which is particularly noticeable for Anaheim. The other four methods in Figure IV-298 are indistinguishable.

Figure IV-299 shows the results for all five methods used to calculate the aggregate chronic hazard index for the MATES V data. The left-most bar (Missing Data method) for Anaheim is much shorter than the bars for the other methods and shows that the cumulative hazard index estimates are artificially low if nothing is substituted for missing data. The other four methods are indistinguishable in Figure IV-299.

Figure IV-300 and Figure IV-301 are similar to Figure IV-298 and Figure IV-299, respectively, except that they show the data for MATES II through MATES V. Note also that Bromomethane is excluded since it was only measured in MATES V and trends cannot be inferred with data for only one MATES study. The five left-most bars in Figure IV-300 show the results for all five methods for MATES II at Anaheim. The next five bars show the results for MATES III at Anaheim, and so on. The Missing Data method is known to show aggregate risks that are artificially low. The other methods show slight variations in aggregate risks in Figure IV-300 and Figure IV-301, particularly for MATES II and MATES III. These variations, however, do not change conclusions about which MATES study had higher or lower aggregate risks relative to other MATES studies at a given station. The highest aggregate risk estimates are found using the Interpolate Trends method, which are the results presented in Figure ES-2 through Figure ES-5 in the Executive Summary and Figure 2-44 through Figure 2-55 in Chapter 2.

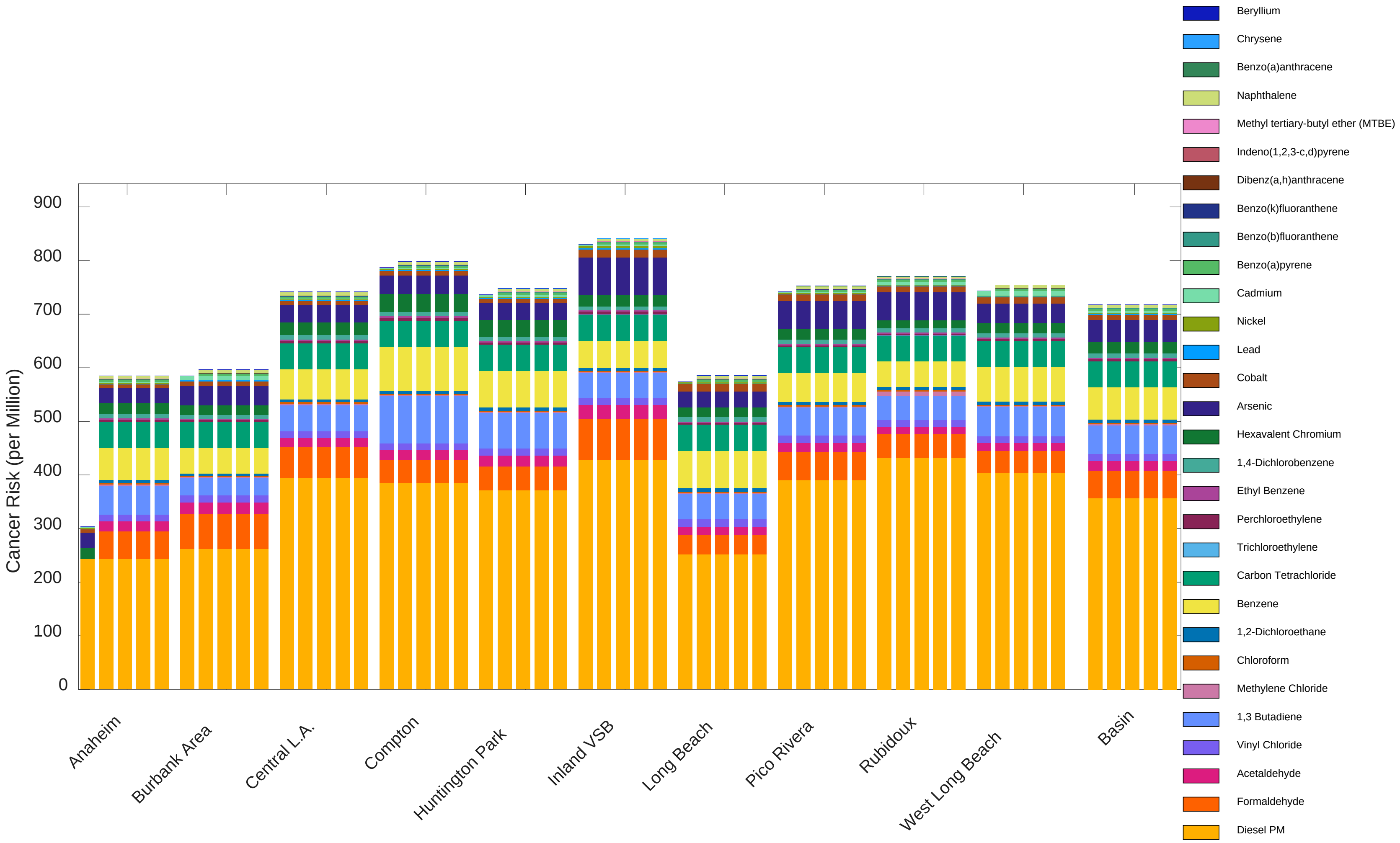


Figure IV-310 Aggregate cancer risks for all stations and for MATES V only using five methods for substituting for missing data. From left to right for each station, the results are shown for the Missing Data, Adjacent MATES, Min MATES, Max MATES, and Interpolate Trends methods.

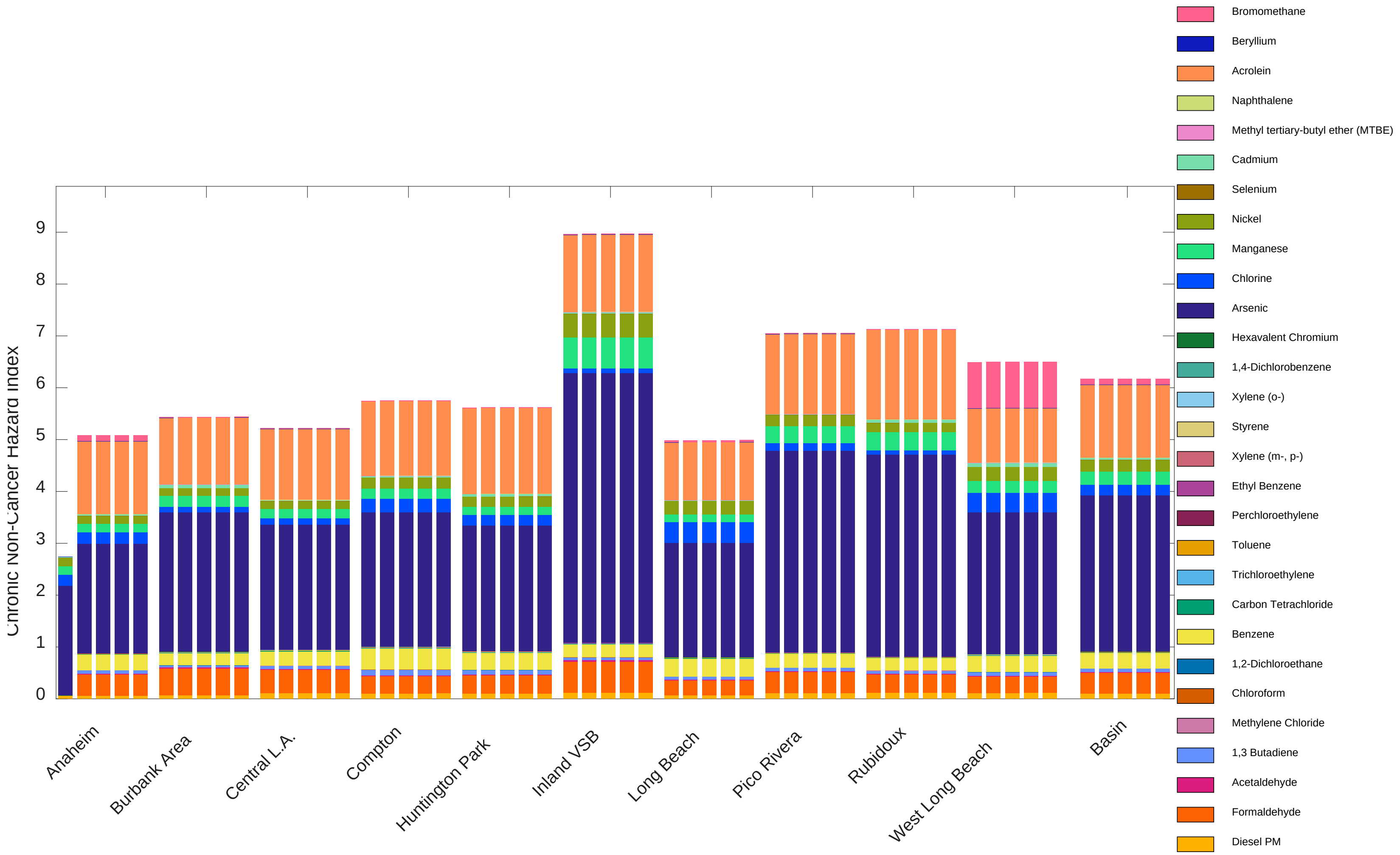


Figure IV-311 Aggregate chronic hazard index for all stations for MATES V only using five methods for substituting for missing data. From left to right for each station, the results are shown for the Missing Data, Adjacent MATES, Min MATES, Max MATES, and Interpolate Trends methods.

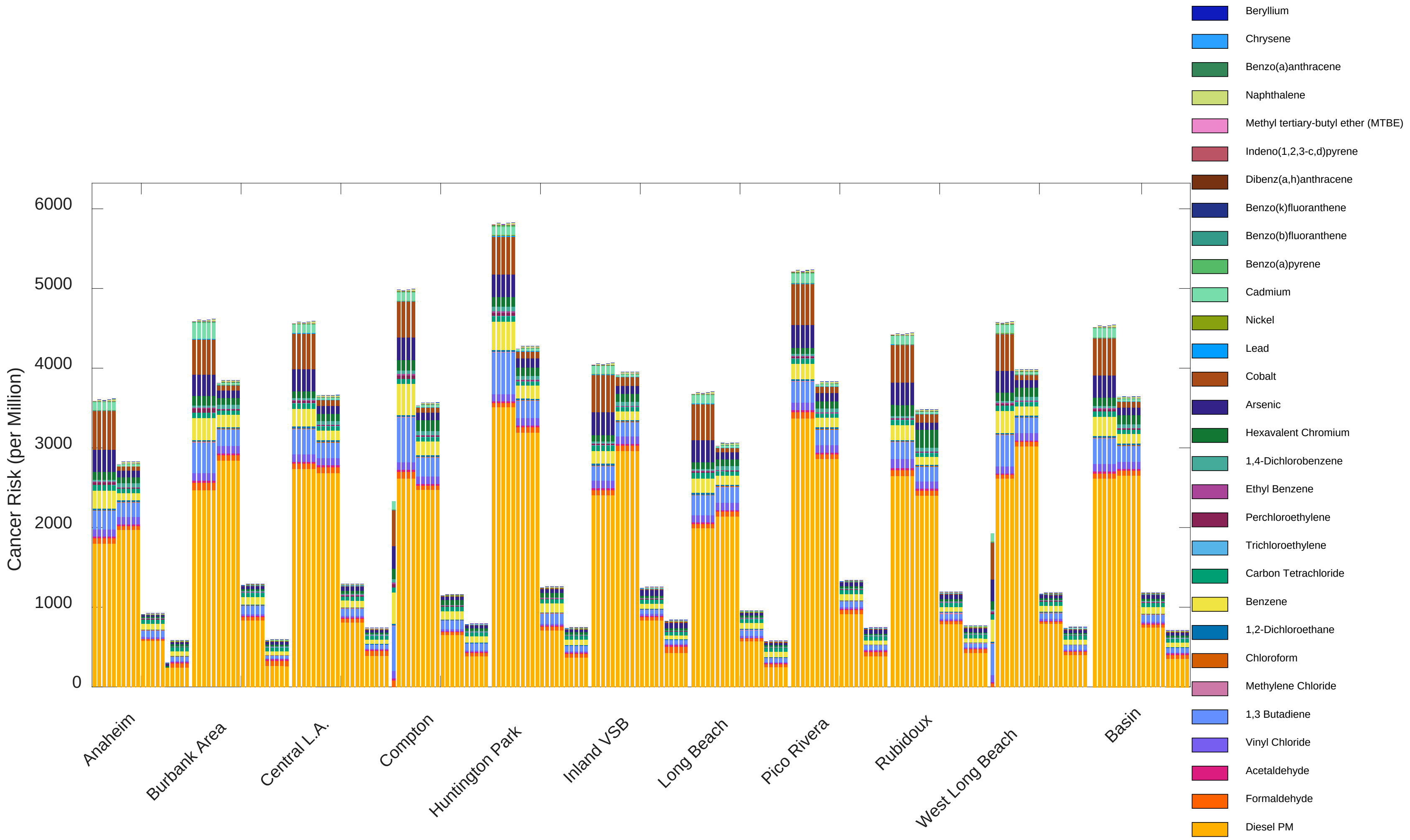


Figure IV-312 Aggregate cancer risks for all stations and all MATES studies using five methods for substituting for missing data. From left to right for each station, the results are shown for the Missing Data, Adjacent MATES, Min MATES, Max MATES, and Interpolate Trends methods. The five left-most bars show the results for all five methods for MATES II at Anaheim. The next five bars show the results for MATES III at Anaheim, and so on.

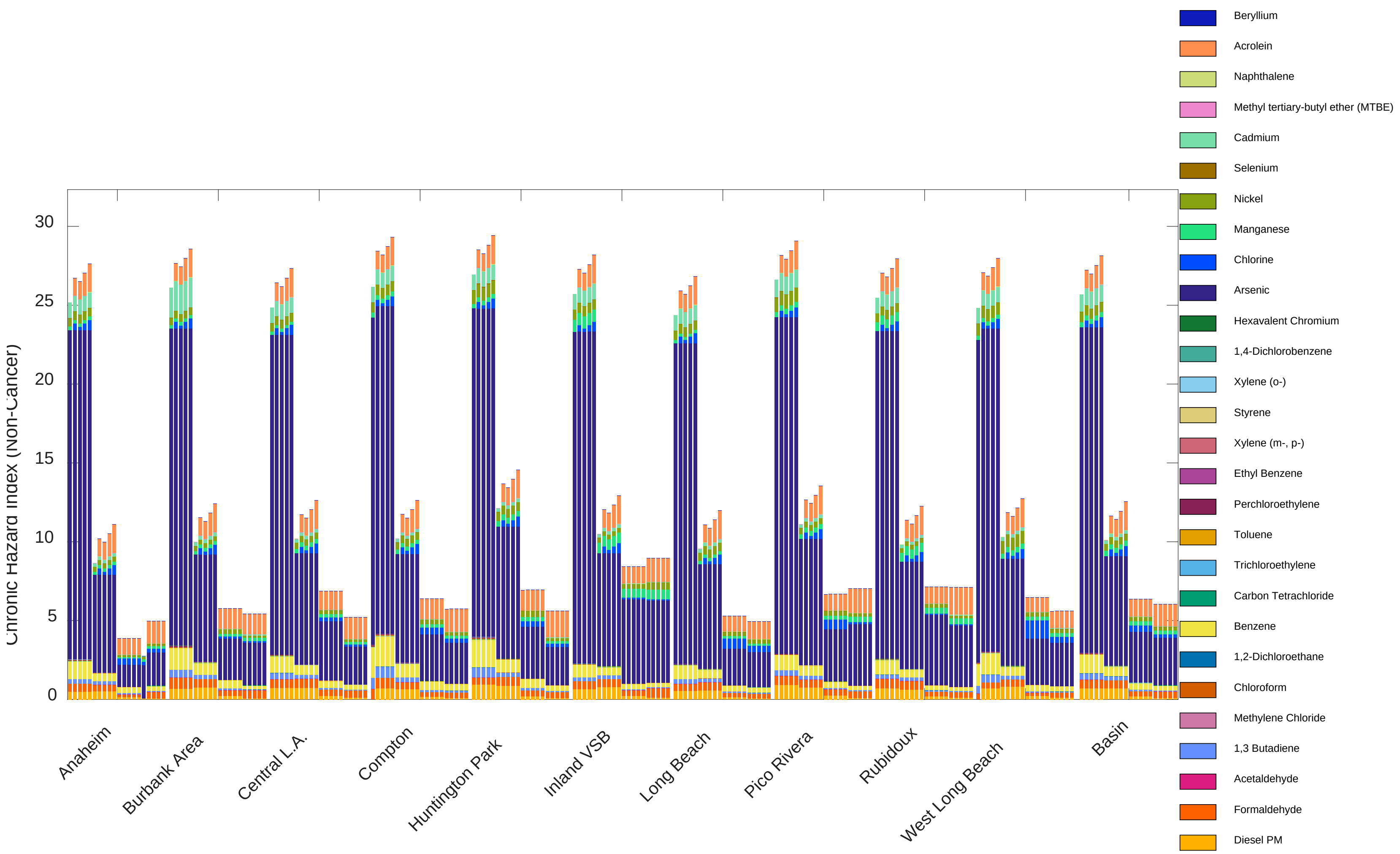


Figure IV-313 Aggregate chronic hazard index for all stations and all MATES studies using five methods for substituting for missing data. From left to right for each station, the results are shown for the Missing Data, Adjacent MATES, Min MATES, Max MATES, and Interpolate Trends methods. The five left-most bars show the results for all five methods for MATES II at Anaheim. The next five bars show the results for MATES III at Anaheim, and so on. Bromomethane is excluded since it was only measured in MATES V and trends cannot be inferred with data for only one MATES study.

APPENDIX V

MATES V

DRAFT FINAL REPORT

Quality Assurance and Quality Control for Monitoring and Analysis

DISCLAIMER

Any or all reference made in this Appendix to a specific product or brand name does not constitute an endorsement of that product or brand by the South Coast Air Quality Management District.

Appendix V

Quality Assurance and Quality Control for Monitoring and Analysis

V.1. INTRODUCTION

This appendix, in association with the sampling and analysis detail provided in Appendix III of this report, describes the objectives, procedures, documentation, and data review techniques that were used by the South Coast AQMD to assure that MATES V produced data that met or exceeded the accepted criteria for its intended use.

V.1.1 Quality Assurance and Quality Control Background

South Coast AQMD is committed to achieving high quality data that meets the objectives for the MATES program, as well as other environmental monitoring programs. The South Coast AQMD is designated by U.S. EPA, with primary responsibility for air monitoring and data quality under its jurisdiction.

V.1.1.1 Quality Management Plan (QMP)

The South Coast AQMD Quality Management Plan (QMP[1]), approved by U.S. EPA in 2017 (South Coast AQMD, 2016; see Section V.4, References), is the foundational document describing the agency’s quality management system for air monitoring and laboratory analyses. It outlines quality assurance goals, policies, procedures, lines of authority, organizational responsibilities, evaluation, and reporting requirements. It is South Coast AQMD policy that sufficient quality assurance activities are conducted to demonstrate that data collected by and on behalf of South Coast AQMD are scientifically and legally valid for the purposes to which they are intended.

Quality Assurance (QA) encompasses all measures taken by management and staff to ensure that the quality of a finished product meets the regulations and standards of the organization and program. Major QA functions include review and oversight of most aspects of a measurement program, including planning documents, training, records, and procedures, as well as independent audits of sampling equipment, field instruments and performance tests of laboratory analyses.

Quality Control (QC) encompasses all the direct actions taken to achieve and maintain a desired level of quality for a given product. From an environmental monitoring perspective, QC includes all the measures taken by project managers and field, laboratory, and data management personnel to achieve a predetermined level of data reliability. QC is applied from the planning and design stages of the monitoring effort, through the implementation stages, to the handling, storage and reporting of accumulated data.

---

[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.

V.1.1.2 Quality Assurance Project Plans (QAPPs)

Quality Assurance Project Plans (QAPPs) describe the quality control, quality assurance, training, records management, measurement objectives, assessment activities, and other related technical activities for a project or program to ensure data is of a known and verifiable quality meeting its intended purpose. QAPPs also describe the responsibilities within the organization for carrying out each program component. They are intended to be sufficiently complete and detailed to ensure that data meet programmatic Data Quality Objectives (DQOs). The DQOs consider the program or project goals and the types of decisions that the data is intended to address by the end users. QAPPs include Standard Operating Procedures (SOPs) and Operational Assistance Guides (OAGs), which are the specific directions for performing sampling, monitoring, and analytical activities. This includes field monitoring operations, support (e.g., maintenance, repairs, calibrations), lab analyses, and independent audit activities. The QAPP documents list the QA and QC requirements for each activity and provide instructions for data review and validation, QA oversight and audits, and the corrective action process that is used to document issues that may have significant or repeated adverse impacts on data quality, completeness or safety, including the issue’s resolution and recurrence minimization.

The QAPPs describe the Data Quality Indicators (DQIs) that are determined to ensure that the data is of known and defensible quality and available in a timely manner to meet the DQOs. DQIs typically include precision, accuracy/bias, completeness, representativeness, sensitivity, and comparability. Precision is a quantitative measure of how reproduceable the data are. Accuracy/bias is a quantitative measure of how well the measurements reflect what is actually in the sample. Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected. Representativeness, related to program site, instrument and method selection, is a measure of the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Comparability is a measure of the confidence with which one data set or method can be compared to another. Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest.

Measurement Quality Objectives (MQOs) are the acceptance or performance criteria for individual DQI’s. QAPPs, along with the associated Standard Operating Procedures (SOPs) or Operational Assistance Guides (OAGs), are designed to document and control the various phases of the measurement process (e.g., preparation, sampling, and analysis) to ensure that the total measurement uncertainty is within the range prescribed by the MQOs. For MATES, the MQOs are based upon comparable measurements from ongoing federal and South Coast AQMD measurement programs, using the quality goals, QA/QC activities and procedures described in South Coast AQMD QAPPs.

The quality goals and QA requirements for gaseous and particle pollutants measured during MATES V are found in the various QAPP documents, as outlined below.

National Air Toxics Trends Stations (NATTS) Program

The MATES V quality goals and QA/QC activities for monitoring ambient levels of volatile organic compounds (VOCs), carbonyls, hexavalent chromium, and polycyclic aromatic hydrocarbons (PAHs), and some metals were adopted from the U.S. EPA National Air Toxics Trends Stations (NATTS) program. The South Coast AQMD NATTS QAPP (South Coast AQMD, 2013a) was last revised in 2013 and is currently under revision to incorporate the October 2016 U.S. EPA revised NATTS Technical Assistance Document (TAD; U.S. EPA 2016) and other recent changes to program elements that have been implemented by South Coast AQMD.

Chemical Speciation Program

The MATES V quality goals and QA/QC activities for monitoring and analyzing the components of fine particulate matter ($PM_{2.5}$), including Organic and Elemental Carbon (OC/EC), Anions and Cations, and trace metals, were adopted from the U.S. EPA CSN program. The requirements can be found in the South Coast AQMD $PM_{2.5}$ Chemical Speciation Program QAPP (South Coast AQMD, 2014), which was last approved by the U.S. EPA Region 9 in May 2014. This QAPP is also under review by staff for revision to more fully incorporate both the U.S. EPA CSN Program, where analyses are done by national contract laboratories, and 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 requirements can be found in the South Coast AQMD Criteria Pollutant Monitoring Program QAPP, which, at the time of the MATES V monitoring, had been last revised in 2016. It was recently revised again in April 2020 to incorporate revised programmatic elements and guidance, including the updated U.S. EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. II, Ambient Air Quality Monitoring Program (U.S. EPA 2017a,b). This latest QAPP revision was approved by U.S. EPA Region 9 in July 2020.

Special Monitoring Program

The South Coast AQMD Special Monitoring program provides air quality measurements in response to events such as wildfires, localized air quality concerns, and pollutants from local sources which also includes rule compliance and rule development monitoring. 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 QAPP (South Coast AQMD, 2013b), which 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 and reviewed by U.S. EPA in August 2014. The Special Monitoring QAPP is undergoing incorporation into a new QAPP for Special Monitoring and AB 617 Community Air Monitoring Programs. As of this writing, this QAPP is under internal review.

V.1.2 Glossary of Quality Assurance Terms

Accuracy/Bias

A determination of how closely reported data values are to true values. Annually conducted performance audits challenge the various samplers and instruments used in this program to assess their accuracy. All valid program data accepted as valid satisfy the criteria set forth in the representative QAPP and SOPs. Accuracy is expressed as “percent” deviation from true and is calculated as follows:

$$\text{Percent Deviation from True} = \frac{\text{Indicated Value - True Value}}{\text{True Value}} \times 100$$

Collocated Sampling

The process of running two identical samplers concurrently at the same location. Collocated data measures a method’s precision. One of the samplers is designated *A* and is treated as the true value; while the other sampler is designated *B* and is regarded as the indicated value.

Data Completeness (DC)

The percent of valid data points actually collected out of the total number of data points possible. The data completeness objectives for the MATES V program. DC is calculated using the following formula:

$$\text{Percent DC} = \frac{\text{Total valid data points}}{\text{Total number of planned data points}} \times 100$$

Data completeness for discrete sampling of air toxics for MATES V, including VOCs and PM metals, is informed by the South Coast AQMD NATTS QAPP, along with the current NATTS TAD (U.S. EPA 2016). A valid sample is one that was collected, analyzed, and reported without null flags, including make-up samples. Note that samples below the MDL that are valid are included as complete. The measurement quality objective for air toxics for annual sample collection completeness is that ≥ 85% of the scheduled annual air samples on a 1-in-6-day sampling schedule must be valid, equivalent to 52 of the annual 61 expected samples (51 during years when there are only 60 collection events). Invalidation of data beyond this threshold triggers a corrective action process to review the cause and to improve sampling, quality control, or analysis procedures, as needed.

For MATES V continuous data (i.e., BC, UFP, meteorology), the Special Monitoring and Criteria Pollutant QAPPs specify a 75% completeness goal of all possible hourly measurements. The continuous measurements for MATES V greatly exceed the 75% goal.

Performance Evaluation

An instrument audit procedure conducted to establish individual analyzer and overall sampling and analysis accuracy. Probe audits are used to measure the integrity of both the sampling and analysis systems. Flow audits measure the accuracy of the flow metering devices that assure the sample’s temporal representativeness. Gas standard audits determine accuracy of laboratory analyzers in measuring known concentrations of toxic compounds.

Performance Test (PT)
A procedure from which data collected by execution of a particular test method to analyze samples containing a known amount of an analyte is used to assess compliance with a data quality objective. This is typically performed on but not limit to laboratory analyses performed in support of the NATTS program.

Precision
The measure of monitoring system repeatability. Precision is determined by amassing a variety of measurements of the same true value over a period of time and assessing the variability of those measurements.

Quality Assurance (QA)
The practice of establishing procedures external to the day-to-day monitoring operations that indicate whether air quality data is accurate, representative, precise, and complete enough to satisfy the needs of the data users. QA activities include, but are not limited to, system and performance evaluation audits and collocated and parallel sampling.

Quality Control (QC)
Any procedure incorporated into the internal, day-to-day operations of collection and analysis of samples to satisfy the data user’s need for valid data.

Representativeness
The goal that samples are representative of both temporal and/or spatial scales at all sites. This is accomplished by conforming to 40CFR58 siting and sampling requirements.

System Audit
An inspection and review of the monitoring program, typically including training, records management, instrumentation, data flow and problems that can impact data quality or completeness.

V.2. MATES V Quality Assurance Activities

MATES V monitoring was accomplished with discrete 24-hour samples, except for the continuous black carbon (BC), Ultrafine Particles (UFP), and meteorology data. The discrete canister VOC, carbonyl, and PM-speciation samples were prepared by the laboratory staff, then sampled in the field and returned to the lab by the field operations staff with chain-of-custody (COC) documentation. The sample data and supporting information was entered into the laboratory information management system (LIMS) for the laboratory analysis and data validation. Following this, the data was submitted to the U.S. EPA AQS and the MATES V databases. The continuous data was collected onsite using data loggers and telemetered in near-real-time to the South Coast AQMD Data Management System (DMS) for further review and validation prior to inclusion in the MATES V database.

The MATES V field monitoring and laboratory instruments, performance specifications, acceptance testing, siting, operations and sampling schedules, quality control (QC) checks, calibrations, repairs, recordkeeping, and data handling are described further in the QAPPs listed above that support ongoing South Coast AQMD monitoring and analysis programs, along with the associated operations, support, QA and laboratory SOPs. Those documents also further describe analytic procedures and methods employed by the laboratory, as well as the sample handling and chain-of-custody (COC) protocols that impact both the field collection of samples and the lab analytic process. Those intersecting program documents, records, procedures and quality objectives and acceptance criteria provide the backbone for the MATES measurements and analyses. Section III.3 of Appendix III also describes canister use and cleaning, sample distribution, and the sampling media and analytic methods used for canister-sampled VOCs, carbonyls, TSP and PM2.5 filter-based samples. The filter samples are used for determination of hexavalent chromium and other metals, ions, total mass, organic carbon (OC), elemental carbon (EC) and total carbon (TC).

For MATES V, the South Coast AQMD Quality Assurance Branch conducted independent instrument performance evaluation audits on a semi-annual basis for the MATES V canister VOC, carbonyl, and filter-based PM sampling instruments at all stations. The QA Branch auditors also conducted systems audits of the program monitoring and support activities, site maintenance, and safety, including review of COC forms, maintenance sheets, work orders, and the station and instrument logbooks. Due to the overlap of MATES with the NATTS, CSN and lead (Pb) programs, laboratory analyses performance tests (PTs) were conducted during MATES V to verify acceptable levels of bias in laboratory analysis as compared to other laboratories performing the same analyses under federal programs and to known spiked samples.

Corrective Action Process

For issues that arose during MATES V with potential to impact data quality or safety, beyond the normal application of routine quality assurance checks, calibrations, repairs, and data validation, the South Coast AQMD Corrective Action Process was employed. The Quality Assurance Alert (QAA), as described in Operations Assistance Guide (OAG) QA0002, is used by staff to inform the QA Branch and relevant supervisors and managers of a potential concern. The Corrective Action Request (CAR), described in OAG QA0001, is issued by the QA Branch to document significant issues and their resolution, including those resulting from an audit finding or in response to a QAA. The closure of a CAR includes documenting the issue and its resolution along with steps taken to avoid recurrence.

V.3. MATES V Sampling Issue and Data Treatment

Sampling Issue

Sampling manifold issues occurred during the MATES V sampling period (May 2018 through April 2019), evident in VOC canister and carbonyl samples from three monitoring stations (Central Los Angeles, Rubidoux and Anaheim).[2] This was discovered during the South Coast AQMD Laboratory data validation process as staff noted anomalously high concentrations of carbonyls as compared to historic data. Lab and field operations staff informed the Quality Assurance Branch about the anomalous data with a Quality Assurance Alert (QAA), submitted near the end of MATES V. This triggered further investigation, evaluation, a data treatment plan, and other corrective actions to resolve the issue and minimize the potential for future recurrence and documented in a Corrective Action Request (CAR).

The canister VOC and carbonyl monitoring through the manifold at Central Los Angeles and Rubidoux was ongoing prior to the start of MATES V, due to sampling for NATTS and PAMS. The canister VOC and carbonyl sampling manifold and samplers at Anaheim were operational by April 2018, installed specifically for MATES V.

To identify the occurrence of manifold issues and to assess the severity and time periods of concern, the following were reviewed:

- Manifold system flow checks (flow differential measured at the inlet and after the manifold) to test for leak potential, conducted at all ten MATES V sites. Note that the routine sampler QC flow checks, flow rate verifications/calibrations, and flow rate audits were not able to identify the manifold leaks; testing of the manifold system was needed.
- Sample data for the presence of an indoor air signature potentially due to a leak (e.g., formaldehyde, acetaldehyde, etc. from shelter building materials & furnishings).
- Manifold system records (e.g., station and instrument logbooks, maintenance sheets, and chain-of-custody forms) for potential root causes and timing.
- The physical manifold configuration, fittings, connections, and instruments where leaks were suspected.

The manifold flow tests done at all ten MATES V stations indicated leaks at Rubidoux and Central Los Angeles and a relatively more severe leak at Anaheim. Through physical review of the manifolds at these sites, the cause of the manifold leakage was determined in each case to be loose fittings on the manifold ports, likely due to operator error. For the Anaheim site, a ferule was missed on the manifold inlet upon installation for MATES V. At Central LA, all the fittings

---

[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 samples as MATES V), Photochemical Air Monitoring Stations (PAMS), and CARB Air Toxics Program (VOC canister samples only, since CARB carbonyls are not on the manifold).

were connected but, when evaluated further, staff noted that some were not completely tight. At Rubidoux, a loose cap was found on an unused manifold port.

Records, including the data, logbooks, maintenance sheets and chain-of-custody forms were reviewed and compared to the atypical shifts in the MATES V data by compound and station to evaluate the period of concern. Using the timing of the presence of an indoor air signature in the analyzed data and the manifold-related records, the timing of the leak problems was associated with field operations activities that impacted these manifolds. For Anaheim, the change from outdoor carbonyl sampling with the Xontech 924 to indoor sampling with the ATEC 8000, starting with the April 2, 2018 sample, showed elevated formaldehyde and acetaldehyde. The missing ferule at the inlet occurred at the initial installation of the manifold for MATES V and was not resolved until the end of the study. With this timing, along with laboratory analysis indicating the strong presence of indoor air for the entire sampling period, all MATES V canister VOC and carbonyl data were invalidated for Anaheim.

For Central Los Angeles and Riverside, the manifold flow checks indicated the presence of leaks, although these leaks were less severe compared to the issues at Anaheim. At Central Los Angeles, the timing of the problem was associated with a manifold cleaning procedure completed prior to the August 18, 2018 sample run that was apparently exacerbated shortly thereafter on September 25 by the replacement of a carbonyl sampler in the manifold. This issue was significantly improved by tightening the loose fittings but was not fully resolved until a large O-ring connecting two manifold parts was replaced to pass a manifold leak test in April 2019.

At Rubidoux, the signature of indoor air in the carbonyls data helped define the period of concern, after the outdoor Xontech 924 was changed to an indoor ATEC 8000 carbonyl sampler on the manifold, at the beginning of April 2018. With that change, slightly elevated carbonyls were evident. A review of manifold-related activities from the station and instrument logbooks conservatively identified the period of concern back to the prior manifold cleaning in late 2017. The later sampling data indicated that the leaks were further exasperated, starting in late July 2018, as indicated by an increased indoor air signature. This was likely associated with manifold activities that included the addition of a Picarro continuous formaldehyde instrument for testing. The leak identified at Rubidoux was a loose fitting of a cap on an unused port of the manifold. Tightening the loose fitting in February 2019 resolved this issue.

The leakages were primarily indicated by unusually elevated formaldehyde and acetaldehyde concentrations for the MATES V samples. The concentrations of these analytes were consistent 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 deemed to be predominantly ambient outdoor air after a thorough statistical evaluation and additional tests. To further evaluate the impact of indoor air leakage on the analyzed compounds, staff conducted indoor/outdoor concurrent VOC canister and carbonyl sampling at each location. These samples were analyzed to identify the potential for the leaks to bias data, by analyte. This sampling also helped to discount initial concern that the elevated values might have been due a nearby ambient source. Staff also reviewed the suspect sample data as compared it to historical data, including PAMS, NATTS, CARB Toxics Program data, as well as to the current and prior MATES data to assess data outliers.

The MATES V portion of the data collected with each of the sampling manifolds included 22 canister VOC compounds and 4 carbonyl compounds. This issue did not impact $PM_{2.5}$ chemical speciation and metals monitoring, as samplers used to collect these type samples were not attached to the compromised manifolds. Criteria pollutant gases are sampled using a separate manifold which was also not compromised; hence they were not impacted.

Data Treatment Plan

Laboratory staff used statistical methods to identify effective screening tools for data outliers (i.e., false positives/negatives). The following data treatment plan was used for the South Coast AQMD samples, including those for MATES V:

- Invalidate all manifold-sampled carbonyls with a null code in the U.S. EPA Air Quality System (AQS) database (BJ= Operator Error). Overall, the indoor/outdoor samples indicate a significant indoor air bias. Routine sample data indicates significant outliers compared to historical trends.
- Invalidate VOC canister data point outliers, by species, with a null code in AQS (BJ= Operator Error), if three conditions are met: (1) indoor/outdoor samples indicate indoor air bias; (2) data points screened as outlier by statistical outlier tests; and (3) data points inconsistent with 5- or 10-year trends, with seasonal variation considered.
- Flag remaining VOC compound data points – with a qualifier code in AQS (3 = Field Issue) to inform data users of the potential issue. In this case the indoor/outdoor sampling did not indicate a significant indoor air contamination bias and the data were not determined to be outliers based on statistical tests and appeared to be consistent with historical trends.

Table V-1 shows the period of the manifold leaks at each station, along with the percentage of the MATES V data invalidated for each site. Due to the presence of significant outliers and a more significant indoor presence of these species in the indoor/outdoor sampling, all MATES V carbonyl data was invalidated during the leak period for the 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 V VOC canister samples for Central Los Angeles and Rubidoux did not indicate outliers for those analytes and the indoor/outdoor sampling did not indicate a significant indoor bias for these analytes; therefore, no MATES V canister data was invalidated at these sites. However, the data was flagged with a qualifier code (AQS Qualifier Code 3, Field Issue) to warn data users of potential data issues should they become evident during data analysis. Due to the more severe magnitude of the manifold leak at Anaheim throughout the entire MATES V sampling period, all VOC data from this site was invalidated.

Table V-1. 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 Period	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%* (49 of 61 samples)	69% (42 of 61 samples)	100% (61 of 61 samples)

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

Corrective Actions

South Coast AQMD staff implemented corrective actions to minimize the chance of similar manifold issues occurring in the future. These actions have strengthened the sampling system operations, maintenance, calibration, and audit procedures, along with stressing the timely identification and reporting of potential sampling concerns raised during the laboratory analysis. The revised procedures enhance the periodic maintenance of the entire sampling system (i.e., inlet, manifold, and sampling instruments), including cleaning, leak tests, flow tests, blanking and known standard challenges, records review, and audits. Routine physical manifold review and manifold leak testing follows significant manifold modifications or instrument changes, manifold cleanings, or when routine laboratory analyses or the analysis from an instrument challenge test (zero air blanking and known standard challenge) indicates the distinctive signature from common indoor air analytes. Reviews of the entire manifold system are also done with the twice-annual canister VOC and carbonyl sampler flow audits by the Quality Assurance Branch.

Several manifold design and handling procedures were implemented or enhanced. The larger manifolds, used at Central Los Angeles and Rubidoux, were replaced to remove potential for leakage where two glass manifolds were joined, now using a single-piece glass manifold with fewer connection ports. Revised VOC manifold sampling system procedures now require replacing all O-rings at each cleaning. Work on the manifold systems is to be done by trained personnel, with oversight by experienced staff. The use of the VOC manifolds for testing instruments or temporary studies (other than MATES, NATTS, and PAMS) has been restricted. The CARB Air Toxics Program canister VOC sampling was recently removed from the Central Los Angeles and Rubidoux manifolds to provide routine, independently analyzed collocation samples that can be used for data comparison to help identify potential concerns.

V.4. References

South Coast AQMD (2013a). *Quality Assurance Project Plan for the National Air Toxics Trends Stations Program*, Version 2.3, September 2013. *[Copies available upon request]*

South Coast AQMD (2013b). *Quality Assurance Project Plan for Special Monitoring*, Revision 0, September 2013 (reviewed by U.S. EPA August 7, 2014 – no federal approval required). *[Copies available upon request]*

South Coast AQMD (2014). *Quality Assurance Project Plan for PM2.5 Speciation Program*, Revision 2.0 (April 2014; Approved May 15, 2014 by U.S. EPA Region 9). *[Copies available upon request]*

South Coast AQMD (2016). *Quality Management Plan for Environmental Measurement Programs*, Revision 1.0 (April 2016; Approved March 13, 2017 by U.S. EPA Region 9). *[Copies available upon request]*

South Coast AQMD (2020). *Quality Assurance Project Plan for Criteria Pollutant Monitoring Program*, Revision 2.0 (April 2020; Approved July 7, 2020 by U.S. EPA Region 9). *[Copies available upon request]*

U.S. EPA (2016). *Technical Assistance Document for the National Air Toxics Trends Stations Program*, Revision 3, October 2016, U.S. EPA, Research Triangle Park, NC. [https://www3.epa.gov/ttn/amtic/files/ambient/pm25/qa/Final%20Handbook%20Document%201_17.pdf]

U.S. EPA (2017a). *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program*, Report No. EPA-454/B-17-001, U.S. EPA, Washington, DC. [https://www3.epa.gov/ttn/amtic/files/ambient/pm25/qa/Final%20Handbook%20Document%201_17.pdf]

U.S. EPA (2017b). *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Appendix D, Measurement Quality Objectives and Validation Templates*, (separated for convenience) U.S. EPA, Washington, DC, March 2017. [https://www3.epa.gov/ttn/amtic/files/ambient/pm25/qa/APP_D%20validation%20template%20version%2003_2017_for%20AMTIC%20Rev_1.pdf]

APPENDIX VI

MATES V

DRAFT FINAL REPORT

Black Carbon Measurements at Fixed Sites

Appendix VI

Black Carbon Measurements at Fixed Sites

VI.1 Preface

Black carbon, or soot, is part of fine particulate air pollution ($PM_{2.5}$). The main sources of black carbon (BC) are incomplete burning of biofuels, burning of fossil fuels, and open biomass burning (e.g. open agriculture burning). Black carbon sources vary by region and anthropogenic activity. Multiple studies reported strong correlation between black carbon concentration and diesel vehicle traffic and that exhaust from diesel engines is the major source of soot in urban areas. Therefore, soot is often considered a good proxy for diesel particulate matter in urban areas (Diesel PM) (Schauer, 2003).

The comparison between the average levels of black carbon during MATES V and MATES IV, and temporal variability of these levels are discussed in Chapter 5. This appendix elaborates on the sampling and analytical methods used for this report and provides a further detailed analysis of the temporal and spatial variability of black carbon. In addition, this appendix includes a detailed comparison between optical and thermo-optical methods that are in use for quantifying soot emissions.

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 Quality Management District (South Coast AQMD), with a particular focus on the South Coast Air Basin (SCAB). Previous MATES studies assessed the carcinogenic risk due to inhalation exposure to air toxics and found that emissions from diesel-powered engines and boilers accounted for 84% and 68% of this risk during MATES III and MATES IV, respectively (South Coast Air Quality Management District, 2008, 2015a).

VI.2 Analytical Methods for Quantifying Atmospheric Soot

Various analytical methods have been developed to quantify the concentration of atmospheric soot particles. Depending on the measurement method used, the non-organic carbon fraction of soot is referred to as black carbon (BC) or elemental carbon (EC). When optical methods that quantify the amount of soot by measuring its interaction with light are used, soot is often referred to as BC. However, when its concentration is measured by thermal or thermal-optical techniques, it is generally referred to as EC.

The measurement of optically absorbing material on a filter is performed by Aethalometers. This instrument measures the attenuation of light of a specific wavelength that is transmitted through a sample collected on a quartz fiber filter, while the filter is continuously collecting ambient aerosols. The measured attenuation is proportional to the mass of BC in the filter deposit. This measurement is affected by the wavelength of the light with which it is made. By using the appropriate value of the specific attenuation for that particular combination of filter and optical components, the concentration of the BC content of the aerosol deposit can be determined at each measurement time.

In the most common thermal analysis EC methods, the particles are collected on a quartz fiber filter. OC can be volatilized and separated from the sample deposit by heating the sample in a non-oxidizing/inert Helium atmosphere. EC is also oxidized by raising the temperature and introducing oxygen. The combusted compounds are then converted to CO_2 using manganese dioxide (MnO_2) as the oxidizer. Subsequently, CO_2 is converted to methane (CH_4) using a nickel catalyst, and the concentration of CH_4 is quantified with a flame ionization detector (FID).

Both optical and thermal measurement techniques are important and considered complementary to each other. However, a significant advantage of monitoring BC by absorption photometry is that it delivers results in real-time with a high time resolution (minutes), in contrast to measuring EC where soot is collected on a filter, usually for 24 hours, and then analyzed. Field deployable versions of the EC/OC methods that provide real-time semi-continuous are also available but require more maintenance than Aethalometers. It should be noted that EC and BC methods do not necessarily yield directly comparable results, although they are generally correlated (Chow et al., 2001; Lack et al., 2014). A comparison between EC and BC measurements during MATES V is provided in the Appendix XIII. Due to higher sampling frequency and lower maintenance and operating costs, BC measurements are often favored for deployment in monitoring networks.

VI.3 BC and EC Measurements during MATES V

BC and EC were measured at all 10 fixed MATES V locations: Anaheim, Burbank Area, Central Los Angeles (Central LA), Compton, Inland Valley San Bernardino (Inland Valley SB), West Long Beach (W. Long Beach), Huntington Park, Long Beach, Pico Rivera, and Rubidoux. Details of the sites, their characteristics and sampling protocols are given in Appendix III of MATES V.

Continuous measurements of BC were carried out from January 2018 until the end of April 2019. Only data collected from May 1, 2018 through April 30, 2019 have been used for the present report to match the sampling period for the MATES V time-integrated samples. For EC and OC analysis, time-integrated PM samples were collected over a period of 24 hours from May 1, 2018 through April 30, 2019 at all fixed MATES V sites.

We note that the locations of three stations: Burbank Area, Long Beach, and Huntington Park have changed from their previous locations during MATES IV. Figure VI-1 presents the locations of all ten sites and the changes of these three sites.

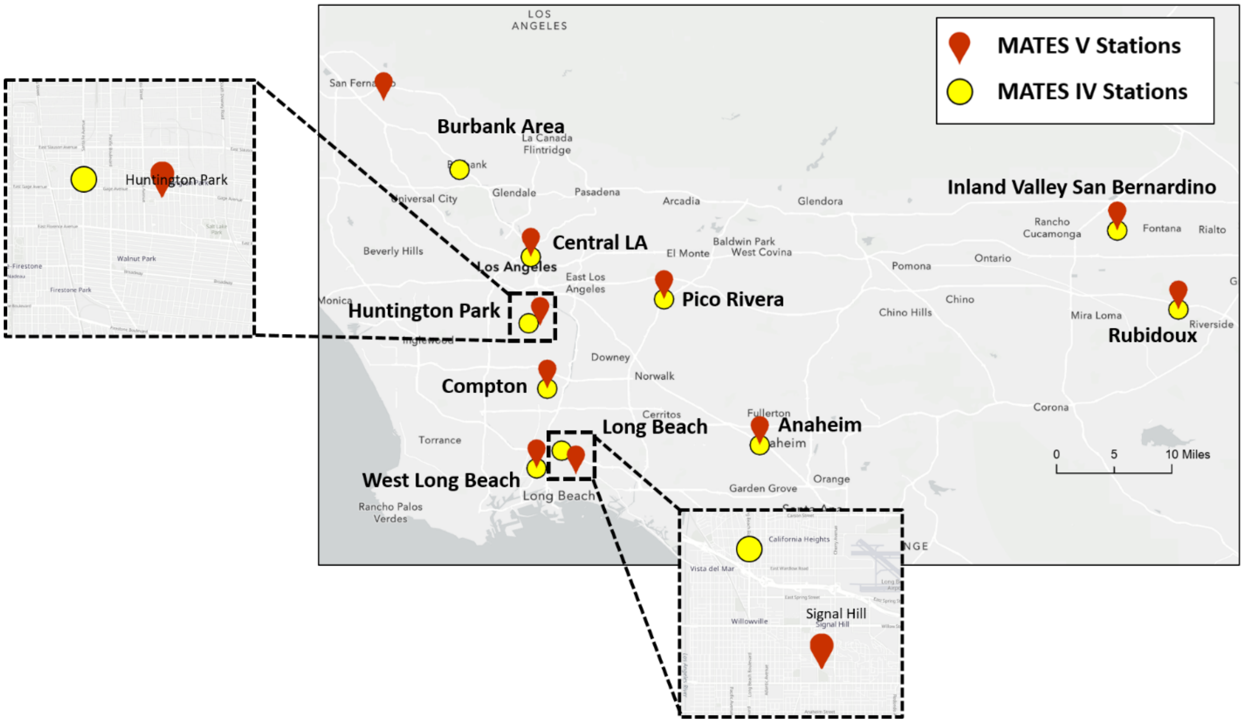


Figure VI-1. The locations of MATES V and their location during MATES IV

VI.3.1 Black Carbon Measurements

The Aethalometer (Magee Scientific, Berkeley, CA) is a photometer that provides a real-time readout of the concentration of black carbon aerosol particles in an air stream. The operating principles of the Aethalometer are described in detail elsewhere (Hansen et al., 1984). 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.

VI.3.2 Elemental Carbon Measurements

OC and EC are determined by thermal-optical analysis of time-integrated PM samples collected over a period of 24 hours. It should be noted that there are several different protocols to measure OC and EC, and results may differ by up to a factor of 2 (HEI, 2010). Hence, extra caution is required when comparing EC measurements from different studies, or when comparing BC and EC measurements. Currently, 24-hour integrated EC concentrations are available for regional and urban monitoring sites throughout the U.S. Interagency Monitoring of Protected Visual Environments (IMPROVE) Network and the U.S. Environmental Protection Agency Chemical Speciation Network.

In MATES V, the EC concentrations were quantified using DRI Model 2001 Thermal/Optical Carbon Analyzer using the IMPROVE_A thermal protocol (South Coast Air Quality Management District, 2020). The operation of the DRI Model 2001 Thermal/Optical Carbon Analyzer is based on the preferential oxidation of organic carbon (OC) compounds and elemental carbon (EC) at different temperatures. Its function relies on the fact that organic compounds are volatilized from the sample deposit in a non-oxidizing Helium atmosphere, while elemental carbon is combusted by an oxidant, in this case oxygen. The analyzer operates by 1) liberating carbon compounds under different temperature and oxidation environments from a small sample punch of known surface area taken from a quartz-fiber filter; 2) converting these compounds to carbon dioxide (CO_2) by passing the volatilized compounds through an oxidizer (heated manganese dioxide, MnO_2); 3) reducing CO_2 to methane (CH_4) by passing the flow through a methanizer (hydrogen-enriched nickel catalyst); and 4) quantifying CH_4 equivalents with a flame ionization detector (FID).

The principal function of the optical (laser reflectance and transmittance) component of the analyzer is to correct for pyrolysis charring of OC compounds into EC. Without this correction, the OC fraction of the sample might be underestimated, and the EC fraction might include some pyrolyzed OC. The correction for pyrolysis is made by continuously monitoring the filter reflectance and/or transmittance (via a helium-neon laser and a photodetector) throughout an analysis cycle. The reflectance and transmittance, largely dominated by the presence of light-absorbing EC, decrease as pyrolysis takes place and increase as light-absorbing carbon is liberated during the latter part of the analysis. By monitoring the reflectance and transmittance, the portion of the EC peak corresponding to pyrolyzed OC can be accurately assigned to the OC fraction. The correction for the charring conversion of OC to EC is essential for reducing bias in the measurement of carbon fractions (Johnson et al., 1981). The Thermal Optical Reflectance (TOR) and Thermal Optical Transmittance (TOT) charring corrections are not necessarily equivalent due to charring of organic vapors adsorbed within the quartz fiber filter (Chen et al., 2013; Chow et al., 2004). South Coast AQMD reports both OC and EC as determined by both methods to U.S. EPA. Seven temperature fractions, as well as the TOR and TOT charring correction, are individually quantified and reported when the IMPROVE A (Chow et al., 2001, 1993) temperature protocol is applied. Values routinely reported include total OC, total EC, total carbon (TC, sum of total OC and total EC), and pyrolyzed carbon, monitored by both reflectance (OPR) and transmittance (OPT). Depending on the thermal/optical protocol applied for quantification, thermally-derived sub-fractions of OC and EC are reported.

VI.4 Results

The procedures of data collection, review, analysis, and validation are described in detail in MATES IV, Black Carbon Measurements at Fixed Sites (South Coast Air Quality Management District, 2015b). The screening processes of the data collected from by the aethalometers yielded excellent data completeness, with average data recovery of 98% overall MATES V sites, an improvement over the 96% completeness of the dataset of MATES IV.

VI.4.1 The Seasonal and diurnal variations in MATES V sites

Typically, BC exhibits a distinct diurnal profile at most locations. BC is associated with primary combustion emissions and is widely considered as one of the best indicators of local mobile sources i.e. diesel exhaust 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 VI-2. The distinct increase in BC mass starts as early as 4 AM. BC concentration reaches its maximum around 7 AM (all reported times are Pacific standard time) and decreases during the morning hours. This pattern is associated with a shallow atmospheric boundary layer in early morning enhanced with emissions from morning commute traffic.

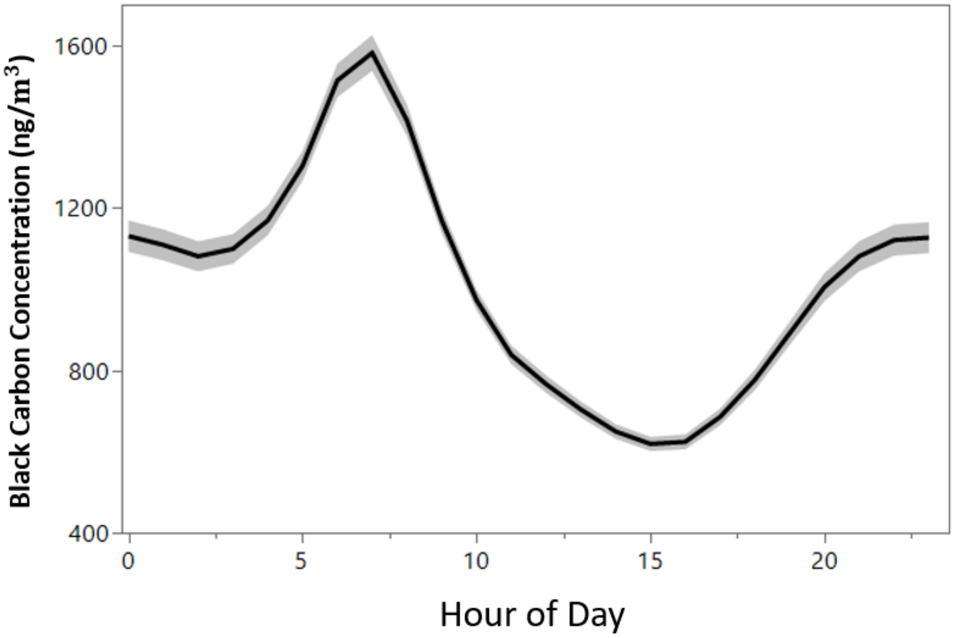


Figure VI-2. Diurnal variation of black carbon concentration in the South Coast Air Basin during MATES V. The shaded areas represent the 95 percent confidence level of the measurement

As the day progresses, the increased solar heating leads to greater dispersion of aerosols due to increased turbulent mixing and deeper boundary layer. The dispersion of aerosols causes a dilution of BC near the surface resulting in a gradual decrease in BC concentrations in the afternoon, reaching daily minimum concentration around 3pm in the afternoon, when the atmospheric convective mixing is the highest. The BC concentration continues to be relatively low until 4 pm and then increases again during the evening hours as the atmospheric boundary layer collapses. Evening commute traffic contribute to the increase too. In addition, lower wind speeds during the 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 other industrial and commercial activities generating BC emissions, however, stable meteorological conditions, and a lower boundary layer result in the accumulation of BC near the surface until the next morning.

The daily and seasonal levels in each MATES V site are presented in Figure VI-3. The seasonal time periods were averaged over a period of three months (i.e. summer: June, July, and August; fall: September, October, and November; winter: December, January and February; and spring: March, April, and May).

In general, there is a distinct seasonal dependence on the diurnal variations of BC (Figure VI-3). BC concentrations during the winter season show the strongest diurnal variations, mainly attributable to the seasonal changes in the boundary layer dynamics. Due to meteorological conditions, the boundary layer in winter is much shallower compared to its summer counterparts, resulting in lower dispersion and ventilation of aerosols in the Basin, causing an increase in the BC concentrations in winter. Moreover, the secondary evening peak is prominent only during the winter season, gradually diminishing during fall and spring seasons, and almost disappearing during the summer months when afternoons are characterized by strong on-shore sea breezes. It is important to note that during the winter months, there can be additional BC emissions due to residential wood burning, particularly during nighttime when the temperatures drop, which would contribute to the evening peak seen in winter.

BC concentrations vary by season significantly with winter showing the highest concentration followed by fall, summer and spring. Burbank Area and Inland Valley San Bernardino stations are exceptions with the highest BC measured during the summer months.

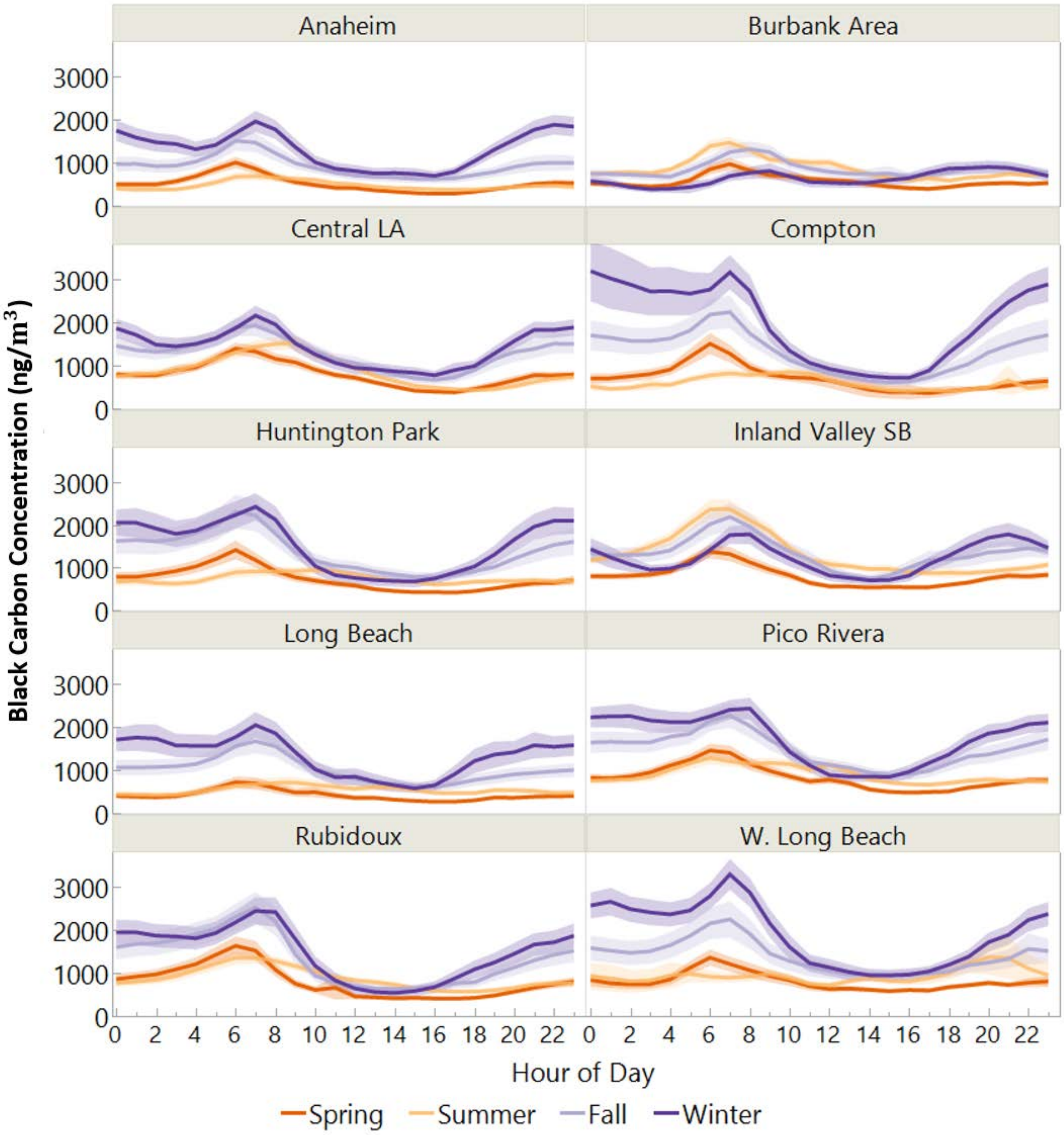


Figure VI-3. Seasonal diurnal trends of black carbon concentrations at each site. The shaded areas represent the 95 percent confidence level of the measurement

In order to assess the temporal associations between each site pair, a linear regression analysis was performed. Figure VI-4 summarizes the correlation coefficients for all site pairs.

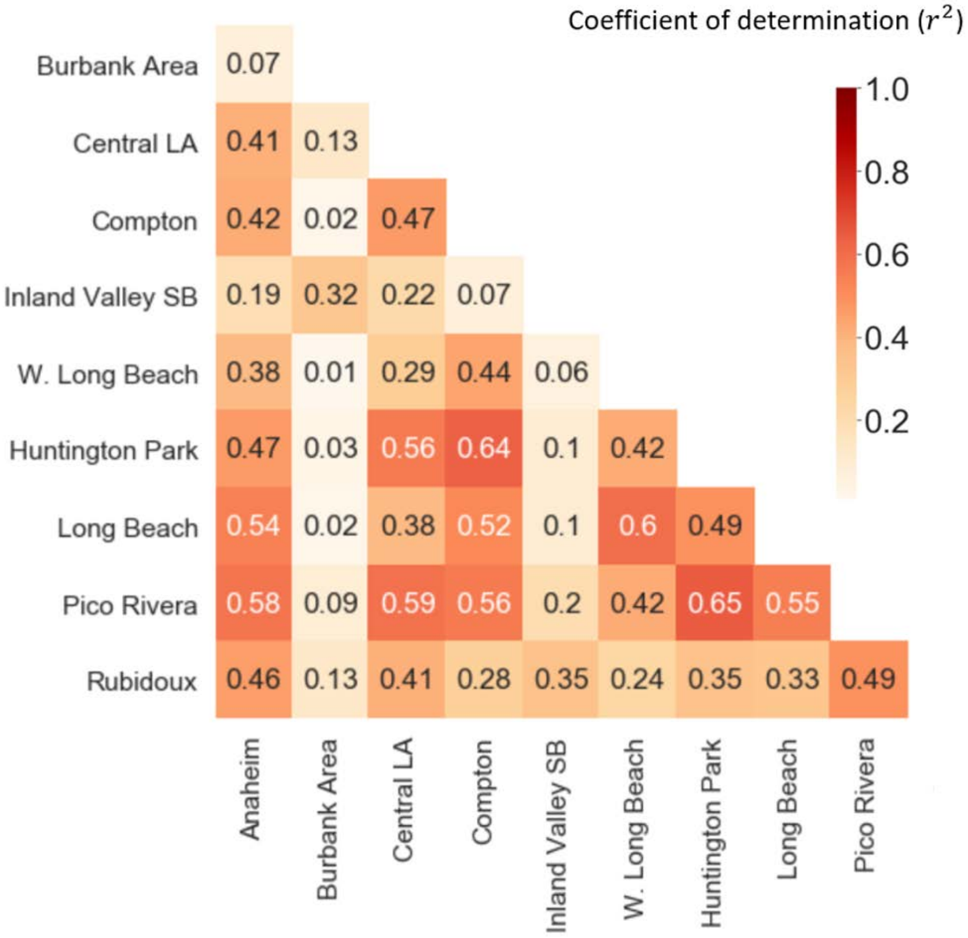


Figure VI-4. Coefficients of determination (r^2) of black carbon trends between each site pair

Among all site pairs, the highest correlation coefficients were obtained between Huntington Park and Pico Rivera, ($r^{2=}0.65$) and Huntington Park and Compton (r^2=0.64). A high correlation was also found between West Long Beach and Long Beach, which are both located close to the ports. On the other hand, Rubidoux, Inland Valley San Bernardino, and Burbank Area which are each located relatively far away from any other station, showed low correlation with the other stations.

The relatively high r2 values between the stations that are in the urban areas and between those that are located near the ports suggest that the meteorological patterns and major sources of BC at each of those are similar and that the concentrations vary with a relatively similar temporal pattern. On the other hand, the lack of correlation between the inland stations (Inland Valley San Bernardino and Rubidoux) and Burbank Area (as a more suburban site) with the urban sites indicates that the temporal trends for BC concentrations at these sites are impacted by different emission sources and meteorological patterns.

VI.4.2 The Directionality of BC Enhancements

The polar plots in Figure VI-5 show the average BC concentration organized by direction and time of day. The polar angle of the data shows the direction from which that average concentration was observed and the distance from the center of each plot (0 – 23) indicates the time of day. For example, the plot for West Long Beach shows that the highest average BC concentrations during the MATES V period come from the northeast direction and usually occur around the morning which can be the result of the proximity of two major highways (Interstates 405 and 710) to the north and east. Stagnant wind condition caused by the transition of the nocturnal offshore wind to the daytime onshore wind is expected to contribute to the high concentration too.

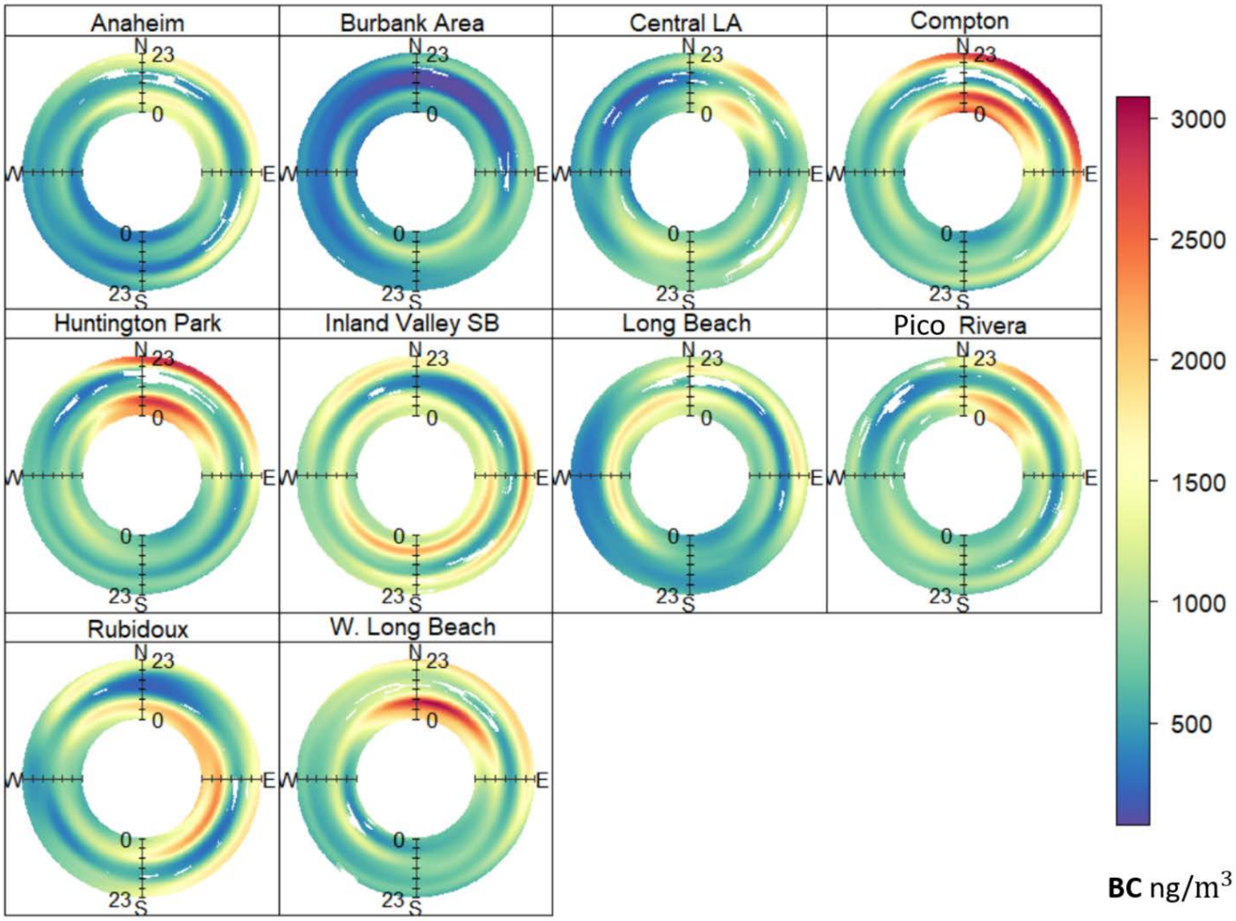


Figure VI-5. Polar time plots of BC concentration at each MATES V station

Compton, Central Los Angles, Anaheim, Pico Rivera, and Huntington Park have morning and evening peaks when winds from the northeast direction. Rubidoux, Burbank Area, and Inland Valley San Bernardino have higher concentrations coming from the southeast direction. The morning peaks are usually associated with nearby on-road and off-road mobile source activities and transport by prevailing wind directions, while the midnight peaks are produced by a combination of lower boundary layer height and higher wood-burning activities during the cold months.

VI.5 Summary

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

Based on the MATES V data, BC concentrations show significant temporal variations on all time scales; annual, seasonal, and diurnal (see Chapter 5 for detailed analysis). The diurnal variations at most sites have a distinct morning peak, which was primarily caused by the diurnal variation of the atmospheric boundary layer and emissions from commute traffic. The diurnal variations are more pronounced during the winter. This effect is particularly pronounced during the colder months when the mixing height is the lowest.

The seasonal variations are mostly related to changes in meteorology and the boundary layer dynamics. High concentrations are generally observed in colder months, when there is less convective mixing. Moreover, biomass burning smoke may contribute to the observed elevated BC concentrations in winter. In general, local traffic sources, meteorological conditions, and boundary layer dynamics are the most important parameters influencing the BC concentrations.

Various existing regulations and emission reduction strategies are designed to control the atmospheric concentration 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 helps to reduce short-lived climate forcing, air toxic exposure, as well as PM exposure.

VI.6 References

Chen, H., Goldberg, M.S., Burnett, R.T., Jerrett, M., Wheeler, A.J., Villeneuve, P.J., 2013. Long-term exposure to traffic-related air pollution and cardiovascular mortality. Epidemiology 24, 35–43. https://doi.org/10.1097/EDE.0b013e318276c005

Chow, J.C., Watson, J.G., Chen, L.-W.A., Arnott, W.P., Moosmüller, H., Fung, K., 2004. Equivalence of elemental carbon by thermal/optical reflectance and transmittance with different temperature protocols. Environ. Sci. Technol. 38, 4414–4422.

Chow, J.C., Watson, J.G., Crow, D., Lowenthal, D.H., Merrifield, T., 2001. Comparison of IMPROVE and NIOSH carbon measurements. Aerosol Sci. Technol. 34, 23–34.

Chow, J.C., Watson, J.G., Pritchett, L.C., Pierson, W.R., Frazier, C.A., Purcell, R.G., 1993. The DRI thermal/optical reflectance carbon analysis system: description, evaluation and applications in US air quality studies. Atmos. Environ. Part A. Gen. Top. 27, 1185–1201.

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.

HEI, 2010. Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects.

Johnson, R.L., Shah, J.J., Cary, R.A., Huntzicker, J.J., 1981. An Automated Thermal-Optical Method for the Analysis of Carbonaceous Aerosol.

Lack, D.A., Moosmüller, H., McMeeking, G.R., Chakrabarty, R.K., Baumgardner, D., 2014. Characterizing elemental, equivalent black, and refractory black carbon aerosol particles: a review of techniques, their limitations and uncertainties. Anal. Bioanal. Chem. 406, 99–122.

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

South Coast Air Quality Management District, 2020. STANDARD OPERATING PROCEDURE FOR ORGANIC/ELEMENTAL CARBON ANALYSIS OF PM2.5 AND PM10 FILTER SAMPLES.

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

South Coast Air Quality Management District, 2015b. Appendix VI Black Carbon Measurements at Fixed Sites MATES IV.

South Coast Air Quality Management District, 2008. “Multiple Air Toxics Exposure Study in the South Coast Air Basin (MATES III).”

APPENDIX VII

MATES V

DRAFT FINAL REPORT

Ultrafine Particle Measurements at Fixed Sites

Appendix VII

Ultrafine Particle Measurements at Fixed Sites

VII.1. Background

A summary of the average concentrations of ultrafine particles (UFPs) measured during MATES V at each site and basin-wide trends (e.g., diurnal and seasonal profiles) is presented in Chapter 5. This appendix provides additional detail to quantify the differences in seasonal and diurnal trends across sites in greater depth, compares MATES V sites and South Coast AQMD near-road monitoring sites, and discusses the potential causes for the observed differences. Additional details on the validation of this data set are also included in this appendix.

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 (Guo et al., 2020). 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 in addition to other air toxics. 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 (Kozawa et al., 2009; Shirmohammadi et al., 2017; Zhu et al., 2002a, b).

Primary emissions of ultrafine particles formed in the engine or tailpipe are mostly sub-micrometer agglomerates of carbonaceous material. These particles may also contain metallic ash (from lubricating oil additives and engine wear), hydrocarbons, and sulfur-containing compounds (Morawska et al., 2008). Ultrafine particles can also be formed as hot exhaust gases are expelled from the tailpipe, which subsequently cool and condense on existing particles or nucleate to form new particles. 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. Once emitted or formed, UFPs undergo dilution with ambient air and are subject to chemical reactions and physical processes such as evaporation, condensation, and coagulation.

VII.2. Data validation

The particle number concentration (PNC) data was downloaded from the instruments using USB drives on a weekly basis. One-minute time resolution data for each site were validated and examined for anomalies. Hourly average particle number concentrations were calculated for each station from the corresponding one-minute data only when the data recovery was 75% or higher (i.e., when more than 45 one-minute data within the hour were valid). The hourly data recoveries for each sampling location are provided in Figure VII-1, with all sites having data recoveries above 85%. The overall hourly data recovery for the ten MATES V sites was 95%.

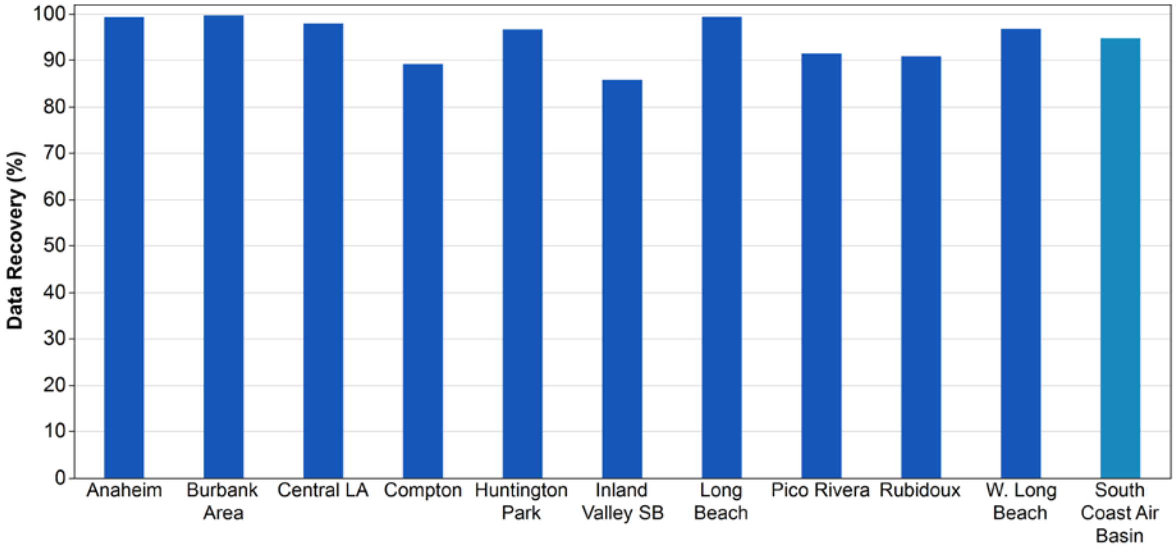


Figure VII-1: Data completeness for hourly ultrafine particle measurements during MATES V.

Three collocation studies were performed against a "Gold Standard" CPC (a reference instrument that was only used for collocation purposes) as a QA/QC check and to determine if correction factors should have been applied to the data to account for intra-model variations between CPC performances. These studies indicated that all ten site instruments were in good agreement with the "Gold Standard" CPC (i.e., high correlation coefficients with slopes close to one and small y-intercepts). Thus, no corrections were applied to the field data.

VII.3. Diurnal, day of week, and seasonal variations by site

Since UFP concentrations are highly spatially variable, it is important to consider the differences between sites. In MATES V, 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 (see Chapter 5, Figure 5-5). In MATES IV, the highest UFP concentrations by season were consistently observed in the winter months. Average winter UFP concentrations have decreased for many sites with the exception of Anaheim, Inland Valley SB, and Rubidoux (Table VII-1 and Figure VII-2). Since UFP concentrations have mostly decreased during the winter from MATES IV to MATES V and summer concentrations have remained relatively constant, the summertime levels contributed more heavily to the annual average MATES V UFP concentrations compared to their contribution in MATES IV. This implies that secondary formation of UFPs may be playing a more prominent role in the overall UFP concentrations observed in the South Coast Air Basin.

Table VII-1. Average summer and winter UFP concentrations for MATES IV and MATES V for each site and overall MATES average.

	Average summer concentration (particles/cm^3)			Average winter concentration (particles/cm^3)		
Site	**MATES IV**	**MATES V**	**Change (%)**	**MATES IV**	**MATES V**	**Change (%)**
Anaheim	9877	11441	**15.8**	16768	17540	**4.6**
Burbank Area	16006	16353	**2.2**	17219	12024	**-30.2**
Central LA	16620	14097	**-15.2**	19676	16903	**-14.1**
Compton	13402	13816	**3.1**	17333	12408	**-28.4**
Huntington Park	22787	23055	**1.2**	28694	19387	**-32.4**
Inland Valley SB	16474	19964	**21.2**	12650	16085	**27.2**
Long Beach	15865	13333	**-16.0**	15968	14498	**-9.2**
Pico Rivera	15164	17634	**16.3**	20861	16635	**-20.3**
Rubidoux	8948	10859	**21.4**	13486	14615	**8.4**
W Long Beach	26303	25947	**-1.4**	27616	21923	**-20.6**
Overall	16145	16650	**3.1**	19027	16202	**-14.8**

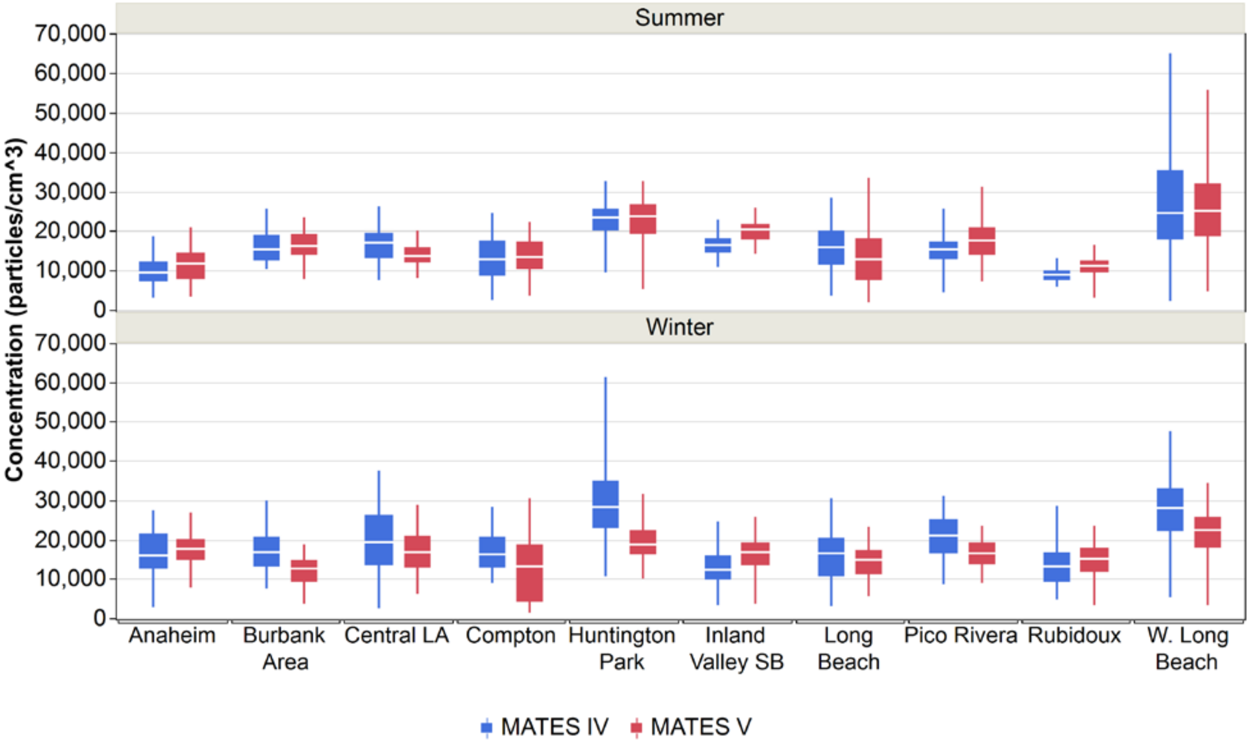


Figure VII-2. Daily average UFP concentrations for summer and winter seasons during MATES IV and V. Box plots show the daily average minimum, first quartile, median, third quartile, and maximum values.

Seasonal diurnal profiles show significant variation by site (Figures VII-3 and VII-4). For example, the summertime midday photochemical peak is more pronounced on the west side of the SCAB, with the exception of Burbank Area, and less distinct in the inland sites of Inland Valley San Bernardino and Rubidoux. Compton, Long Beach, West Long Beach, and Huntington Park show the largest midday peaks during the summer, exceeding the maximum hourly concentrations observed during the winter at these sites. The Inland Valley San Bernardino location did not reflect the same seasonal trends as Rubidoux. At Inland Valley San Bernardino, a large broad peak begins in the early morning commute hours at 04:00, reaches a maximum at 14:00, and remains elevated during the evening. This is one of few sites where the summer evening particle number concentrations are higher than the winter evening concentrations. The photochemical peak was also in an earlier time frame compared to the other sampling locations. On the other hand, Rubidoux is the only site where the wintertime morning rush hour peak significantly exceeds the summertime midday peak. The UFP concentrations at Burbank show unique profiles where there is an increase in particle number in the early morning which persists throughout the day for all seasons. Generally, sites that show a prominent morning rush hour peak in the winter on the weekdays, do not show the same peak on the weekends (Figure VII-4). However, sites that show a large midday peak in the summer have equally large peaks on the weekdays and weekends. In fact, in Compton, the midday summer peak is larger on the weekends, further suggesting that secondary formation is important to particle number concentrations, especially during the summer when photochemical activity is the highest.

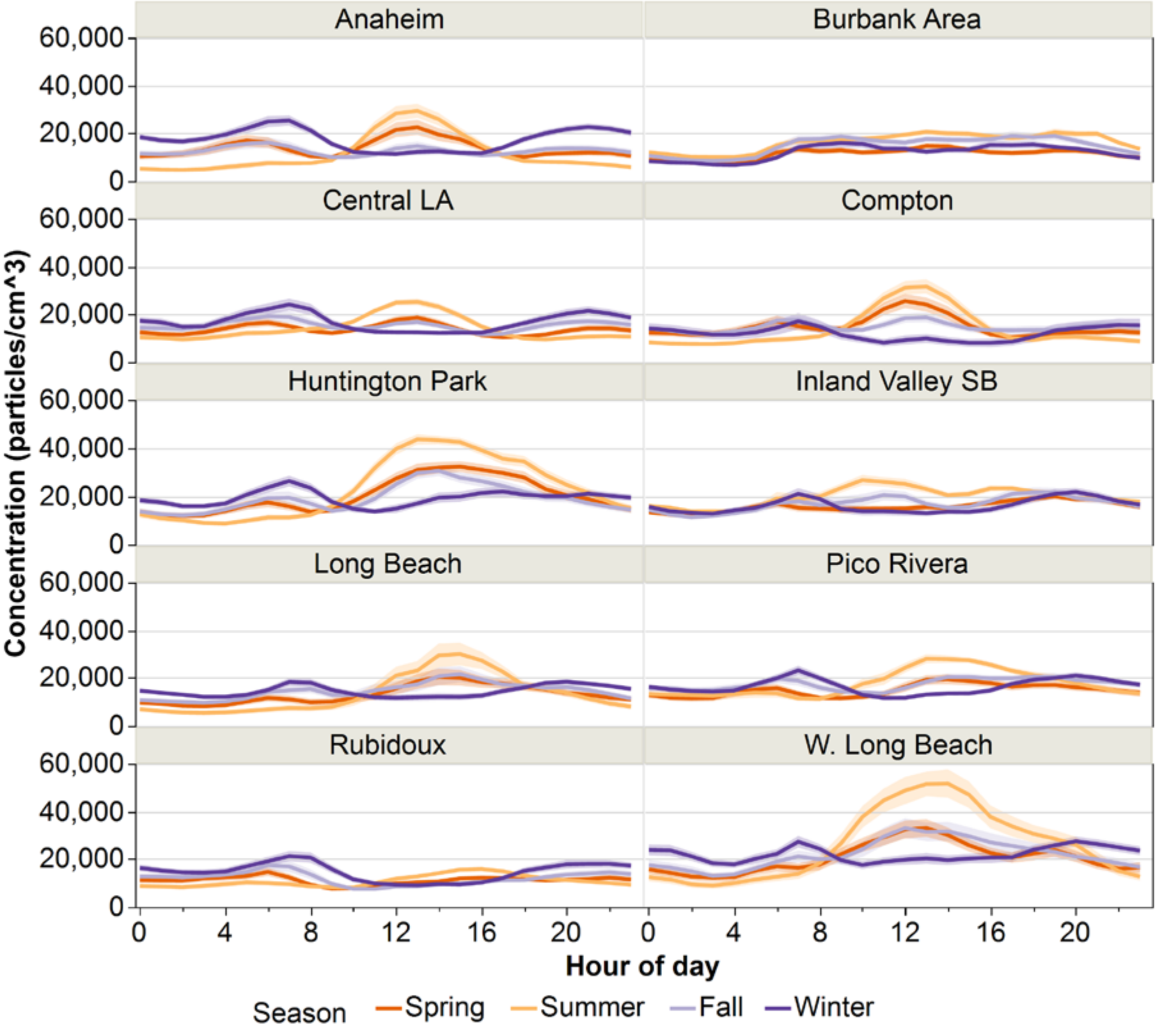


Figure VII-3 Seasonal diurnal profiles of ultrafine particle number concentration by site.

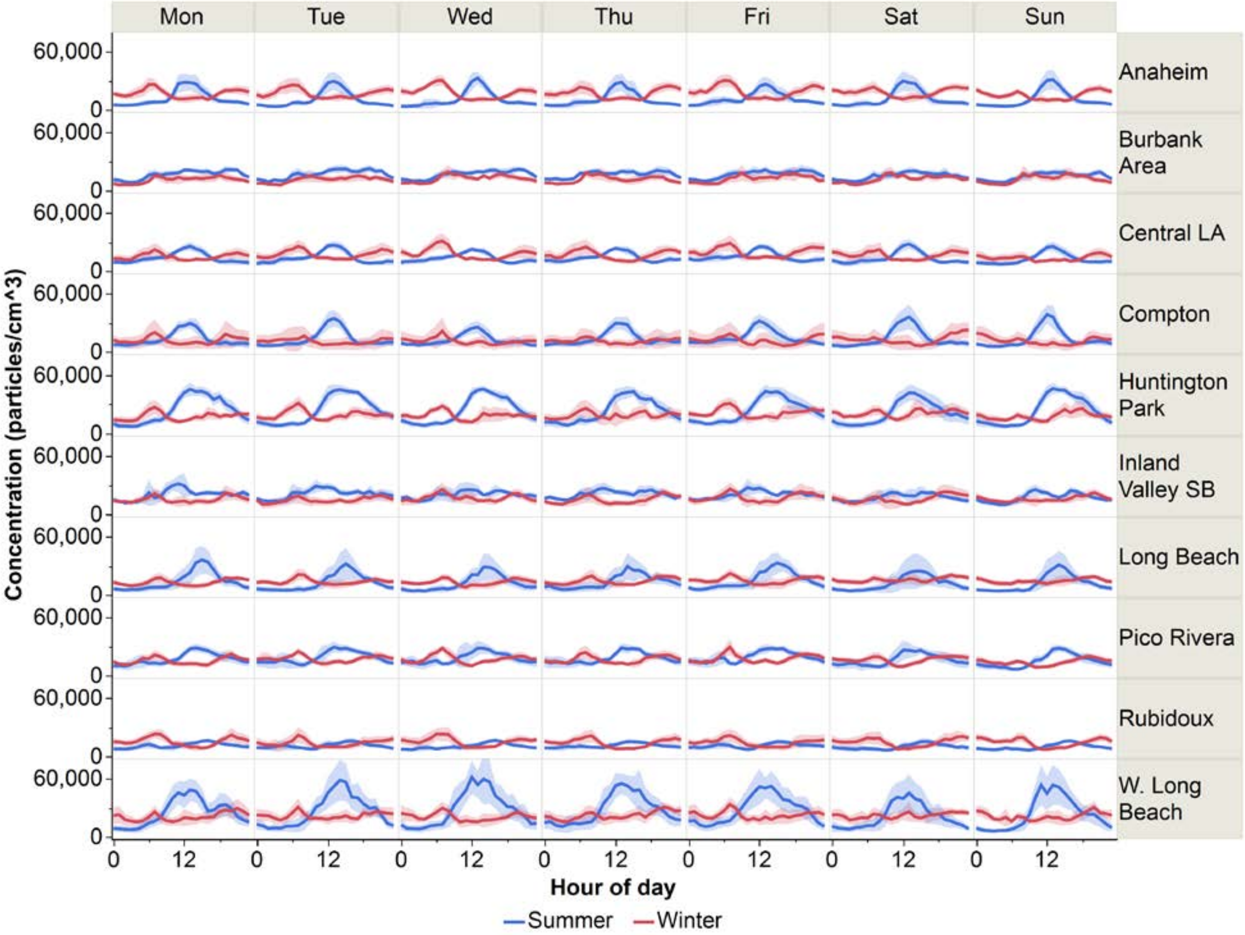


Figure VII-4. Summer and winter UFP diurnal profiles by day of week and site.

The seasonal polar time plots (Carslaw and Ropkins, 2012) in Figure VII-5 show the relative UFP concentration at each site organized by source direction and time of day. The polar angle of the data shows the direction from which that average concentration was observed and the distance from the center of each plot (0 – 23) indicates the hour of day. For example, the plots for Long Beach show that the highest average UFP concentrations during the MATES V period come from the northwest direction and usually occurs around midday for spring, summer, and fall. West Long Beach, despite the proximity of two major highways (Interstates 405 and 710) to the north and east, shows that the highest UFP concentrations in the summer come from the west around noon, with a consistent pattern during weekday and weekend, suggesting secondary particle formation when the predominant wind is westerly. Measurements of sulfur dioxide (SO_2), a potentially important precursor for new particle formation based on the available literature (Saha et al., 2018), also showed higher concentrations at this site during the summer around noon. The distribution of high concentrations seen at West Long Beach indicate the importance of wind direction and local sources to observed particle number concentrations. Some sites show that the direction (i.e., source) of highest UFP concentrations changes with season. For example, in Central Los Angeles, the highest concentrations in the summer come from the southwest direction around noon, suggesting a secondary source. However, the highest concentrations in the fall and winter come from the northeast in the early morning and evening, suggesting a traffic-related source. 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.

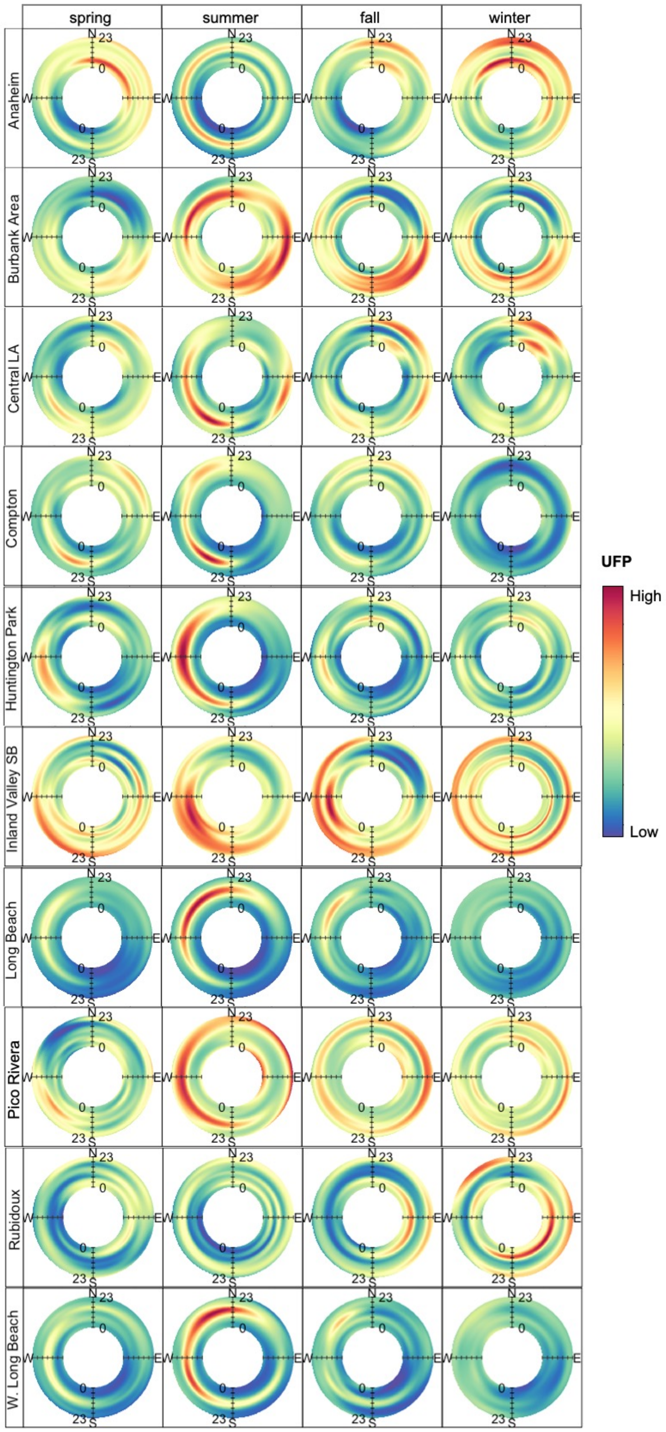


Figure VII-5. Polar time plots of relative UFP concentration by site and season.

VII.4. Comparison with near road sites

In addition to the MATES V sites, South Coast AQMD operates several near-road monitoring stations where ultrafine particles are measured. These sites include near-road stations in Ontario near CA-60 (60 NR), Anaheim near I-5 (Anaheim NR), Ontario near I-10 (Ontario NR), and Long Beach near I-710 (W710). UFP concentrations measured during the MATES V period for the near road monitoring stations are significantly elevated compared to the ten MATES V designated sites (Fig. VII-6). Average concentrations measured at these near-road stations are nearly twice that measured at the MATES V sites. The near-road sites also measured much higher maximum values compared to the MATES V sites, with hourly concentrations in some cases exceeding 100,000 particles per cubic centimeter (W710). These measurements provide further evidence that traffic emissions are major sources of UFPs (Sowlat et al., 2016; Zhu et al., 2002a, b).

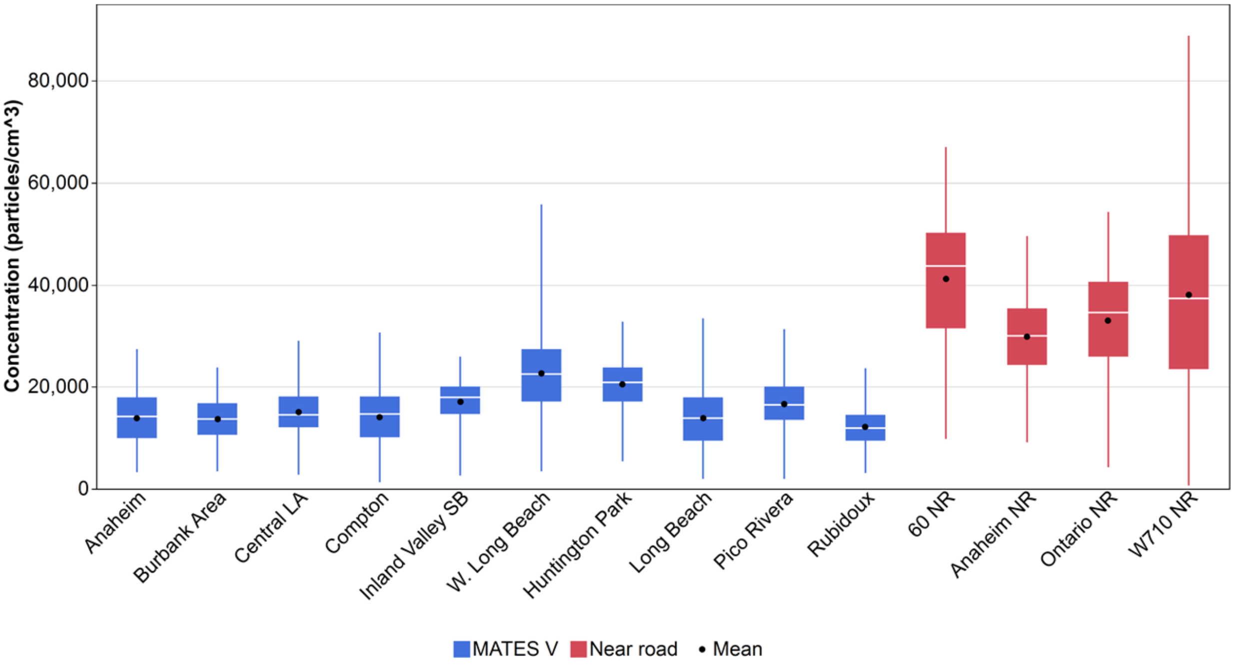


Figure VII-6. Comparison of UFP concentrations for MATES V sites (blue) and near-road sites (red). Box plots showing the minimum, first quartile, median, third quartile and maximum values observed at each site with outliers removed. Mean values for each site are marked with a black circle.

VII.5. Correlations between sites

Many factors contribute to ultrafine particle formation, including emissions, meteorology, and chemistry. Previous studies have also showed that UFP concentrations show high spatial variability, with very high levels near sources such as major highways, and decreasing steeply with distance from that source (Zhu et al., 2002 a, b). Therefore, it is not surprising that the ten sites studied for MATES V show significantly different UFP concentrations on a day-by-day basis. Figure VII-7 shows the coefficient of determination (r^2) matrix between the daily UFP concentrations at each site as a measure of their similarity. All r^2 values are 0.51 or below, with several sites showing little to no correlation with each other. The highest value observed is between West Long Beach and Long Beach, sites that are close in proximity to each other. In general, Burbank Area, Compton, and Inland Valley San Bernardino show very low r^2 values with the other sites. Other sites typically show more intermediate r^2 values from 0.2 – 0.4.

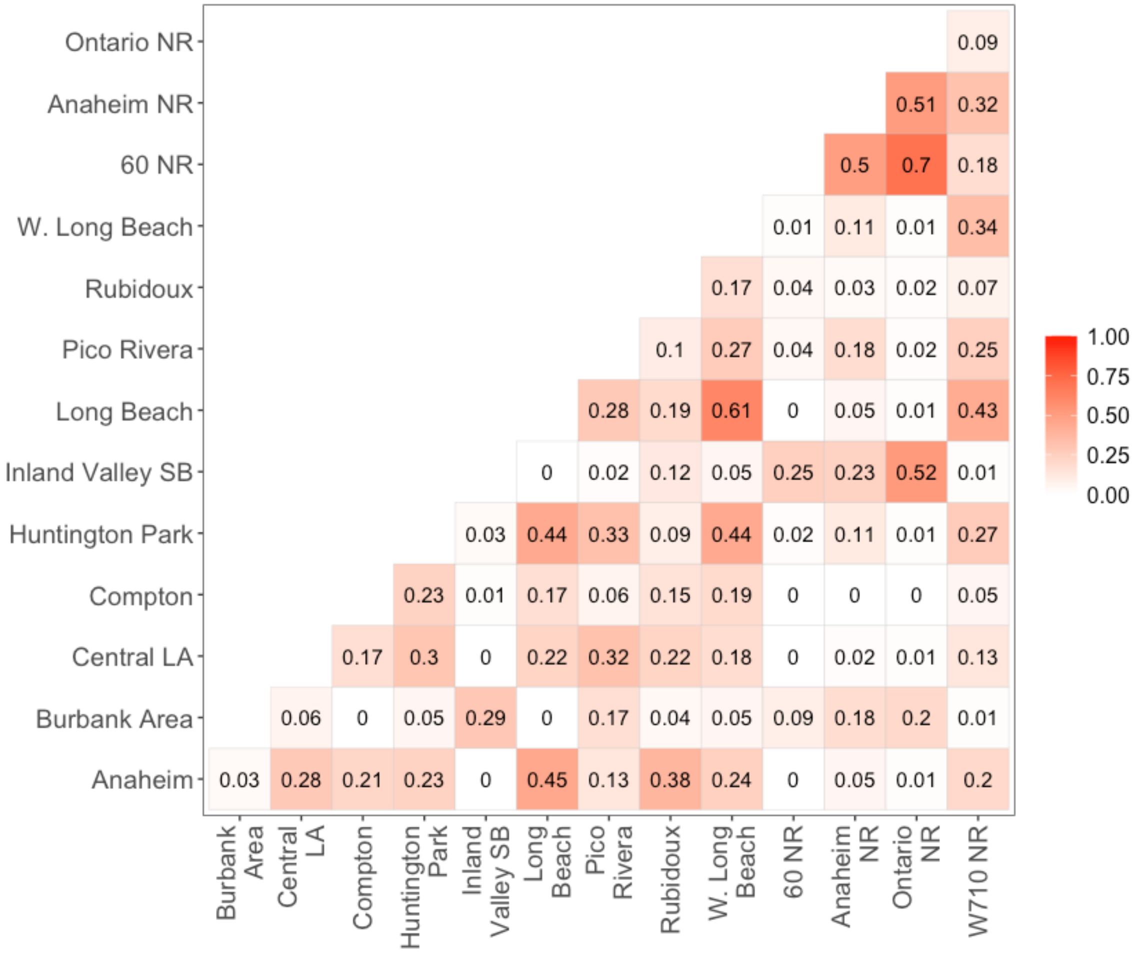


Figure VII-7. Coefficient of determination (r^2) matrix for MATES V and near-road sites.

The variability shown here at regionally representative sites emphasizes the heterogeneity of UFPs in the Basin and the impact of the proximity to nearby sources and precursors on measured UFP concentrations. As there is continued interest in studying the health effects of UFPs and continued research to develop improved modeling techniques to estimate long-term UFP exposures, the fixed-site monitoring data from the MATES program can help inform those efforts by providing year-long data in these locations, repeated over time.

In areas impacted by multiple sources of UFP emissions or its precursors, measurements with higher spatial resolution would be important to better quantify and characterize community UFP exposures. This can be achieved by conducting measurements at multiple sites or combining stationary and mobile monitoring to improve the characterization of UFPs.

VII.6. Summary

Continuous real-time UFP measurements collected at ten South Coast AQMD monitoring sites during MATES V show high temporal and spatial variability. Generally, wintertime concentrations of UFPs have decreased (15% decrease in SCAB average) between the MATES IV (July 2012 – June 2013) and MATES V (May 2018 – April 2019) periods; however, summertime concentrations have either remained constant or increased (3% increase in SCAB average). This suggests the growing importance of secondary particle formation to UFP concentrations in the Basin. Diurnal and seasonal profiles vary significantly across sites. 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. Furthermore, incorporating wind direction data shows that the sources that most impact UFP concentrations at a given site can change throughout the day and over the seasons. Measurements of UFPs at near-road sites are relatively new and show significantly higher UFP concentrations relative to the MATES sites, emphasizing that traffic is still a major source of UFPs. Continued measurements are needed to make robust conclusions on the long-term trends and spatial patterns of UFPs (Presto et al., 2021). 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.

VII.7. References

Carslaw, D.C., Ropkins, K. (2012) “openair – An R package for air quality data analysis”, Environmental Modeling & Software. Volume 27-28, 52-61.

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”, Proceedings of the National Academy of Sciences, 117(7), 3427–3432.

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.

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.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.

Saha, P.K., Robinson, E.S., Shah, R.U., Zimmerman, N., Apte, J.S., Robinson, A.L., Presto, A.A. (2018). “Reduced Ultrafine Particle Concentration in Urban Air: Changes in Nucleation and Anthropogenic Emissions”, Environmental Science and Technology, 52 (12) 6798 – 6806.

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.

Sowlat, M. H., Hasheminassab, S., Sioutas, C. (2016) "Source Apportionment of Ambient Particle Number Concentrations in Central Los Angeles Using Positive Matrix Factorization (PMF)", Atmos. Chem. Phys. 16 (8), 4849–4866.

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.

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: 1032-10.

APPENDIX VIII

MATES V

DRAFT FINAL REPORT

2018 Emissions by Major Source Category

Appendix VIII

2018 Emissions by Major Source Category

The 2018 air toxics emissions inventory by major source category is presented in a table in this appendix. Emissions inventory data is presented separately for the South Coast Air Basin and the Coachella Valley. Toxic gases are provided first, in alphabetical order, followed by the toxic particulates, also in alphabetical order. The particulates are estimated total mass from all size fractions.

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Acetaldehyde	Acetone	Benzene	1,3 Butadiene	Carbon tetrachloride	Chloroform	1,1 Dichloroethane	1,4 dioxane	Ethylene dibromide
	Fuel Combustion									
10	Electric Utilities	1.81	0.31	19.01	0.01	0.00	0.00	0.00	0.00	0.00
20	Cogeneration	0.02	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00
30	Oil and Gas Production (combustion)	0.90	0.25	3.99	0.02	0.00	0.00	0.00	0.00	0.00
40	Petroleum Refining (Combustion)	3.19	0.00	11.72	0.00	0.00	0.00	0.00	0.00	0.00
50	Manufacturing and Industrial	43.10	30.01	180.22	1.15	0.00	0.00	0.00	0.00	0.00
52	Food and Agricultural Processing	0.44	0.44	4.86	0.02	0.00	0.00	0.00	0.00	0.00
60	Service and Commercial	14.94	14.03	676.27	0.50	0.00	0.00	0.00	0.00	0.00
99	Other (Fuel Combustion)	24.69	26.44	26.41	2.13	0.51	0.08	0.00	0.00	0.00
	Total	**89.08**	**71.47**	**923.41**	**3.82**	**0.51**	**0.08**	**0.00**	**0.00**	**0.00**
	Waste Disposal									
110	Sewage Treatment	1.02	1.14	3.05	0.00	0.46	51.07	0.00	0.20	0.15
120	Landfills	0.00	123.13	262.26	0.00	0.13	0.90	70.40	0.00	0.00
130	Incineration	0.00	0.00	27.70	0.00	0.00	0.00	0.00	0.00	0.00
140	Soil Remediation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	0.03	2299.99	4.17	0.00	0.02	1.75	0.04	0.01	0.01
	Total	**1.05**	**2424.27**	**297.18**	**0.00**	**0.61**	**53.71**	**70.43**	**0.21**	**0.16**
	Cleaning and Surface Coatings									
210	Laundering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220	Degreasing	0.00	3044.60	4.25	0.00	0.00	0.00	0.00	0.00	0.00
230	Coatings and Related Processes	0.00	808.96	0.63	0.00	0.00	0.00	0.00	0.00	0.00
240	Printing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	Adhesives and Sealants	0.00	1198.99	1.78	0.00	0.00	0.00	0.00	0.00	0.00
299	Other (Cleaning and Surface Coatings)	0.00	3.65	1.97	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**5056.20**	**8.63**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Petroleum Production and Marketing									

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Acetaldehyde	Acetone	Benzene	1,3 Butadiene	Carbon tetrachloride	Chloroform	1,1 Dichloroethane	1,4 dioxane	Ethylene dibromide
310	Oil and Gas Production	0.00	0.00	36.39	0.00	0.00	0.00	0.00	0.00	0.00
320	Petroleum Refining	0.23	0.33	22.13	0.11	0.04	0.01	0.00	0.00	0.00
330	Petroleum Marketing	0.23	0.34	137.82	1.27	0.04	0.01	0.00	0.00	0.00
399	Other (Petroleum Production and Marketing)	0.00	0.00	7.01	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.45**	**0.67**	**203.35**	**1.38**	**0.07**	**0.01**	**0.00**	**0.00**	**0.00**
	Industrial Processes									
410	Chemical	4.12	8.61	38.50	113.77	0.66	0.09	0.00	0.00	0.00
420	Food and Agriculture	0.06	0.00	0.69	0.01	0.00	0.00	0.00	0.00	0.00
430	Mineral Processes	0.06	0.09	8.69	0.03	0.01	0.00	0.00	0.00	0.00
440	Metal Processes	0.73	1.07	19.95	0.36	0.12	0.02	0.00	0.00	0.00
450	Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
460	Glass and Related Products	0.10	0.15	0.57	0.05	0.02	0.00	0.00	0.00	0.00
470	Electronics	0.29	0.42	1.63	0.13	0.05	0.01	0.00	0.00	0.00
499	Other (Industrial Processes)	53.20	122.36	309.99	25.66	8.50	1.27	0.00	0.00	0.00
	Total	**58.56**	**132.70**	**380.02**	**140.00**	**9.36**	**1.39**	**0.00**	**0.00**	**0.00**
	Solvent Evaporation									
510	Consumer Products	0.00	15525.17	0.01	0.00	0.00	0.00	0.00	0.00	0.00
520	Architectural Coatings and Related Solvent	4.15	1095.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
530	Pesticides/Fertilizers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
540	Asphalt Paving/Roofing	0.00	0.00	5.34	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**4.15**	**16620.50**	**5.35**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Miscellaneous Processes									
610	Residential Fuel Combustion	1328.39	980.24	189.50	0.00	0.00	0.00	0.00	0.00	0.00
620	Farming Operations	0.00	1015.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
630	Construction and Demolition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Acetaldehyde	Acetone	Benzene	1,3 Butadiene	Carbon tetrachloride	Chloroform	1,1 Dichloroethane	1,4 dioxane	Ethylene dibromide
640	Paved Road Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
645	Unpaved Road Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
650	Fugitive Windblown Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
660	Fires	0.00	0.00	0.00	6.36	0.00	0.00	0.00	0.00	0.00
670	Waste Burning and Disposal	0.00	0.00	4.39	14.74	0.00	0.00	0.00	0.00	0.00
690	Cooking	262.85	0.00	14.67	18.56	0.00	0.00	0.00	0.00	0.00
699	Other (Miscellaneous Processes	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**1591.24**	**1995.33**	**208.60**	**39.66**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	333.63	200.89	1535.86	181.11	0.00	0.00	0.00	0.00	0.00
722	Light Duty Trucks 1 (T1)	59.63	39.27	321.80	30.00	0.00	0.00	0.00	0.00	0.00
723	Light Duty Trucks 2 (T2)	175.04	105.25	853.68	96.51	0.00	0.00	0.00	0.00	0.00
724	Medium Duty Trucks (T3)	159.31	94.16	723.09	91.51	0.00	0.00	0.00	0.00	0.00
732	Light Heavy Duty Gas Trucks 1 (T4)	11.87	7.98	94.54	6.06	0.00	0.00	0.00	0.00	0.00
733	Light Heavy Duty Gas Trucks 2 (T5)	2.28	1.50	18.99	1.15	0.00	0.00	0.00	0.00	0.00
734	Medium Heavy Duty Gas Trucks (T6)	5.04	3.69	25.78	2.33	0.00	0.00	0.00	0.00	0.00
736	Heavy Heavy Duty Gas Trucks ((HHD)	3.05	2.59	14.24	1.19	0.00	0.00	0.00	0.00	0.00
742	Light Heavy Duty Diesel Trucks 1 (T4)	52.37	53.47	14.25	1.35	0.00	0.00	0.00	0.00	0.00
743	Light Heavy Duty Diesel Trucks 2 (T5)	20.96	21.40	5.70	0.54	0.00	0.00	0.00	0.00	0.00
744	Medium Heavy Duty Diesel Truck (T6)	240.57	245.61	65.47	6.22	0.00	0.00	0.00	0.00	0.00
746	Heavy Heavy Duty Diesel Trucks (HHD)	588.82	601.15	160.24	15.22	0.00	0.00	0.00	0.00	0.00
750	Motorcycles (MCY)	135.06	88.15	597.27	91.83	0.00	0.00	0.00	0.00	0.00
760	Diesel Urban Buses (UB)	753.03	768.80	204.92	19.46	0.00	0.00	0.00	0.00	0.00
762	Gas Urban Buses (UB)	0.26	0.17	1.18	0.13	0.00	0.00	0.00	0.00	0.00
771	Gas School Buses (SB)	0.83	0.75	3.68	0.25	0.00	0.00	0.00	0.00	0.00
772	Diesel School Buses (SB)	5.55	5.67	1.51	0.14	0.00	0.00	0.00	0.00	0.00
777	Gas Other Buses (OB)	1.81	1.31	8.86	0.84	0.00	0.00	0.00	0.00	0.00

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Acetaldehyde	Acetone	Benzene	1,3 Butadiene	Carbon tetrachloride	Chloroform	1,1 Dichloroethane	1,4 dioxane	Ethylene dibromide
778	Motor Coaches	9.95	10.16	2.71	0.26	0.00	0.00	0.00	0.00	0.00
779	Diesel Other Buses (OB)	13.78	14.07	3.75	0.36	0.00	0.00	0.00	0.00	0.00
780	Motor Homes (MH)	2.25	2.16	5.07	0.38	0.00	0.00	0.00	0.00	0.00
	Total	**2575.09**	**2268.20**	**4662.59**	**546.85**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Other Mobile Sources									
810	Aircraft	296.38	26.20	127.23	118.53	0.00	0.00	0.00	0.00	0.00
820	Trains	149.49	152.62	40.68	3.86	0.00	0.00	0.00	0.00	0.00
833	Ocean Going Vessels	126.18	128.83	38.31	3.26	0.00	0.00	0.00	0.00	0.00
835	Commercial Habor Crafts	69.35	70.80	18.87	1.79	0.00	0.00	0.00	0.00	0.00
840	Recreational Boats	425.33	205.50	1535.39	362.70	0.00	0.00	0.00	0.00	0.00
850	Off-Road Recreational Vehicles	10.86	5.24	60.44	9.27	0.00	0.00	0.00	0.00	0.00
860	Off-Road Equipment	1315.96	1050.76	2252.93	483.72	0.00	0.00	0.00	0.00	0.00
870	Farm Equipment	55.66	55.83	22.13	2.97	0.00	0.00	0.00	0.00	0.00
890	Fuel Storage and Handling	0.00	0.00	60.23	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**2449.21**	**1695.79**	**4156.20**	**986.11**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total	**Stationary**	1744.54	26301.13	2026.52	184.86	**10.55**	**55.19**	**70.43**	**0.21**	**0.16**
Total	**On-Road Vehicles**	2575.09	2268.20	4662.59	546.85	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total	**Other Mobile**	2449.21	1695.79	4156.20	986.11	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total	**Anthropogenic**	**6768.85**	**30265.12**	**10845.32**	**1717.82**	**10.55**	**55.19**	**70.43**	**0.21**	**0.16**

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Ethylene dichloride	Ethylene oxide	Formalde-hyde	Methyl ethyl ketone	Methylene chloride	MTBE	Naphthalene	p-Dichloro-benzene	Perchloro-ethylene
	Fuel Combustion									
10	Electric Utilities	0.00	0.00	68.18	0.06	0.00	0.00	0.00	0.00	0.00
20	Cogeneration	0.00	0.00	0.46	0.00	0.00	0.00	0.03	0.00	0.00
30	Oil and Gas Production (combustion)	0.00	0.00	20.64	0.05	0.00	0.00	0.02	0.00	0.00
40	Petroleum Refining (Combustion)	0.00	0.00	250.06	0.00	0.00	0.00	0.00	0.00	0.00
50	Manufacturing and Industrial	0.00	0.00	913.26	5.89	0.00	0.00	0.49	0.00	0.00
52	Food and Agricultural Processing	0.00	0.00	10.46	0.09	0.00	0.00	0.01	0.00	0.00
60	Service and Commercial	0.00	0.00	1442.51	2.75	0.00	0.00	0.18	0.00	0.00
99	Other (Fuel Combustion)	4.29	0.13	56.62	7.53	0.00	0.00	0.48	5.49	0.00
	Total	**4.29**	**0.13**	**2762.19**	**16.37**	**0.00**	**0.00**	**1.21**	**5.49**	**0.00**
	Waste Disposal									
110	Sewage Treatment	0.28	0.00	5.37	0.00	78.47	0.00	0.00	7.77	63.93
120	Landfills	12.29	0.00	53.91	154.62	367.34	0.00	0.00	0.00	187.13
130	Incineration	0.00	0.00	4.02	0.00	0.00	0.00	0.00	0.00	0.00
140	Soil Remediation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	0.02	0.00	0.39	0.08	2.88	0.00	0.00	0.27	2.29
	Total	**12.58**	**0.00**	**63.69**	**154.69**	**448.69**	**0.00**	**0.00**	**8.04**	**253.35**
	Cleaning and Surface Coatings									
210	Laundering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1109.72
220	Degreasing	0.00	0.00	0.00	1309.36	7708.81	0.00	2.43	0.00	1020.06
230	Coatings and Related Processes	0.00	0.00	0.00	2157.36	0.00	0.00	0.00	0.00	0.00
240	Printing	0.00	0.00	0.00	219.96	0.00	0.00	3.07	0.00	0.00
250	Adhesives and Sealants	0.00	0.00	0.00	1008.18	32.69	0.00	0.00	0.00	0.00
299	Other (Cleaning and Surface Coatings)	0.00	1.18	0.00	3.43	168.47	0.00	0.64	0.00	184.62
	Total	**0.00**	**1.18**	**0.00**	**4698.29**	**7909.97**	**0.00**	**6.14**	**0.00**	**2314.40**
	Petroleum Production and Marketing									

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Ethylene dichloride	Ethylene oxide	Formalde-hyde	Methyl ethyl ketone	Methylene chloride	MTBE	Naphthalene	p-Dichloro-benzene	Perchloro-ethylene
310	Oil and Gas Production	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00
320	Petroleum Refining	0.31	0.01	883.85	0.23	0.00	0.00	0.02	0.39	0.00
330	Petroleum Marketing	0.31	0.01	0.34	0.24	0.00	0.00	7.11	0.40	0.00
399	Other (Petroleum Production and Marketing)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	Total	**0.62**	**0.02**	**884.47**	**0.47**	**0.00**	**0.00**	**7.13**	**0.79**	**0.00**
	Industrial Processes									
410	Chemical	5.58	0.16	0.07	8.25	0.00	0.00	0.04	7.13	0.00
420	Food and Agriculture	0.00	0.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00
430	Mineral Processes	0.08	0.00	5.71	0.06	0.00	0.00	21.03	0.10	0.00
440	Metal Processes	0.99	0.03	6.94	0.75	0.00	0.00	0.09	1.27	0.00
450	Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
460	Glass and Related Products	0.14	0.00	0.15	0.10	0.00	0.00	0.01	0.17	0.00
470	Electronics	0.40	0.01	0.38	0.30	0.00	0.00	0.02	0.51	0.00
499	Other (Industrial Processes)	71.43	2.12	90.11	54.35	15.80	0.00	4.80	91.42	53.73
	Total	**78.62**	**2.33**	**104.80**	**63.81**	**15.80**	**0.00**	**25.98**	**100.60**	**53.73**
	Solvent Evaporation									
510	Consumer Products	0.00	0.00	5.30	1085.09	4281.63	0.00	7.73	2185.31	586.96
520	Architectural Coatings and Related Solvent	0.00	0.00	0.00	24.56	46.93	0.00	2.79	0.00	15.85
530	Pesticides/Fertilizers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
540	Asphalt Paving/Roofing	0.00	0.00	0.00	0.00	0.00	0.00	95.55	0.00	0.00
	Total	**0.00**	**0.00**	**5.30**	**1109.65**	**4328.56**	**0.00**	**106.07**	**2185.31**	**602.81**
	Miscellaneous Processes									
610	Residential Fuel Combustion	0.00	0.00	1811.50	0.00	0.00	0.00	0.00	0.00	0.00
620	Farming Operations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
630	Construction and Demolition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Ethylene dichloride	Ethylene oxide	Formaldehyde	Methyl ethyl ketone	Methylene chloride	MTBE	Naphthalene	p-Dichlorobenzene	Perchloroethylene
640	Paved Road Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
645	Unpaved Road Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
650	Fugitive Windblown Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
660	Fires	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
670	Waste Burning and Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
690	Cooking	0.00	0.00	285.72	0.00	0.00	0.00	2.72	0.00	0.00
699	Other (Miscellaneous Processes	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
	Total	**0.00**	**0.00**	**2097.24**	**0.00**	**0.00**	**0.00**	**2.73**	**0.00**	**0.00**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	0.00	0.00	651.20	40.80	0.00	76.97	66.42	0.00	0.00
722	Light Duty Trucks 1 (T1)	0.00	0.00	122.11	7.68	0.00	16.87	14.25	0.00	0.00
723	Light Duty Trucks 2 (T2)	0.00	0.00	347.17	21.15	0.00	42.72	36.92	0.00	0.00
724	Medium Duty Trucks (T3)	0.00	0.00	326.12	18.70	0.00	34.71	31.58	0.00	0.00
732	Light Heavy Duty Gas Trucks 1 (T4)	0.00	0.00	25.06	1.55	0.00	3.51	2.98	0.00	0.00
733	Light Heavy Duty Gas Trucks 2 (T5)	0.00	0.00	4.61	0.29	0.00	0.67	0.56	0.00	0.00
734	Medium Heavy Duty Gas Trucks (T6)	0.00	0.00	10.92	0.70	0.00	1.74	1.44	0.00	0.00
736	Heavy Heavy Duty Gas Trucks ((HHD)	0.00	0.00	7.71	0.44	0.00	1.26	1.08	0.00	0.00
742	Light Heavy Duty Diesel Trucks 1 (T4)	0.00	0.00	104.81	10.52	0.00	0.00	0.61	0.00	0.00
743	Light Heavy Duty Diesel Trucks 2 (T5)	0.00	0.00	41.94	4.21	0.00	0.00	0.24	0.00	0.00
744	Medium Heavy Duty Diesel Truck (T6)	0.00	0.00	481.40	48.32	0.00	0.00	2.78	0.00	0.00
746	Heavy Heavy Duty Diesel Trucks (HHD)	0.00	0.00	1178.28	118.28	0.00	0.00	6.81	0.00	0.00
750	Motorcycles (MCY)	0.00	0.00	371.06	14.94	0.00	26.08	30.84	0.00	0.00
760	Diesel Urban Buses (UB)	0.00	0.00	1506.87	151.26	0.00	0.00	8.70	0.00	0.00
762	Gas Urban Buses (UB)	0.00	0.00	0.53	0.03	0.00	0.08	0.06	0.00	0.00
771	Gas School Buses (SB)	0.00	0.00	1.93	0.13	0.00	0.40	0.32	0.00	0.00
772	Diesel School Buses (SB)	0.00	0.00	11.11	1.12	0.00	0.00	0.06	0.00	0.00
777	Gas Other Buses (OB)	0.00	0.00	3.87	0.25	0.00	0.62	0.51	0.00	0.00

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Ethylene dichloride	Ethylene oxide	Formaldehyde	Methyl ethyl ketone	Methylene chloride	MTBE	Naphthalene	p-Dichlorobenzene	Perchloroethylene
778	Motor Coaches	0.00	0.00	19.92	2.00	0.00	0.00	0.12	0.00	0.00
779	Diesel Other Buses (OB)	0.00	0.00	27.57	2.77	0.00	0.00	0.16	0.00	0.00
780	Motor Homes (MH)	0.00	0.00	4.97	0.40	0.00	0.46	0.39	0.00	0.00
	Total	**0.00**	**0.00**	**5249.17**	**445.56**	**0.00**	**206.09**	**206.83**	**0.00**	**0.00**
	Other Mobile Sources									
810	Aircraft	0.00	0.00	851.95	0.21	0.00	0.78	37.68	0.00	0.00
820	Trains	0.00	0.00	299.14	30.03	0.00	0.00	1.73	0.00	0.00
833	Ocean Going Vessels	0.00	0.00	252.69	25.35	0.00	0.00	1.59	0.00	0.00
835	Commercial Habor Crafts	0.00	0.00	138.77	13.93	0.00	0.00	0.80	0.00	0.00
840	Recreational Boats	0.00	0.00	1309.03	26.65	0.00	0.00	57.97	0.00	0.00
850	Off-Road Recreational Vehicles	0.00	0.00	33.45	0.68	0.00	0.00	1.51	0.00	0.00
860	Off-Road Equipment	0.00	0.00	3224.52	189.11	0.00	0.00	83.15	0.00	0.00
870	Farm Equipment	0.00	0.00	113.39	10.93	0.00	0.00	0.88	0.00	0.00
890	Fuel Storage and Handling	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
	Total	**0.00**	**0.00**	**6222.93**	**296.87**	**0.00**	**0.78**	**185.35**	**0.00**	**0.00**
Total	**Stationary**	**96.11**	**3.66**	5917.69	6043.28	**12703.01**	**0.00**	149.27	**2300.24**	**3224.28**
Total	**On-Road Vehicles**	**0.00**	**0.00**	5249.17	445.56	**0.00**	**206.09**	206.83	**0.00**	**0.00**
Total	**Other Mobile**	**0.00**	**0.00**	6222.93	296.87	**0.00**	**0.78**	185.35	**0.00**	**0.00**
Total	**Anthropogenic**	**96.11**	**3.66**	**17389.79**	**6785.71**	**12703.01**	**206.86**	**541.46**	**2300.24**	**3224.28**

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Propylene oxide	Styrene	Toluene	Trichloro-ethylene	Vinyl chloride	Arsenic	Cadmium	Chromium	Diesel PM (DPM)
	Fuel Combustion									
10	Electric Utilities	0.00	0.00	8.77	0.00	0.00	0.03	0.00	0.01	12.84
20	Cogeneration	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.00	0.00
30	Oil and Gas Production (combustion)	0.00	0.00	2.01	0.00	0.00	0.01	0.00	0.01	12.53
40	Petroleum Refining (Combustion)	0.00	0.00	18.53	0.00	0.00	0.12	0.88	0.92	0.00
50	Manufacturing and Industrial	0.00	0.29	99.51	0.00	0.00	0.05	0.05	0.09	31.33
52	Food and Agricultural Processing	0.00	0.00	2.49	0.00	0.00	0.01	0.01	0.01	3.45
60	Service and Commercial	0.00	0.13	337.92	0.00	0.00	0.13	0.02	0.06	142.94
99	Other (Fuel Combustion)	0.03	7.86	9.42	0.00	2.73	0.01	0.19	0.01	82.52
	Total	**0.03**	**8.30**	**479.54**	**0.00**	**2.73**	**0.37**	**1.14**	**1.11**	**285.61**
	Waste Disposal									
110	Sewage Treatment	0.00	0.14	36.29	7.86	0.33	0.00	0.02	0.01	0.00
120	Landfills	0.00	0.00	4598.52	112.12	138.74	0.00	0.00	0.00	0.00
130	Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
140	Soil Remediation	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	0.00	0.00	16.21	0.33	0.08	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.14**	**4651.03**	**120.31**	**139.16**	**0.00**	**0.02**	**0.01**	**0.00**
	Cleaning and Surface Coatings									
210	Laundering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220	Degreasing	0.00	0.00	802.29	555.57	0.00	0.00	0.06	0.00	0.00
230	Coatings and Related Processes	0.00	0.00	10141.13	0.00	0.00	0.00	4.68	0.00	0.00
240	Printing	0.00	0.00	4.39	0.00	0.00	0.00	0.00	0.00	0.00
250	Adhesives and Sealants	0.00	0.00	308.80	0.00	0.00	0.00	0.06	0.00	0.00
299	Other (Cleaning and Surface Coatings)	0.00	0.00	207.76	118.53	0.00	0.00	0.06	0.00	0.00
	Total	**0.00**	**0.00**	**11464.38**	**674.10**	**0.00**	**0.00**	**4.86**	**0.00**	**0.00**
	Petroleum Production and Marketing									

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Propylene oxide	Styrene	Toluene	Trichloro-ethylene	Vinyl chloride	Arsenic	Cadmium	Chromium	Diesel PM (DPM)
310	Oil and Gas Production	0.00	0.00	17.03	0.00	0.00	0.04	0.00	0.00	0.00
320	Petroleum Refining	0.00	0.55	51.85	0.00	0.19	0.71	0.00	0.00	0.00
330	Petroleum Marketing	0.00	0.56	488.53	0.00	0.20	0.00	0.01	0.00	0.00
399	Other (Petroleum Production and Marketing	0.00	0.00	22.43	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**1.10**	**579.84**	**0.00**	**0.39**	**0.75**	**0.01**	**0.00**	**0.00**
	Industrial Processes									
410	Chemical	0.04	3710.94	137.17	0.00	1093.19	0.01	0.53	0.07	0.00
420	Food and Agriculture	0.00	0.00	6.82	0.00	0.00	0.00	0.00	0.03	0.00
430	Mineral Processes	0.00	0.14	4.37	0.00	0.05	4.43	0.17	8.35	0.00
440	Metal Processes	0.01	1.78	10.07	0.00	0.63	0.58	0.83	6.57	0.00
450	Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
460	Glass and Related Products	0.00	0.24	0.12	0.00	0.09	0.00	0.00	0.00	0.00
470	Electronics	0.00	0.70	0.34	0.00	0.25	0.00	0.00	0.00	0.00
499	Other (Industrial Processes)	0.43	181.82	147.04	6.25	45.59	0.39	1.15	1.34	0.00
	Total	**0.48**	**3895.63**	**305.93**	**6.25**	**1139.80**	**5.40**	**2.68**	**16.37**	**0.00**
	Solvent Evaporation									
510	Consumer Products	0.28	749.45	4797.62	354.17	0.00	0.00	0.00	0.00	0.00
520	Architectural Coatings and Related Solvent	0.00	0.82	93.43	0.00	0.00	0.00	0.00	0.00	0.00
530	Pesticides/Fertilizers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
540	Asphalt Paving/Roofing	0.00	0.00	12.67	0.00	0.00	0.00	0.07	0.00	0.00
	Total	**0.28**	**750.27**	**4903.72**	**354.17**	**0.00**	**0.00**	**0.07**	**0.00**	**0.00**
	Miscellaneous Processes									
610	Residential Fuel Combustion	0.00	0.00	513.90	0.00	0.00	0.13	0.05	1.40	0.00
620	Farming Operations	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.49	0.00
630	Construction and Demolition	0.00	0.00	0.00	0.00	0.00	1.57	1.95	20.75	0.00

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Propylene oxide	Styrene	Toluene	Trichloro-ethylene	Vinyl chloride	Arsenic	Cadmium	Chromium	Diesel PM (DPM)
640	Paved Road Dust	0.00	0.00	0.00	0.00	0.00	3.06	0.71	4.01	0.00
645	Unpaved Road Dust	0.00	0.00	0.00	0.00	0.00	0.30	0.26	0.34	0.00
650	Fugitive Windblown Dust	0.00	0.00	0.00	0.00	0.00	0.10	0.14	1.42	0.00
660	Fires	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00
670	Waste Burning and Disposal	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.01	0.00
690	Cooking	0.00	0.00	11.68	0.00	0.00	0.04	0.08	0.32	0.00
699	Other (Miscellaneous Processes	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**525.58**	**0.00**	**0.00**	**5.27**	**3.27**	**28.74**	**0.00**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	0.00	89.91	3979.15	0.00	0.00	0.19	0.05	22.38	70.41
722	Light Duty Trucks 1 (T1)	0.00	15.96	851.37	0.00	0.00	0.02	0.01	1.86	8.03
723	Light Duty Trucks 2 (T2)	0.00	47.91	2232.49	0.00	0.00	0.07	0.02	8.13	2.98
724	Medium Duty Trucks (T3)	0.00	41.71	1838.28	0.00	0.00	0.05	0.01	5.21	13.12
732	Light Heavy Duty Gas Trucks 1 (T4)	0.00	3.17	301.94	0.00	0.00	0.01	0.00	0.72	0.00
733	Light Heavy Duty Gas Trucks 2 (T5)	0.00	0.63	62.39	0.00	0.00	0.00	0.00	0.18	0.00
734	Medium Heavy Duty Gas Trucks (T6)	0.00	1.31	60.22	0.00	0.00	0.00	0.00	0.28	0.00
736	Heavy Heavy Duty Gas Trucks ((HHD)	0.00	0.68	24.33	0.00	0.00	0.00	0.00	0.01	0.00
742	Light Heavy Duty Diesel Trucks 1 (T4)	0.00	0.41	10.49	0.00	0.00	0.01	0.01	0.58	139.31
743	Light Heavy Duty Diesel Trucks 2 (T5)	0.00	0.17	4.20	0.00	0.00	0.00	0.00	0.30	58.71
744	Medium Heavy Duty Diesel Truck (T6)	0.00	1.90	48.19	0.00	0.00	0.02	0.00	3.05	1733.33
746	Heavy Heavy Duty Diesel Trucks (HHD)	0.00	4.64	117.96	0.00	0.00	0.01	0.00	2.69	1994.15
750	Motorcycles (MCY)	0.00	26.47	1246.73	0.00	0.00	0.00	0.00	0.06	0.00
760	Diesel Urban Buses (UB)	0.00	5.94	150.85	0.00	0.00	0.00	0.00	0.11	6.70
762	Gas Urban Buses (UB)	0.00	0.07	2.77	0.00	0.00	0.00	0.00	0.08	0.00
771	Gas School Buses (SB)	0.00	0.20	5.39	0.00	0.00	0.00	0.00	0.15	0.00
772	Diesel School Buses (SB)	0.00	0.04	1.11	0.00	0.00	0.00	0.00	0.40	26.29
777	Gas Other Buses (OB)	0.00	0.47	20.14	0.00	0.00	0.00	0.00	0.13	0.00

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	Propylene oxide	Styrene	Toluene	Trichloro-ethylene	Vinyl chloride	Arsenic	Cadmium	Chromium	Diesel PM (DPM)
778	Motor Coaches	0.00	0.08	1.99	0.00	0.00	0.00	0.00	0.07	45.51
779	Diesel Other Buses (OB)	0.00	0.11	2.76	0.00	0.00	0.00	0.00	0.13	89.12
780	Motor Homes (MH)	0.00	0.25	7.76	0.00	0.00	0.00	0.00	0.14	22.95
	Total	**0.00**	**242.04**	**10970.51**	**0.00**	**0.00**	**0.39**	**0.11**	**46.67**	**4210.61**
	Other Mobile Sources									
810	Aircraft	0.00	22.15	66.36	0.00	0.00	0.00	0.00	0.39	0.00
820	Trains	0.00	1.18	29.95	0.00	0.00	0.00	0.04	0.01	645.73
833	Ocean Going Vessels	0.00	1.00	29.23	0.00	0.00	1.83	0.17	1.83	393.65
835	Commercial Habor Crafts	0.00	0.55	13.89	0.00	0.00	0.00	0.01	0.01	234.97
840	Recreational Boats	0.00	58.32	3216.03	0.00	0.00	0.00	0.00	1.22	6.87
850	Off-Road Recreational Vehicles	0.00	1.48	133.26	0.00	0.00	0.00	0.00	0.01	0.00
860	Off-Road Equipment	0.00	80.14	4415.34	0.00	0.00	0.01	0.11	1.55	3678.18
870	Farm Equipment	0.00	0.68	26.58	0.00	0.00	0.00	0.01	0.02	253.56
890	Fuel Storage and Handling	0.00	0.00	147.64	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**165.50**	**8078.28**	**0.00**	**0.00**	**1.84**	**0.34**	**5.04**	**5212.97**
Total	**Stationary**	**0.79**	4655.44	22910.02	**1154.83**	1282.09	11.79	12.04	46.23	285.61
Total	**On-Road Vehicles**	**0.00**	242.04	10970.51	**0.00**	0.00	0.39	0.11	46.67	4210.61
Total	**Other Mobile**	**0.00**	165.50	8078.28	**0.00**	0.00	1.84	0.34	5.04	5212.97
Total	**Anthropogenic**	**0.79**	**5062.98**	**41958.82**	**1154.83**	**1282.09**	**14.03**	**12.49**	**97.93**	**9709.19**

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	DPM2.5	Elemental carbon (EC)	EC2.5	Hexavalent chromium	Lead	Nickel	Organic carbon	Selenium	Silicon
	Fuel Combustion									
10	Electric Utilities	12.22	43.59	42.95	0.00	0.12	0.76	630.19	0.00	20.76
20	Cogeneration	0.00	0.20	0.20	0.00	0.00	0.00	5.41	0.00	0.14
30	Oil and Gas Production (combustion)	11.89	15.53	14.98	0.00	0.03	0.55	107.33	0.00	3.76
40	Petroleum Refining (Combustion)	0.00	203.25	200.84	0.00	0.43	3.08	2007.72	0.00	103.38
50	Manufacturing and Industrial	29.82	153.90	119.09	0.00	0.32	4.52	1310.01	0.00	98.34
52	Food and Agricultural Processing	3.24	8.81	8.65	0.00	0.02	0.20	36.33	0.00	2.89
60	Service and Commercial	135.99	201.15	195.77	0.00	0.31	2.44	1361.29	0.00	51.94
99	Other (Fuel Combustion)	78.52	59.90	56.90	0.00	0.01	0.15	87.03	0.00	12.30
	Total	**271.67**	**686.34**	**639.37**	**0.00**	**1.25**	**11.70**	**5545.29**	**0.00**	**293.50**
	Waste Disposal									
110	Sewage Treatment	0.00	0.01	0.01	0.00	1.33	0.00	0.19	0.00	0.01
120	Landfills	0.00	9.17	9.07	0.00	0.04	0.12	248.84	0.00	8.11
130	Incineration	0.00	21.81	21.80	0.00	0.00	8.76	9.80	0.00	9.02
140	Soil Remediation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	0.00	0.12	0.12	0.00	0.00	0.00	3.25	0.00	0.09
	Total	**0.00**	**31.11**	**31.00**	**0.00**	**1.37**	**8.89**	**262.09**	**0.00**	**17.22**
	Cleaning and Surface Coatings									
210	Laundering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220	Degreasing	0.00	0.42	0.38	0.00	0.00	0.00	9.30	0.00	3.14
230	Coatings and Related Processes	0.00	34.22	31.65	0.00	0.00	0.00	748.66	0.00	253.01
240	Printing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	Adhesives and Sealants	0.00	0.42	0.39	0.00	0.00	0.00	9.41	0.00	3.18
299	Other (Cleaning and Surface Coatings)	0.00	1.61	1.58	0.00	0.00	0.00	9.52	0.00	3.22
	Total	**0.00**	**36.67**	**34.00**	**0.00**	**0.00**	**0.00**	**776.89**	**0.00**	**262.55**
	Petroleum Production and Marketing									

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	DPM2.5	Elemental carbon (EC)	EC2.5	Hexavalent chromium	Lead	Nickel	Organic carbon	Selenium	Silicon
310	Oil and Gas Production	0.00	1.96	2.12	0.00	0.04	0.04	0.42	0.00	8.29
320	Petroleum Refining	0.00	38.12	40.65	0.00	0.71	0.70	0.00	0.00	138.50
330	Petroleum Marketing	0.00	0.04	0.04	0.00	0.00	0.00	0.86	0.00	0.29
399	Other (Petroleum Production and Marketing)	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01
	Total	**0.00**	**40.12**	**42.81**	**0.00**	**0.75**	**0.75**	**1.32**	**0.00**	**147.10**
	Industrial Processes									
410	Chemical	0.00	2.53	1.72	0.00	0.08	0.52	9.15	0.00	1.12
420	Food and Agriculture	0.00	71.99	1.65	0.00	0.01	0.04	38.75	0.00	36.68
430	Mineral Processes	0.00	98.90	79.55	0.01	0.17	8.23	0.94	0.55	5570.51
440	Metal Processes	0.00	75.86	50.49	0.07	11.38	2.89	8.05	0.06	7.95
450	Wood and Paper	0.00	5.70	1.71	0.00	0.01	0.01	5.40	0.00	0.04
460	Glass and Related Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
470	Electronics	0.00	0.04	0.01	0.00	0.00	0.00	0.23	0.00	0.15
499	Other (Industrial Processes)	0.00	47.79	22.81	0.01	0.28	1.50	231.43	0.01	354.92
	Total	**0.00**	**302.82**	**157.96**	**0.09**	**11.92**	**13.19**	**293.95**	**0.63**	**5971.37**
	Solvent Evaporation									
510	Consumer Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
520	Architectural Coatings and Related Solvent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
530	Pesticides/Fertilizers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
540	Asphalt Paving/Roofing	0.00	0.50	0.47	0.00	0.00	0.00	11.28	0.00	3.81
	Total	**0.00**	**0.50**	**0.47**	**0.00**	**0.00**	**0.00**	**11.28**	**0.00**	**3.81**
	Miscellaneous Processes									
610	Residential Fuel Combustion	0.00	2597.96	1899.94	0.00	0.22	2.35	7964.40	1.61	7.46
620	Farming Operations	0.00	16.22	3.33	0.00	0.14	0.12	271.23	0.01	420.35
630	Construction and Demolition	0.00	428.37	28.04	0.00	51.60	5.47	4072.01	0.19	17621.34

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	DPM2.5	Elemental carbon (EC)	EC2.5	Hexavalent chromium	Lead	Nickel	Organic carbon	Selenium	Silicon
640	Paved Road Dust	0.00	1819.60	125.55	0.00	29.23	2.83	14084.77	0.47	71593.95
645	Unpaved Road Dust	0.00	22.98	1.36	0.00	2.57	0.73	665.01	0.06	6413.14
650	Fugitive Windblown Dust	0.00	19.88	1.16	0.00	2.42	0.35	180.75	0.01	1230.21
660	Fires	0.00	219.29	193.06	0.00	0.05	0.00	215.66	0.00	37.27
670	Waste Burning and Disposal	0.00	275.22	239.23	0.00	0.05	0.00	688.09	0.01	5.54
690	Cooking	0.00	1189.21	1189.19	0.00	3.19	0.73	15145.60	0.01	61.06
699	Other (Miscellaneous Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.14
	Total	**0.00**	**6588.73**	**3680.85**	**0.00**	**89.49**	**12.59**	**43287.52**	**2.35**	**97392.45**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	66.96	1625.92	660.59	0.24	2.02	12.33	4269.45	0.45	1273.36
722	Light Duty Trucks 1 (T1)	7.64	151.82	69.70	0.02	0.20	1.02	380.04	0.04	106.26
723	Light Duty Trucks 2 (T2)	2.83	591.81	240.28	0.09	0.75	4.48	1547.04	0.16	463.00
724	Medium Duty Trucks (T3)	12.48	385.36	159.86	0.06	0.49	2.88	1006.79	0.10	296.67
732	Light Heavy Duty Gas Trucks 1 (T4)	0.00	32.29	12.70	0.01	0.05	0.40	97.73	0.01	40.69
733	Light Heavy Duty Gas Trucks 2 (T5)	0.00	7.59	2.96	0.00	0.01	0.10	23.66	0.00	10.43
734	Medium Heavy Duty Gas Trucks (T6)	0.00	11.30	4.24	0.00	0.02	0.15	35.70	0.01	15.81
736	Heavy Heavy Duty Gas Trucks ((HHD)	0.00	1.24	0.45	0.00	0.00	0.01	3.24	0.00	0.79
742	Light Heavy Duty Diesel Trucks 1 (T4)	132.48	64.71	44.38	0.01	0.04	0.32	182.23	0.01	33.20
743	Light Heavy Duty Diesel Trucks 2 (T5)	55.83	28.66	19.24	0.00	0.02	0.16	81.97	0.01	16.92
744	Medium Heavy Duty Diesel Truck (T6)	1648.40	449.58	380.05	0.03	0.11	1.15	626.36	0.04	116.71
746	Heavy Heavy Duty Diesel Trucks (HHD)	1896.44	576.86	410.54	0.02	0.22	0.95	991.56	0.04	93.15
750	Motorcycles (MCY)	0.00	7.25	3.52	0.00	0.02	0.04	19.18	0.00	3.60
760	Diesel Urban Buses (UB)	6.37	13.26	4.96	0.00	0.01	0.06	33.79	0.00	6.01
762	Gas Urban Buses (UB)	0.00	3.13	1.12	0.00	0.00	0.04	10.10	0.00	4.56
771	Gas School Buses (SB)	0.00	3.66	1.51	0.00	0.01	0.08	14.28	0.00	8.61
772	Diesel School Buses (SB)	25.00	11.77	5.84	0.00	0.02	0.22	47.80	0.01	22.32
777	Gas Other Buses (OB)	0.00	5.13	1.88	0.00	0.01	0.07	16.34	0.00	7.30

Table VIII-1. 2018 Air Toxics Emissions (lbs/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	DPM2.5	Elemental carbon (EC)	EC2.5	Hexavalent chromium	Lead	Nickel	Organic carbon	Selenium	Silicon
778	Motor Coaches	43.28	7.12	5.62	0.00	0.00	0.03	19.88	0.00	2.80
779	Diesel Other Buses (OB)	84.76	13.71	10.99	0.00	0.01	0.05	37.91	0.00	5.02
780	Motor Homes (MH)	21.82	11.76	7.95	0.00	0.01	0.08	34.12	0.00	8.04
	Total	**4004.29**	**4003.92**	**2048.38**	**0.49**	**4.01**	**24.63**	**9479.17**	**0.89**	**2535.25**
	Other Mobile Sources									
810	Aircraft	0.00	245.38	219.22	0.02	0.46	0.77	603.41	0.00	9.62
820	Trains	591.18	166.04	156.29	0.00	0.02	0.01	443.69	0.00	1.85
833	Ocean Going Vessels	362.16	72.29	66.50	0.09	1.90	0.17	205.49	0.17	0.00
835	Commercial Habor Crafts	216.10	145.60	133.91	0.00	0.00	0.00	54.78	0.00	0.52
840	Recreational Boats	4.65	437.56	297.52	0.06	3.27	3.26	1678.59	0.00	44.36
850	Off-Road Recreational Vehicles	0.00	3.56	2.43	0.00	0.03	0.03	13.79	0.00	0.36
860	Off-Road Equipment	3383.30	2788.56	2444.54	0.08	3.86	3.90	2960.01	0.03	63.70
870	Farm Equipment	233.32	160.10	146.62	0.00	0.03	0.02	70.65	0.00	0.86
890	Fuel Storage and Handling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**4790.72**	**4019.10**	**3467.04**	**0.26**	**9.56**	**8.16**	**6030.40**	**0.21**	**121.27**
Total	**Stationary**	271.67	7686.29	4586.45	0.09	104.78	47.11	50178.34	2.98	104088.00
Total	**On-Road Vehicles**	4004.29	4003.92	2048.38	0.49	4.01	24.63	9479.17	0.89	2535.25
Total	**Other Mobile**	4790.72	4019.10	3467.04	0.26	9.56	8.16	6030.40	0.21	121.27
Total	**Anthropogenic**	**9066.68**	**15709.30**	**10101.87**	**0.84**	**118.35**	**79.90**	**65687.91**	**4.09**	**106744.52**

Table VIII-2. 2018 Criteria Emissions (tons/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	TOG	VOC	CO	NOx	SOx	TSP	PM10	PM2.5	NH3
	Fuel Combustion									
10	Electric Utilities	2.69	0.31	4.25	0.59	0.22	0.51	0.51	0.51	0.68
20	Cogeneration	0.05	0.02	0.12	0.02	0.00	0.02	0.02	0.01	0.18
30	Oil and Gas Production (combustion)	1.11	0.12	0.61	0.71	0.01	0.10	0.09	0.09	0.22
40	Petroleum Refining (Combustion)	6.48	1.33	4.87	0.00	0.01	1.78	1.77	1.77	1.50
50	Manufacturing and Industrial	25.94	4.19	15.30	10.01	0.21	1.25	1.16	1.12	2.26
52	Food and Agricultural Processing	0.07	0.03	0.34	0.11	0.00	0.03	0.03	0.03	0.04
60	Service and Commercial	10.64	4.16	13.58	9.25	0.79	1.16	1.16	1.16	2.70
99	Other (Fuel Combustion)	0.58	0.27	1.31	2.54	0.07	0.18	0.16	0.15	0.05
	Total	**47.56**	**10.43**	**40.38**	**23.23**	**1.33**	**5.03**	**4.92**	**4.85**	**7.62**
	Waste Disposal									
110	Sewage Treatment	0.37	0.27	0.00	0.00	0.00	0.02	0.00	0.00	0.23
120	Landfills	640.10	8.88	0.39	0.45	0.37	0.20	0.20	0.20	3.97
130	Incineration	0.19	0.04	0.25	0.98	0.07	0.12	0.06	0.05	0.22
140	Soil Remediation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	57.94	4.67	0.01	0.01	0.00	0.00	0.00	0.00	1.08
	Total	**698.60**	**13.86**	**0.65**	**1.44**	**0.44**	**0.34**	**0.26**	**0.25**	**5.51**
	Cleaning and Surface Coatings									
210	Laundering	3.41	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220	Degreasing	66.07	12.12	0.00	0.00	0.00	0.02	0.02	0.02	0.01
230	Coatings and Related Processes	19.08	18.57	0.00	0.00	0.00	1.67	1.60	1.54	0.09
240	Printing	1.17	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.06
250	Adhesives and Sealants	4.82	4.21	0.00	0.00	0.00	0.02	0.02	0.02	0.00
299	Other (Cleaning and Surface Coatings)	1.42	1.08	0.11	0.01	0.00	0.02	0.02	0.02	0.00
	Total	**95.98**	**37.29**	**0.12**	**0.01**	**0.00**	**1.74**	**1.67**	**1.60**	**0.16**
	Petroleum Production and Marketing									

Table VIII-2. 2018 Criteria Emissions (tons/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	TOG	VOC	CO	NOx	SOx	TSP	PM10	PM2.5	NH3
310	Oil and Gas Production	4.86	2.18	0.02	0.01	0.06	0.04	0.03	0.02	0.00
320	Petroleum Refining	6.35	4.43	2.39	0.23	0.24	1.87	1.25	0.88	0.07
330	Petroleum Marketing	54.79	13.80	0.23	0.00	0.00	0.01	0.00	0.00	0.00
399	Other (Petroleum Production and Marketing	0.60	0.58	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	Total	**66.60**	**20.99**	**2.65**	**0.25**	**0.30**	**1.92**	**1.28**	**0.91**	**0.07**
	Industrial Processes									
410	Chemical	5.20	3.88	0.12	0.03	0.05	0.59	0.49	0.44	0.01
420	Food and Agriculture	0.58	0.56	0.01	0.00	0.00	0.16	0.07	0.03	0.00
430	Mineral Processes	0.35	0.31	0.29	0.02	0.04	8.22	4.49	2.51	0.08
440	Metal Processes	0.11	0.09	0.25	0.04	0.03	0.38	0.30	0.22	0.00
450	Wood and Paper	0.19	0.19	0.00	0.00	0.00	6.43	4.50	2.70	0.00
460	Glass and Related Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
470	Electronics	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
499	Other (Industrial Processes)	7.01	5.30	0.13	0.05	0.00	1.81	1.12	0.80	9.29
	Total	**13.45**	**10.35**	**0.79**	**0.14**	**0.13**	**17.60**	**10.98**	**6.69**	**9.39**
	Solvent Evaporation									
510	Consumer Products	105.32	87.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
520	Architectural Coatings and Related Solvent	12.23	11.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
530	Pesticides/Fertilizers	1.34	1.34	0.00	0.00	0.00	0.00	0.00	0.00	1.20
540	Asphalt Paving/Roofing	1.06	0.98	0.00	0.00	0.00	0.03	0.02	0.02	0.00
	Total	**119.96**	**101.41**	**0.00**	**0.00**	**0.00**	**0.03**	**0.02**	**0.02**	**1.20**
	Miscellaneous Processes									
610	Residential Fuel Combustion	19.29	8.43	46.75	14.56	0.48	7.15	6.79	6.60	0.11
620	Farming Operations	25.38	1.43	0.00	0.00	0.00	1.60	0.78	0.16	8.52
630	Construction and Demolition	0.00	0.00	0.00	0.00	0.00	46.32	22.65	2.27	0.00
640	Paved Road Dust	0.00	0.00	0.00	0.00	0.00	117.88	53.87	8.13	0.00

Table VIII-2. 2018 Criteria Emissions (tons/day) by Major Source Category for the South Coast Air Basin

Code	Source Category	TOG	VOC	CO	NOx	SOx	TSP	PM10	PM2.5	NH3
645	Unpaved Road Dust	0.00	0.00	0.00	0.00	0.00	9.87	5.86	0.58	0.00
650	Fugitive Windblown Dust	0.00	0.00	0.00	0.00	0.00	3.20	1.62	0.23	0.00
660	Fires	0.34	0.23	3.02	0.08	0.00	0.45	0.44	0.41	0.00
670	Waste Burning and Disposal	0.81	0.47	6.31	0.19	0.05	0.72	0.70	0.63	0.03
690	Cooking	2.76	1.93	0.00	0.00	0.01	11.46	11.46	11.46	0.00
699	Other (Miscellaneous Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.98
	RECLAIM				17.77	5.48				
	Total	**48.57**	**12.48**	**56.08**	**32.59**	**6.01**	**198.65**	**104.17**	**30.48**	**34.65**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	32.11	28.96	311.82	23.59	0.73	11.62	11.38	4.79	6.16
722	Light Duty Trucks 1 (T1)	7.06	6.41	51.60	5.01	0.07	0.99	0.96	0.42	0.63
723	Light Duty Trucks 2 (T2)	17.98	16.24	160.67	17.21	0.35	4.22	4.13	1.74	3.29
724	Medium Duty Trucks (T3)	14.64	13.17	128.33	14.30	0.27	2.72	2.66	1.13	3.19
732	Light Heavy Duty Gas Trucks 1 (T4)	2.39	2.25	8.59	2.06	0.03	0.33	0.33	0.14	0.25
733	Light Heavy Duty Gas Trucks 2 (T5)	0.49	0.47	1.60	0.46	0.01	0.08	0.08	0.03	0.05
734	Medium Heavy Duty Gas Trucks (T6)	0.49	0.43	4.89	0.84	0.02	0.13	0.12	0.05	0.04
736	Heavy Heavy Duty Gas Trucks ((HHD)	0.22	0.18	5.07	0.70	0.00	0.01	0.01	0.00	0.00
742	Light Heavy Duty Diesel Trucks 1 (T4)	0.36	0.31	1.88	9.34	0.01	0.35	0.34	0.18	0.01
743	Light Heavy Duty Diesel Trucks 2 (T5)	0.14	0.13	0.73	3.51	0.01	0.17	0.17	0.08	0.00
744	Medium Heavy Duty Diesel Truck (T6)	1.64	1.44	5.02	27.69	0.06	1.80	1.78	1.20	0.17
746	Heavy Heavy Duty Diesel Trucks (HHD)	4.00	2.70	14.55	66.49	0.17	2.06	2.04	1.33	0.29
750	Motorcycles (MCY)	10.35	9.09	46.65	2.46	0.00	0.04	0.04	0.02	0.02
760	Diesel Urban Buses (UB)	5.12	0.25	24.41	2.02	0.00	0.07	0.07	0.03	0.00
762	Gas Urban Buses (UB)	0.02	0.02	0.19	0.09	0.01	0.04	0.04	0.01	0.01
771	Gas School Buses (SB)	0.05	0.04	0.42	0.05	0.00	0.06	0.06	0.03	0.00
772	Diesel School Buses (SB)	0.04	0.03	0.12	2.21	0.00	0.18	0.18	0.08	0.01
777	Gas Other Buses (OB)	0.16	0.14	1.67	0.34	0.01	0.06	0.06	0.02	0.02
778	Motor Coaches	0.07	0.06	0.25	1.11	0.00	0.05	0.04	0.03	0.00

Table VIII-2. 2018 Criteria Emissions (tons/day) by Major Source Category for the South Coast Air Basin

Code	**Source Category**	**TOG**	**VOC**	**CO**	**NOx**	**SOx**	**TSP**	**PM10**	**PM2.5**	**NH3**
779	Diesel Other Buses (OB)	0.09	0.08	0.26	1.39	0.00	0.08	0.08	0.06	0.01
780	Motor Homes (MH)	0.08	0.07	1.22	0.62	0.01	0.08	0.07	0.04	0.02
	Total	**97.51**	**82.45**	**769.96**	**181.50**	**1.75**	**25.13**	**24.65**	**11.43**	**14.17**
	Other Mobile Sources									
810	Aircraft	3.68	3.63	37.66	15.51	1.77	0.75	0.73	0.66	0.00
820	Trains	1.02	0.85	3.98	17.66	0.01	0.32	0.32	0.30	0.01
833	Ocean Going Vessels	2.61	2.18	3.45	33.35	2.21	0.69	0.69	0.64	0.03
835	Commercial Habor Crafts	1.27	1.07	6.47	11.45	0.00	0.48	0.48	0.44	0.00
840	Recreational Boats	26.02	22.45	86.44	4.88	0.01	1.54	1.39	1.05	0.01
850	Off-Road Recreational Vehicles	2.63	2.54	3.68	0.07	0.00	0.01	0.01	0.01	0.00
860	Off-Road Equipment	47.83	42.09	544.65	49.95	0.09	3.75	3.57	3.03	0.11
870	Farm Equipment	0.56	0.48	4.92	2.07	0.00	0.14	0.14	0.12	0.00
890	Fuel Storage and Handling	5.48	5.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**91.09**	**80.75**	**691.25**	**134.94**	**4.09**	**7.69**	**7.33**	**6.25**	**0.15**
Total	**Stationary**	**1090.72**	**206.81**	**100.67**	**57.67**	**8.21**	**225.30**	**123.29**	**44.81**	**58.61**
Total	**On-Road Vehicles**	**97.51**	**82.45**	**769.96**	**181.50**	**1.75**	**25.13**	**24.65**	**11.43**	**14.17**
Total	**Other Mobile**	**91.09**	**80.75**	**691.25**	**134.94**	**4.09**	**7.69**	**7.33**	**6.25**	**0.15**
Total	**Anthropogenic**	**1279.32**	**370.02**	**1561.87**	**374.11**	**14.06**	**258.12**	**155.27**	**62.49**	**72.93**

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Acetaldehyde	Acetone	Benzene	1,3 Butadiene	Carbon tetrachloride	Chloroform	1,1 Dichloroethane	1,4 dioxane	Ethylene dibromide
	Fuel Combustion									
10	Electric Utilities	0.04	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00
20	Cogeneration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	Oil and Gas Production (combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	Petroleum Refining (Combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	Manufacturing and Industrial	1.06	1.06	0.72	0.03	0.00	0.00	0.00	0.00	0.00
52	Food and Agricultural Processing	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
60	Service and Commercial	0.19	0.19	22.71	0.00	0.00	0.00	0.00	0.00	0.00
99	Other (Fuel Combustion)	2.55	2.08	0.68	0.02	0.00	0.00	0.00	0.00	0.00
	Total	**3.85**	**3.34**	**24.31**	**0.05**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Waste Disposal									
110	Sewage Treatment	0.05	0.06	0.15	0.00	0.02	2.62	0.00	0.01	0.01
120	Landfills	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
130	Incineration	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
140	Soil Remediation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	0.00	359.57	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	Total	**0.05**	**359.63**	**0.25**	**0.00**	**0.02**	**2.63**	**0.00**	**0.01**	**0.01**
	Cleaning and Surface Coatings									
210	Laundering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220	Degreasing	0.00	76.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
230	Coatings and Related Processes	0.00	77.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
240	Printing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	Adhesives and Sealants	0.00	66.59	0.10	0.00	0.00	0.00	0.00	0.00	0.00
299	Other (Cleaning and Surface Coatings)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**221.24**	**0.10**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Petroleum Production and Marketing									
310	Oil and Gas Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
320	Petroleum Refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Acetalde-hyde	Acetone	Benzene	1,3 Butadiene	Carbon tetrachloride	Chloroform	1,1 Dichloro-ethane	1,4 dioxane	Ethylene dibromide
330	Petroleum Marketing	0.00	0.00	2.84	0.03	0.00	0.00	0.00	0.00	0.00
399	Other (Petroleum Production and Marketing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**2.84**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Industrial Processes									
410	Chemical	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
420	Food and Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
430	Mineral Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
440	Metal Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
450	Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
460	Glass and Related Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
470	Electronics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
499	Other (Industrial Processes)	0.13	0.19	0.74	0.06	0.02	0.00	0.00	0.00	0.00
	Total	**0.13**	**0.19**	**0.74**	**0.06**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**
	Solvent Evaporation									
510	Consumer Products	0.00	413.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00
520	Architectural Coatings and Related Solvent	0.13	34.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
530	Pesticides/Fertilizers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
540	Asphalt Paving/Roofing	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.13**	**448.35**	**0.20**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Miscellaneous Processes									
610	Residential Fuel Combustion	68.95	50.88	4.77	0.00	0.00	0.00	0.00	0.00	0.00
620	Farming Operations	0.00	27.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
630	Construction and Demolition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
640	Paved Road Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
645	Unpaved Road Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
650	Fugitive Windblown Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
660	Fires	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00
670	Waste Burning and Disposal	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Acetalde-hyde	Acetone	Benzene	1,3 Butadiene	Carbon tetrachloride	Chloroform	1,1 Dichloro-ethane	1,4 dioxane	Ethylene dibromide
690	Cooking	6.21	0.00	0.35	0.44	0.00	0.00	0.00	0.00	0.00
699	Other (Miscellaneous Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**75.16**	**78.18**	**5.12**	**0.84**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	9.25	5.16	47.09	5.36	0.00	0.00	0.00	0.00	0.00
722	Light Duty Trucks 1 (T1)	1.94	1.29	11.19	0.98	0.00	0.00	0.00	0.00	0.00
723	Light Duty Trucks 2 (T2)	5.36	3.22	28.00	2.96	0.00	0.00	0.00	0.00	0.00
724	Medium Duty Trucks (T3)	4.89	2.88	24.11	2.79	0.00	0.00	0.00	0.00	0.00
732	Light Heavy Duty Gas Trucks 1 (T4)	0.40	0.26	3.36	0.22	0.00	0.00	0.00	0.00	0.00
733	Light Heavy Duty Gas Trucks 2 (T5)	0.09	0.06	0.77	0.05	0.00	0.00	0.00	0.00	0.00
734	Medium Heavy Duty Gas Trucks (T6)	0.32	0.24	1.61	0.14	0.00	0.00	0.00	0.00	0.00
736	Heavy Heavy Duty Gas Trucks ((HHD)	0.35	0.29	1.60	0.15	0.00	0.00	0.00	0.00	0.00
742	Light Heavy Duty Diesel Trucks 1 (T4)	2.22	2.27	0.60	0.06	0.00	0.00	0.00	0.00	0.00
743	Light Heavy Duty Diesel Trucks 2 (T5)	0.94	0.96	0.26	0.02	0.00	0.00	0.00	0.00	0.00
744	Medium Heavy Duty Diesel Truck (T6)	9.48	9.68	2.58	0.24	0.00	0.00	0.00	0.00	0.00
746	Heavy Heavy Duty Diesel Trucks (HHD)	51.62	52.70	14.05	1.33	0.00	0.00	0.00	0.00	0.00
750	Motorcycles (MCY)	5.40	3.53	23.73	3.60	0.00	0.00	0.00	0.00	0.00
760	Diesel Urban Buses (UB)	15.94	16.28	4.34	0.41	0.00	0.00	0.00	0.00	0.00
762	Gas Urban Buses (UB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
771	Gas School Buses (SB)	0.01	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00
772	Diesel School Buses (SB)	0.13	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00
777	Gas Other Buses (OB)	0.04	0.03	0.17	0.02	0.00	0.00	0.00	0.00	0.00
778	Motor Coaches	0.16	0.17	0.04	0.00	0.00	0.00	0.00	0.00	0.00
779	Diesel Other Buses (OB)	0.23	0.24	0.06	0.01	0.00	0.00	0.00	0.00	0.00
780	Motor Homes (MH)	0.07	0.07	0.12	0.01	0.00	0.00	0.00	0.00	0.00
	Total	**108.85**	**99.44**	**163.78**	**18.36**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Other Mobile Sources									
810	Aircraft	6.03	0.57	3.16	2.49	0.00	0.00	0.00	0.00	0.00
820	Trains	16.70	17.05	4.55	0.43	0.00	0.00	0.00	0.00	0.00

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Acetalde-hyde	Acetone	Benzene	1,3 Butadiene	Carbon tetrachloride	Chloroform	1,1 Dichloro-ethane	1,4 dioxane	Ethylene dibromide
833	Ocean Going Vessels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
835	Commercial Habor Crafts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
840	Recreational Boats	7.93	3.83	28.83	6.76	0.00	0.00	0.00	0.00	0.00
850	Off-Road Recreational Vehicles	1.34	0.65	6.54	1.14	0.00	0.00	0.00	0.00	0.00
860	Off-Road Equipment	50.00	41.26	76.61	16.33	0.00	0.00	0.00	0.00	0.00
870	Farm Equipment	7.99	8.06	2.91	0.37	0.00	0.00	0.00	0.00	0.00
890	Fuel Storage and Handling	0.00	0.00	1.81	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**89.99**	**71.41**	**124.41**	**27.52**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total	**Stationary**	**79.32**	**1110.93**	**33.57**	**0.99**	**0.04**	**2.63**	**0.00**	**0.01**	**0.01**
Total	**On-Road Vehicles**	**108.85**	**99.44**	**163.78**	**18.36**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total	**Other Mobile**	**89.99**	**71.41**	**124.41**	**27.52**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total	**Anthropogenic**	**278.16**	**1281.79**	**321.77**	**46.87**	**0.04**	**2.63**	**0.00**	**0.01**	**0.01**

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Ethylene dichloride	Ethylene oxide	Formalde-hyde	Methyl ethyl ketone	Methylene chloride	MTBE	Naphthalene	p-Dichloro-benzene	Perchloro-ethylene
	Fuel Combustion									
10	Electric Utilities	0.00	0.00	1.11	0.00	0.00	0.00	0.00	0.00	0.00
20	Cogeneration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	Oil and Gas Production (combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	Petroleum Refining (Combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	Manufacturing and Industrial	0.00	0.00	34.91	0.21	0.00	0.00	0.01	0.00	0.00
52	Food and Agricultural Processing	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
60	Service and Commercial	0.00	0.00	45.20	0.04	0.00	0.00	0.00	0.00	0.00
99	Other (Fuel Combustion)	0.00	0.00	3.56	0.14	0.00	0.00	0.01	0.00	0.00
	Total	**0.00**	**0.00**	**84.88**	**0.39**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**
	Waste Disposal									
110	Sewage Treatment	0.01	0.00	0.28	0.00	4.02	0.00	0.00	0.40	3.28
120	Landfills	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
130	Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
140	Soil Remediation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01
	Total	**0.01**	**0.00**	**0.28**	**0.00**	**4.04**	**0.00**	**0.00**	**0.40**	**3.29**
	Cleaning and Surface Coatings									
210	Laundering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.27
220	Degreasing	0.00	0.00	0.00	32.59	171.41	0.00	0.00	0.00	4.48
230	Coatings and Related Processes	0.00	0.00	0.00	228.32	0.00	0.00	0.00	0.00	10.10
240	Printing	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
250	Adhesives and Sealants	0.00	0.00	0.00	55.99	1.91	0.00	0.00	0.00	0.00
299	Other (Cleaning and Surface Coatings)	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.05
	Total	**0.00**	**0.00**	**0.00**	**316.90**	**173.36**	**0.00**	**0.10**	**0.00**	**47.90**
	Petroleum Production and Marketing									
310	Oil and Gas Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
320	Petroleum Refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Ethylene dichloride	Ethylene oxide	Formaldehyde	Methyl ethyl ketone	Methylene chloride	MTBE	Naphthalene	p-Dichlorobenzene	Perchloroethylene
330	Petroleum Marketing	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00
399	Other (Petroleum Production and Marketing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.19**	**0.00**	**0.00**
	Industrial Processes									
410	Chemical	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
420	Food and Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
430	Mineral Processes	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00
440	Metal Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
450	Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
460	Glass and Related Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
470	Electronics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
499	Other (Industrial Processes)	0.18	0.01	0.19	0.13	0.51	0.00	0.01	0.23	1.72
	Total	**0.18**	**0.01**	**0.19**	**0.13**	**0.51**	**0.00**	**1.40**	**0.23**	**1.72**
	Solvent Evaporation									
510	Consumer Products	0.00	0.00	0.16	28.94	128.54	0.00	0.20	66.92	17.88
520	Architectural Coatings and Related Solvent	0.00	0.00	0.00	0.77	1.48	0.00	0.09	0.00	0.50
530	Pesticides/Fertilizers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
540	Asphalt Paving/Roofing	0.00	0.00	0.00	0.00	0.00	0.00	5.58	0.00	0.00
	Total	**0.00**	**0.00**	**0.16**	**29.71**	**130.02**	**0.00**	**5.87**	**66.92**	**18.38**
	Miscellaneous Processes									
610	Residential Fuel Combustion	0.00	0.00	83.81	0.00	0.00	0.00	0.00	0.00	0.00
620	Farming Operations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
630	Construction and Demolition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
640	Paved Road Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
645	Unpaved Road Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
650	Fugitive Windblown Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
660	Fires	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
670	Waste Burning and Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Ethylene dichloride	Ethylene oxide	Formalde-hyde	Methyl ethyl ketone	Methylene chloride	MTBE	Naphthalene	p-Dichloro-benzene	Perchloro-ethylene
690	Cooking	0.00	0.00	6.77	0.00	0.00	0.00	0.06	0.00	0.00
699	Other (Miscellaneous Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**90.58**	**0.00**	**0.00**	**0.00**	**0.06**	**0.00**	**0.00**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	0.00	0.00	17.54	1.08	0.00	1.84	1.63	0.00	0.00
722	Light Duty Trucks 1 (T1)	0.00	0.00	4.02	0.25	0.00	0.55	0.47	0.00	0.00
723	Light Duty Trucks 2 (T2)	0.00	0.00	10.65	0.65	0.00	1.31	1.13	0.00	0.00
724	Medium Duty Trucks (T3)	0.00	0.00	9.82	0.58	0.00	1.09	0.97	0.00	0.00
732	Light Heavy Duty Gas Trucks 1 (T4)	0.00	0.00	0.84	0.05	0.00	0.11	0.09	0.00	0.00
733	Light Heavy Duty Gas Trucks 2 (T5)	0.00	0.00	0.18	0.01	0.00	0.02	0.02	0.00	0.00
734	Medium Heavy Duty Gas Trucks (T6)	0.00	0.00	0.70	0.05	0.00	0.12	0.10	0.00	0.00
736	Heavy Heavy Duty Gas Trucks ((HHD)	0.00	0.00	0.89	0.05	0.00	0.13	0.12	0.00	0.00
742	Light Heavy Duty Diesel Trucks 1 (T4)	0.00	0.00	4.44	0.45	0.00	0.00	0.03	0.00	0.00
743	Light Heavy Duty Diesel Trucks 2 (T5)	0.00	0.00	1.88	0.19	0.00	0.00	0.01	0.00	0.00
744	Medium Heavy Duty Diesel Truck (T6)	0.00	0.00	18.97	1.90	0.00	0.00	0.11	0.00	0.00
746	Heavy Heavy Duty Diesel Trucks (HHD)	0.00	0.00	103.30	10.37	0.00	0.00	0.60	0.00	0.00
750	Motorcycles (MCY)	0.00	0.00	14.93	0.58	0.00	1.05	1.25	0.00	0.00
760	Diesel Urban Buses (UB)	0.00	0.00	31.91	3.20	0.00	0.00	0.18	0.00	0.00
762	Gas Urban Buses (UB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
771	Gas School Buses (SB)	0.00	0.00	0.03	0.00	0.00	0.01	0.01	0.00	0.00
772	Diesel School Buses (SB)	0.00	0.00	0.27	0.03	0.00	0.00	0.00	0.00	0.00
777	Gas Other Buses (OB)	0.00	0.00	0.08	0.01	0.00	0.01	0.01	0.00	0.00
778	Motor Coaches	0.00	0.00	0.33	0.03	0.00	0.00	0.00	0.00	0.00
779	Diesel Other Buses (OB)	0.00	0.00	0.46	0.05	0.00	0.00	0.00	0.00	0.00
780	Motor Homes (MH)	0.00	0.00	0.15	0.01	0.00	0.01	0.01	0.00	0.00
	Total	**0.00**	**0.00**	**221.39**	**19.53**	**0.00**	**6.25**	**6.74**	**0.00**	**0.00**
	Other Mobile Sources									
810	Aircraft	0.00	0.00	17.22	0.02	0.00	0.06	0.77	0.00	0.00
820	Trains	0.00	0.00	33.42	3.36	0.00	0.00	0.19	0.00	0.00

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Ethylene dichloride	Ethylene oxide	Formalde-hyde	Methyl ethyl ketone	Methylene chloride	MTBE	Naphthalene	p-Dichloro-benzene	Perchloro-ethylene
833	Ocean Going Vessels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
835	Commercial Habor Crafts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
840	Recreational Boats	0.00	0.00	24.40	0.50	0.00	0.00	1.08	0.00	0.00
850	Off-Road Recreational Vehicles	0.00	0.00	4.12	0.08	0.00	0.00	0.18	0.00	0.00
860	Off-Road Equipment	0.00	0.00	119.68	7.53	0.00	0.00	2.85	0.00	0.00
870	Farm Equipment	0.00	0.00	16.21	1.58	0.00	0.00	0.12	0.00	0.00
890	Fuel Storage and Handling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**215.06**	**13.06**	**0.00**	**0.06**	**5.20**	**0.00**	**0.00**
Total	**Stationary**	**0.19**	**0.01**	**176.09**	**347.14**	**307.92**	**0.00**	**7.66**	**67.55**	**71.29**
Total	**On-Road Vehicles**	**0.00**	**0.00**	**221.39**	**19.53**	**0.00**	**6.25**	**6.74**	**0.00**	**0.00**
Total	**Other Mobile**	**0.00**	**0.00**	**215.06**	**13.06**	**0.00**	**0.06**	**5.20**	**0.00**	**0.00**
Total	**Anthropogenic**	**0.19**	**0.01**	**612.54**	**379.72**	**307.92**	**6.30**	**19.60**	**67.55**	**71.29**

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Propylene oxide	Styrene	Toluene	Trichloro-ethylene	Vinyl chloride	Arsenic	Cadmium	Chromium	Diesel PM (DPM)
	Fuel Combustion									
10	Electric Utilities	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.04
20	Cogeneration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	Oil and Gas Production (combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	Petroleum Refining (Combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	Manufacturing and Industrial	0.00	0.01	0.42	0.00	0.00	0.00	0.00	0.00	0.25
52	Food and Agricultural Processing	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
60	Service and Commercial	0.00	0.00	10.84	0.00	0.00	0.00	0.00	0.00	2.05
99	Other (Fuel Combustion)	0.00	0.01	0.77	0.00	0.00	0.00	0.07	0.00	3.60
	Total	**0.00**	**0.02**	**12.11**	**0.00**	**0.00**	**0.00**	**0.07**	**0.00**	**5.94**
	Waste Disposal									
110	Sewage Treatment	0.00	0.01	1.86	0.40	0.02	0.00	0.00	0.00	0.00
120	Landfills	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
130	Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
140	Soil Remediation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.01**	**1.87**	**0.40**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**
	Cleaning and Surface Coatings									
210	Laundering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220	Degreasing	0.00	0.00	5.81	0.74	0.00	0.00	0.00	0.00	0.00
230	Coatings and Related Processes	0.00	0.00	508.30	0.00	0.00	0.00	0.20	0.00	0.00
240	Printing	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00
250	Adhesives and Sealants	0.00	0.00	17.15	0.00	0.00	0.00	0.00	0.00	0.00
299	Other (Cleaning and Surface Coatings)	0.00	0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**531.46**	**0.78**	**0.00**	**0.00**	**0.20**	**0.00**	**0.00**
	Petroleum Production and Marketing									
310	Oil and Gas Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
320	Petroleum Refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Propylene oxide	Styrene	Toluene	Trichloro-ethylene	Vinyl chloride	Arsenic	Cadmium	Chromium	Diesel PM (DPM)
330	Petroleum Marketing	0.00	0.00	10.77	0.00	0.00	0.00	0.00	0.00	0.00
399	Other (Petroleum Production and Marketing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**10.77**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Industrial Processes									
410	Chemical	0.00	98.16	0.00	0.00	26.52	0.00	0.01	0.00	0.00
420	Food and Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
430	Mineral Processes	0.00	0.00	1.49	0.00	0.00	0.36	0.00	0.60	0.00
440	Metal Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
450	Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
460	Glass and Related Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
470	Electronics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
499	Other (Industrial Processes)	0.00	5.43	0.19	0.20	0.11	0.00	0.00	0.00	0.00
	Total	**0.00**	**103.59**	**1.68**	**0.20**	**26.63**	**0.36**	**0.01**	**0.60**	**0.00**
	Solvent Evaporation									
510	Consumer Products	0.01	22.66	123.41	10.91	0.00	0.00	0.00	0.00	0.00
520	Architectural Coatings and Related Solvent	0.00	0.03	2.94	0.00	0.00	0.00	0.00	0.00	0.00
530	Pesticides/Fertilizers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
540	Asphalt Paving/Roofing	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.01**	**22.69**	**126.83**	**10.91**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Miscellaneous Processes									
610	Residential Fuel Combustion	0.00	0.00	24.14	0.00	0.00	0.01	0.00	0.04	0.00
620	Farming Operations	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.38	0.00
630	Construction and Demolition	0.00	0.00	0.00	0.00	0.00	0.76	0.94	10.05	0.00
640	Paved Road Dust	0.00	0.00	0.00	0.00	0.00	0.23	0.05	0.30	0.00
645	Unpaved Road Dust	0.00	0.00	0.00	0.00	0.00	0.09	0.08	0.10	0.00
650	Fugitive Windblown Dust	0.00	0.00	0.00	0.00	0.00	0.05	0.08	0.79	0.00
660	Fires	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
670	Waste Burning and Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Propylene oxide	Styrene	Toluene	Trichloro-ethylene	Vinyl chloride	Arsenic	Cadmium	Chromium	Diesel PM (DPM)
690	Cooking	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.01	0.00
699	Other (Miscellaneous Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**24.31**	**0.00**	**0.00**	**1.17**	**1.19**	**11.67**	**0.00**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	0.00	2.58	133.50	0.00	0.00	0.01	0.00	0.66	1.84
722	Light Duty Trucks 1 (T1)	0.00	0.52	30.26	0.00	0.00	0.00	0.00	0.06	0.25
723	Light Duty Trucks 2 (T2)	0.00	1.48	75.55	0.00	0.00	0.00	0.00	0.26	0.09
724	Medium Duty Trucks (T3)	0.00	1.32	64.15	0.00	0.00	0.00	0.00	0.19	0.37
732	Light Heavy Duty Gas Trucks 1 (T4)	0.00	0.11	11.11	0.00	0.00	0.00	0.00	0.03	0.00
733	Light Heavy Duty Gas Trucks 2 (T5)	0.00	0.03	2.57	0.00	0.00	0.00	0.00	0.01	0.00
734	Medium Heavy Duty Gas Trucks (T6)	0.00	0.08	3.57	0.00	0.00	0.00	0.00	0.02	0.00
736	Heavy Heavy Duty Gas Trucks ((HHD)	0.00	0.07	2.81	0.00	0.00	0.00	0.00	0.00	0.00
742	Light Heavy Duty Diesel Trucks 1 (T4)	0.00	0.02	0.44	0.00	0.00	0.00	0.00	0.02	6.10
743	Light Heavy Duty Diesel Trucks 2 (T5)	0.00	0.01	0.19	0.00	0.00	0.00	0.00	0.01	2.65
744	Medium Heavy Duty Diesel Truck (T6)	0.00	0.07	1.90	0.00	0.00	0.00	0.00	0.14	94.19
746	Heavy Heavy Duty Diesel Trucks (HHD)	0.00	0.41	10.34	0.00	0.00	0.00	0.00	0.40	302.02
750	Motorcycles (MCY)	0.00	1.04	48.54	0.00	0.00	0.00	0.00	0.00	0.00
760	Diesel Urban Buses (UB)	0.00	0.13	3.19	0.00	0.00	0.00	0.00	0.00	0.24
762	Gas Urban Buses (UB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
771	Gas School Buses (SB)	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.01	0.00
772	Diesel School Buses (SB)	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.59
777	Gas Other Buses (OB)	0.00	0.01	0.33	0.00	0.00	0.00	0.00	0.00	0.00
778	Motor Coaches	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	1.00
779	Diesel Other Buses (OB)	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	1.80
780	Motor Homes (MH)	0.00	0.01	0.19	0.00	0.00	0.00	0.00	0.00	1.41
	Total	**0.00**	**7.88**	**388.84**	**0.00**	**0.00**	**0.01**	**0.00**	**1.84**	**412.55**
	Other Mobile Sources									
810	Aircraft	0.00	0.49	2.53	0.00	0.00	0.00	0.00	0.02	0.00
820	Trains	0.00	0.13	3.35	0.00	0.00	0.00	0.01	0.00	78.43

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	Propylene oxide	Styrene	Toluene	Trichloro-ethylene	Vinyl chloride	Arsenic	Cadmium	Chromium	Diesel PM (DPM)
833	Ocean Going Vessels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
835	Commercial Habor Crafts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
840	Recreational Boats	0.00	1.09	60.58	0.00	0.00	0.00	0.00	0.02	0.12
850	Off-Road Recreational Vehicles	0.00	0.18	14.19	0.00	0.00	0.00	0.00	0.00	0.00
860	Off-Road Equipment	0.00	2.73	148.02	0.00	0.00	0.00	0.00	0.06	170.95
870	Farm Equipment	0.00	0.09	3.24	0.00	0.00	0.00	0.00	0.00	36.94
890	Fuel Storage and Handling	0.00	0.00	4.45	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**4.71**	**236.35**	**0.00**	**0.00**	**0.00**	**0.01**	**0.11**	**286.43**
Total	**Stationary**	**0.01**	**126.31**	**709.02**	**12.29**	**26.65**	**1.53**	**1.47**	**12.27**	**5.94**
Total	**On-Road Vehicles**	**0.00**	**7.88**	**388.84**	**0.00**	**0.00**	**0.01**	**0.00**	**1.84**	**412.55**
Total	**Other Mobile**	**0.00**	**4.71**	**236.35**	**0.00**	**0.00**	**0.00**	**0.01**	**0.11**	**286.43**
Total	**Anthropogenic**	**0.01**	**138.90**	**1334.21**	**12.29**	**26.65**	**1.54**	**1.49**	**14.22**	**704.93**

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	DPM2.5	Elemental carbon (EC)	EC2.5	Hexavalent chromium	Lead	Nickel	Organic carbon	Selenium	Silicon
	Fuel Combustion									
10	Electric Utilities	0.04	0.80	0.79	0.00	0.00	0.01	20.93	0.00	0.55
20	Cogeneration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	Oil and Gas Production (combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	Petroleum Refining (Combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	Manufacturing and Industrial	0.24	0.83	0.80	0.00	0.00	0.01	13.85	0.00	0.42
52	Food and Agricultural Processing	0.00	0.09	0.09	0.00	0.00	0.00	0.42	0.00	0.04
60	Service and Commercial	1.93	3.37	3.28	0.00	0.01	0.04	35.13	0.00	1.12
99	Other (Fuel Combustion)	3.42	3.19	3.05	0.00	0.00	0.00	11.59	0.00	3.64
	Total	**5.63**	**8.29**	**8.00**	**0.00**	**0.01**	**0.06**	**81.93**	**0.00**	**5.77**
	Waste Disposal									
110	Sewage Treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120	Landfills	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
130	Incineration	0.00	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00
140	Soil Remediation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.12**	**0.12**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Cleaning and Surface Coatings									
210	Laundering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220	Degreasing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
230	Coatings and Related Processes	0.00	1.44	1.33	0.00	0.00	0.00	32.24	0.00	10.89
240	Printing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	Adhesives and Sealants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
299	Other (Cleaning and Surface Coatings)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**1.44**	**1.33**	**0.00**	**0.00**	**0.00**	**32.24**	**0.00**	**10.89**
	Petroleum Production and Marketing									
310	Oil and Gas Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
320	Petroleum Refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	DPM2.5	Elemental carbon (EC)	EC2.5	Hexavalent chromium	Lead	Nickel	Organic carbon	Selenium	Silicon
330	Petroleum Marketing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
399	Other (Petroleum Production and Marketing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Industrial Processes									
410	Chemical	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
420	Food and Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
430	Mineral Processes	0.00	4.97	5.06	0.00	0.00	0.17	0.02	0.00	138.74
440	Metal Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
450	Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
460	Glass and Related Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
470	Electronics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
499	Other (Industrial Processes)	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.00	1.23
	Total	**0.00**	**4.98**	**5.06**	**0.00**	**0.00**	**0.18**	**0.06**	**0.00**	**139.97**
	Solvent Evaporation									
510	Consumer Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
520	Architectural Coatings and Related Solvent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
530	Pesticides/Fertilizers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
540	Asphalt Paving/Roofing	0.00	0.01	0.01	0.00	0.00	0.00	0.28	0.00	0.10
	Total	**0.00**	**0.01**	**0.01**	**0.00**	**0.00**	**0.00**	**0.28**	**0.00**	**0.10**
	Miscellaneous Processes									
610	Residential Fuel Combustion	0.00	119.17	86.11	0.00	0.01	0.06	328.43	0.04	0.19
620	Farming Operations	0.00	8.09	0.44	0.00	0.11	0.09	49.39	0.00	345.83
630	Construction and Demolition	0.00	207.45	13.58	0.00	24.99	2.65	1971.97	0.09	8533.57
640	Paved Road Dust	0.00	135.16	9.33	0.00	2.17	0.21	1046.25	0.04	5318.19
645	Unpaved Road Dust	0.00	6.84	0.40	0.00	0.76	0.22	197.96	0.02	1909.04
650	Fugitive Windblown Dust	0.00	8.47	0.52	0.00	1.86	0.20	99.91	0.00	670.83
660	Fires	0.00	5.11	4.53	0.00	0.00	0.00	4.30	0.00	0.99
670	Waste Burning and Disposal	0.00	3.98	3.55	0.00	0.00	0.00	7.77	0.00	0.15

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	DPM2.5	Elemental carbon (EC)	EC2.5	Hexavalent chromium	Lead	Nickel	Organic carbon	Selenium	Silicon
690	Cooking	0.00	27.07	27.07	0.00	0.07	0.02	348.00	0.00	1.34
699	Other (Miscellaneous Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**521.36**	**145.54**	**0.00**	**29.98**	**3.44**	**4054.00**	**0.19**	**16780.13**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	1.75	46.61	18.38	0.01	0.06	0.36	123.68	0.01	37.38
722	Light Duty Trucks 1 (T1)	0.23	4.65	2.08	0.00	0.01	0.03	11.80	0.00	3.35
723	Light Duty Trucks 2 (T2)	0.08	18.79	7.41	0.00	0.02	0.15	49.66	0.01	15.05
724	Medium Duty Trucks (T3)	0.35	13.29	5.27	0.00	0.02	0.10	35.24	0.00	10.62
732	Light Heavy Duty Gas Trucks 1 (T4)	0.00	1.20	0.46	0.00	0.00	0.01	3.65	0.00	1.53
733	Light Heavy Duty Gas Trucks 2 (T5)	0.00	0.33	0.12	0.00	0.00	0.00	1.04	0.00	0.46
734	Medium Heavy Duty Gas Trucks (T6)	0.00	0.73	0.27	0.00	0.00	0.01	2.31	0.00	1.03
736	Heavy Heavy Duty Gas Trucks ((HHD)	0.00	0.08	0.03	0.00	0.00	0.00	0.21	0.00	0.05
742	Light Heavy Duty Diesel Trucks 1 (T4)	5.81	2.74	1.91	0.00	0.00	0.01	7.70	0.00	1.35
743	Light Heavy Duty Diesel Trucks 2 (T5)	2.52	1.22	0.84	0.00	0.00	0.01	3.48	0.00	0.67
744	Medium Heavy Duty Diesel Truck (T6)	89.57	23.49	20.33	0.00	0.00	0.05	30.93	0.00	4.94
746	Heavy Heavy Duty Diesel Trucks (HHD)	287.22	90.74	66.54	0.00	0.03	0.14	140.66	0.01	13.34
750	Motorcycles (MCY)	0.00	0.32	0.14	0.00	0.00	0.00	0.83	0.00	0.17
760	Diesel Urban Buses (UB)	0.23	0.37	0.15	0.00	0.00	0.00	0.97	0.00	0.20
762	Gas Urban Buses (UB)	0.00	0.24	0.07	0.00	0.00	0.00	0.58	0.00	0.11
771	Gas School Buses (SB)	0.00	0.14	0.06	0.00	0.00	0.00	0.57	0.00	0.34
772	Diesel School Buses (SB)	0.56	0.34	0.16	0.00	0.00	0.01	1.36	0.00	0.67
777	Gas Other Buses (OB)	0.00	0.19	0.07	0.00	0.00	0.00	0.60	0.00	0.27
778	Motor Coaches	0.95	0.15	0.12	0.00	0.00	0.00	0.43	0.00	0.06
779	Diesel Other Buses (OB)	1.71	0.33	0.24	0.00	0.00	0.00	0.95	0.00	0.18
780	Motor Homes (MH)	1.34	0.55	0.42	0.00	0.00	0.00	1.55	0.00	0.26
	Total	**392.34**	**206.49**	**125.09**	**0.02**	**0.15**	**0.90**	**418.19**	**0.03**	**92.00**
	Other Mobile Sources									
810	Aircraft	0.00	11.31	9.54	0.00	0.03	0.04	30.81	0.00	0.58
820	Trains	71.63	20.17	18.94	0.00	0.00	0.00	53.89	0.00	0.23

Table VIII-3. 2018 Air Toxics Emissions (lbs/day) by Major Sources Category for the Coachella Valley

Code	Source Category	DPM2.5	Elemental carbon (EC)	EC2.5	Hexavalent chromium	Lead	Nickel	Organic carbon	Selenium	Silicon
833	Ocean Going Vessels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
835	Commercial Habor Crafts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
840	Recreational Boats	0.10	8.11	5.54	0.00	0.06	0.06	31.12	0.00	0.82
850	Off-Road Recreational Vehicles	0.00	0.36	0.25	0.00	0.00	0.00	1.40	0.00	0.04
860	Off-Road Equipment	157.14	126.58	111.46	0.00	0.16	0.16	120.88	0.00	2.52
870	Farm Equipment	34.08	23.20	21.34	0.00	0.00	0.00	9.83	0.00	0.11
890	Fuel Storage and Handling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**262.96**	**189.73**	**167.06**	**0.01**	**0.26**	**0.27**	**247.94**	**0.00**	**4.29**
Total	**Stationary**	**5.63**	**536.19**	**160.06**	**0.00**	**30.00**	**3.69**	**4168.51**	**0.19**	**16936.87**
Total	**On-Road Vehicles**	**392.34**	**206.49**	**125.09**	**0.02**	**0.15**	**0.90**	**418.19**	**0.03**	**92.00**
Total	**Other Mobile**	**262.96**	**189.73**	**167.06**	**0.01**	**0.26**	**0.27**	**247.94**	**0.00**	**4.29**
Total	**Anthropogenic**	**660.93**	**932.41**	**452.22**	**0.02**	**30.40**	**4.86**	**4834.63**	**0.23**	**17033.16**

Table VIII-4. 2018 Criteria Emissions (tons/day) by Major Source Category for the Coachella Valley

Code	Source Category	TOG	VOC	CO	NOx	SOx	TSP	PM10	PM2.5	NH3
	Fuel Combustion									
10	Electric Utilities	0.07	0.01	0.03	0.00	0.00	0.02	0.02	0.02	0.02
20	Cogeneration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	Oil and Gas Production (combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	Petroleum Refining (Combustion)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	Manufacturing and Industrial	0.25	0.16	0.39	0.29	0.02	0.01	0.01	0.01	0.00
52	Food and Agricultural Processing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	Service and Commercial	0.29	0.13	0.39	0.31	0.01	0.03	0.03	0.03	0.01
99	Other (Fuel Combustion)	0.03	0.02	0.12	0.60	0.15	0.03	0.03	0.02	0.00
	Total	**0.65**	**0.31**	**0.94**	**1.20**	**0.19**	**0.08**	**0.08**	**0.08**	**0.04**
	Waste Disposal									
110	Sewage Treatment	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120	Landfills	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
130	Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
140	Soil Remediation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199	Other (Waste Disposal)	8.99	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.12
	Total	**9.01**	**0.73**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.13**
	Cleaning and Surface Coatings									
210	Laundering	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220	Degreasing	1.59	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00
230	Coatings and Related Processes	1.32	1.27	0.00	0.00	0.00	0.07	0.07	0.07	0.00
240	Printing	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	Adhesives and Sealants	0.27	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
299	Other (Cleaning and Surface Coatings)	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**3.33**	**1.82**	**0.00**	**0.00**	**0.00**	**0.07**	**0.07**	**0.07**	**0.00**
	Petroleum Production and Marketing									
310	Oil and Gas Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
320	Petroleum Refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-4. 2018 Criteria Emissions (tons/day) by Major Source Category for the Coachella Valley

Code	Source Category	TOG	VOC	CO	NOx	SOx	TSP	PM10	PM2.5	NH3
330	Petroleum Marketing	1.35	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
399	Other (Petroleum Production and Marketing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**1.35**	**0.34**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Industrial Processes									
410	Chemical	0.12	0.09	0.00	0.00	0.00	0.01	0.01	0.01	0.00
420	Food and Agriculture	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
430	Mineral Processes	0.02	0.02	0.00	0.00	0.00	0.24	0.09	0.03	0.00
440	Metal Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
450	Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.23	0.16	0.09	0.00
460	Glass and Related Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
470	Electronics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
499	Other (Industrial Processes)	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	Total	**0.24**	**0.20**	**0.00**	**0.00**	**0.00**	**0.48**	**0.26**	**0.14**	**0.02**
	Solvent Evaporation									
510	Consumer Products	3.09	2.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
520	Architectural Coatings and Related Solvent	0.38	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
530	Pesticides/Fertilizers	0.30	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.57
540	Asphalt Paving/Roofing	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**3.83**	**3.30**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.57**
	Miscellaneous Processes									
610	Residential Fuel Combustion	0.94	0.41	2.13	0.38	0.02	0.30	0.29	0.28	0.00
620	Farming Operations	0.68	0.05	0.00	0.00	0.00	0.92	0.42	0.06	0.27
630	Construction and Demolition	0.00	0.00	0.00	0.00	0.00	22.43	10.97	1.10	0.00
640	Paved Road Dust	0.00	0.00	0.00	0.00	0.00	8.76	4.00	0.60	0.00
645	Unpaved Road Dust	0.00	0.00	0.00	0.00	0.00	2.94	1.75	0.17	0.00
650	Fugitive Windblown Dust	0.00	0.00	0.00	0.00	0.00	1.73	0.92	0.13	0.00
660	Fires	0.01	0.01	0.08	0.00	0.00	0.01	0.01	0.01	0.00
670	Waste Burning and Disposal	0.01	0.01	0.09	0.00	0.00	0.01	0.01	0.01	0.00
690	Cooking	0.06	0.05	0.00	0.00	0.00	0.26	0.26	0.26	0.00

Table VIII-4. 2018 Criteria Emissions (tons/day) by Major Source Category for the Coachella Valley

Code	Source Category	TOG	VOC	CO	NOx	SOx	TSP	PM10	PM2.5	NH3
699	Other (Miscellaneous Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81
	RECLAIM				0.11	0.00				
	Total	**1.71**	**0.52**	**2.29**	**0.49**	**0.02**	**37.36**	**18.62**	**2.63**	**1.08**
	Onroad Motor Vehicles									
710	Light Duty Passenger Auto (LDA)	1.10	1.03	8.93	0.67	0.02	0.34	0.33	0.14	0.18
722	Light Duty Trucks 1 (T1)	0.26	0.24	1.86	0.18	0.00	0.03	0.03	0.01	0.02
723	Light Duty Trucks 2 (T2)	0.63	0.58	5.47	0.58	0.01	0.14	0.13	0.06	0.11
724	Medium Duty Trucks (T3)	0.53	0.48	4.40	0.50	0.01	0.10	0.09	0.04	0.12
732	Light Heavy Duty Gas Trucks 1 (T4)	0.09	0.08	0.30	0.08	0.00	0.01	0.01	0.01	0.01
733	Light Heavy Duty Gas Trucks 2 (T5)	0.02	0.02	0.06	0.02	0.00	0.00	0.00	0.00	0.00
734	Medium Heavy Duty Gas Trucks (T6)	0.03	0.03	0.32	0.07	0.00	0.01	0.01	0.00	0.00
736	Heavy Heavy Duty Gas Trucks ((HHD)	0.03	0.02	0.78	0.12	0.00	0.00	0.00	0.00	0.00
742	Light Heavy Duty Diesel Trucks 1 (T4)	0.02	0.01	0.10	0.46	0.00	0.01	0.01	0.01	0.00
743	Light Heavy Duty Diesel Trucks 2 (T5)	0.01	0.01	0.04	0.19	0.00	0.01	0.01	0.00	0.00
744	Medium Heavy Duty Diesel Truck (T6)	0.06	0.06	0.22	1.24	0.00	0.09	0.09	0.06	0.01
746	Heavy Heavy Duty Diesel Trucks (HHD)	0.35	0.29	1.78	7.79	0.02	0.30	0.30	0.20	0.04
750	Motorcycles (MCY)	0.42	0.37	2.20	0.11	0.00	0.00	0.00	0.00	0.00
760	Diesel Urban Buses (UB)	0.11	0.01	0.53	0.04	0.00	0.00	0.00	0.00	0.00
762	Gas Urban Buses (UB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
771	Gas School Buses (SB)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
772	Diesel School Buses (SB)	0.00	0.00	0.00	0.06	0.00	0.01	0.01	0.00	0.00
777	Gas Other Buses (OB)	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00
778	Motor Coaches	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
779	Diesel Other Buses (OB)	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
780	Motor Homes (MH)	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.00
	Total	**3.65**	**3.22**	**27.07**	**12.19**	**0.07**	**1.06**	**1.04**	**0.54**	**0.49**
	Other Mobile Sources									
810	Aircraft	0.08	0.08	1.28	0.24	0.03	0.03	0.03	0.03	0.00
820	Trains	0.11	0.10	0.68	2.36	0.00	0.04	0.04	0.04	0.00
833	Ocean Going Vessels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table VIII-4. 2018 Criteria Emissions (tons/day) by Major Source Category for the Coachella Valley

Code	Source Category	TOG	VOC	CO	NOx	SOx	TSP	PM10	PM2.5	NH3
835	Commercial Habor Crafts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
840	Recreational Boats	0.50	0.43	1.61	0.09	0.00	0.03	0.03	0.02	0.00
850	Off-Road Recreational Vehicles	0.24	0.23	0.38	0.01	0.00	0.00	0.00	0.00	0.00
860	Off-Road Equipment	1.60	1.41	16.08	2.08	0.00	0.16	0.15	0.13	0.00
870	Farm Equipment	0.07	0.06	0.57	0.30	0.00	0.02	0.02	0.02	0.00
890	Fuel Storage and Handling	0.17	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**2.77**	**2.47**	**20.59**	**5.08**	**0.04**	**0.28**	**0.27**	**0.23**	**0.01**
Total	**Stationary**	**20.12**	**7.21**	**3.23**	**1.70**	**0.20**	**37.99**	**19.03**	**2.91**	**1.85**
Total	**On-Road Vehicles**	**3.65**	**3.22**	**27.07**	**12.19**	**0.07**	**1.06**	**1.04**	**0.54**	**0.49**
Total	**Other Mobile**	**2.77**	**2.47**	**20.59**	**5.08**	**0.04**	**0.28**	**0.27**	**0.23**	**0.01**
Total	**Anthropogenic**	**26.54**	**12.91**	**50.90**	**18.97**	**0.31**	**39.34**	**20.34**	**3.68**	**2.34**

APPENDIX IX

MATES V

DRAFT FINAL REPORT

Regional Modeling Analyses

Table of Contents

Appendix IX

Regional Modeling Analyses

IX.1 Introduction

The MATES V regional modeling analysis is presented in Chapter 4 of the main report. This appendix provides the analyses to complement and support the regional modeling demonstration. These include characterization and validation of the meteorological input data, development of the MATES V modeling emissions inventory, development of boundary conditions, model performance, and risk analysis.

The Comprehensive Air Quality Model with Extensions enhanced with a reactive tracer modeling capability (CAMx RTRAC, Ramboll Environment and Health, 2018) provided the dispersion modeling platform and chemistry used to simulate annual impacts of both gaseous and aerosol toxic compounds in the Basin. The version of the RTRAC "probing tool" in CAMx used in the modeling simulations includes an air toxics chemistry module to treat the formation and destruction of reactive air toxic compounds.

Numerical modeling was conducted on a domain that includes Coachella Valley, the entire Orange and Los Angeles Counties and populated areas of Riverside and San Bernardino Counties (Figure IX-1-1). Compared to the MATES IV domain, the MATES V domain is extended further east by 40 kilometers. The 2016 Air Quality Management Plan (AQMP) is the basis for the toxics emissions inventory developed for MATES V with updates incorporated for several source categories. The 2018 inventory used for the MATES V modeling analysis is projected from the 2012 baseline emissions inventory in the 2016 AQMP for area and off-road sources while the point source emissions are based on the 2018 Annual Emissions Reports (AER). Emissions from ocean-going vessels (OGV) from the 2018 CARB SIP update (CARB, 2018) are used. On-road emissions are updated based on the latest CARB's on-road emissions model, EMFAC 2017 (CARB, 2017) and travel activity data from Southern California Association of Governments 2016 Regional Transportation Plan (SCAG, 2016).

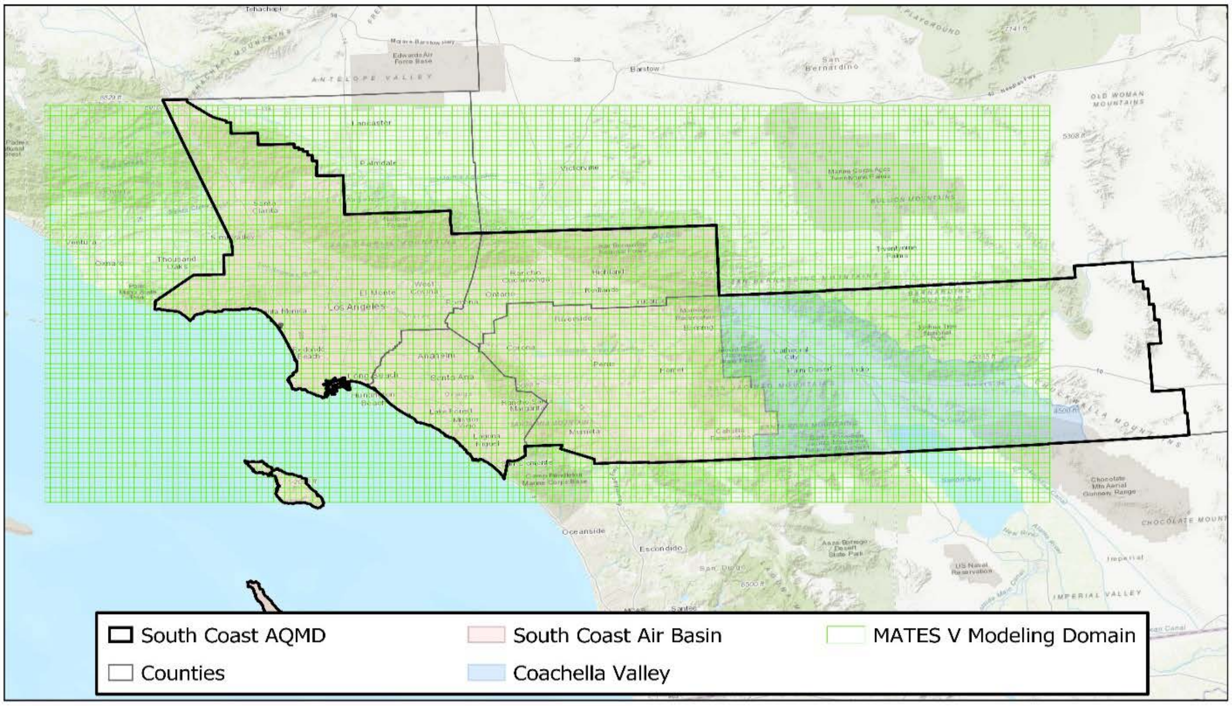


Figure IX-1-1.
MATES V Modeling Domain

Grid-based, hourly meteorological fields were generated from the Weather Research Forecast (WRF) mesoscale model (Skamarock, 2008). The National Centers for Environmental Prediction (NCEP) North American Regional Reanalysis (NARR) field was employed as initial and lateral boundary values for the WRF modeling. Four Dimensional Data Assimilation (FDDA) was conducted using grid analysis data, so the NARR data was enhanced with available surface and vertical sounding data. The WRF model was simulated for the period of May 1, 2018 to April 30, 2019, which provided the dispersion platform for the chemical transport modeling using CAMx.

IX.2 Background

The modeling system used for MATES air toxics cancer risk simulations has evolved over the past decades. The MATES II (South Coast AQMD, 2000) analysis used the Urban Airshed Model with TOX (UAMTOX) chemistry to simulate the advection and accumulation of toxic compound emissions throughout the Basin. UAMTOX was simulated for 2 km by 2 km grid domain that overlaid the Basin. The analysis relied on the 1997-1998 emissions projection from the 1997 AQMP and meteorological data fields for 1997-1998 generated from objective analysis using a diagnostic wind model. These tools were consistent with those used in both the 1997 and 2003 AQMP attainment demonstrations.

For the MATES III analysis (South Coast AQMD, 2007), the regional modeling dispersion platform and chemistry simulations progressed from the UAMTOX model to CAMx RTRAC. The second major change in the MATES III modeling analysis was the incorporation of the

Mesoscale Meteorological Model 5 (MM5, Grell, 1994) to drive the meteorological data simulation. At that time, MM5 was the state-of-the-art meteorological model used in numerous regional modeling analyses, worldwide. The transition to CAMx and MM5 was made based on suggestions from peer review for the 2003 AQMP modeling efforts.

The CAMx-MM5 modeling platform from MATES III was updated to the CAMx-WRF coupled system in MATES IV. The WRF, a state-of-the-science meteorological modeling tool, offers a variety of user options to cover atmospheric boundary layer parameterizations, turbulent diffusion, cumulus parameterizations, land surface-atmosphere interactions, which can be customized to specific geographical and climatological situations. South Coast AQMD performed extensive sensitivity tests and developments to improve the WRF performance for the South Coast Air Basin, of which geographical and climatological characteristics impose great challenges in predicting complex meteorological structures associated with air quality episodes.

MATES V simulations continued to rely on CAMx-WRF modeling system. Same as previous MATES, RTRAC algorithms available in CAMx continued to serve to track chemically active toxic elements individually to assess the contribution of each source category. The RTRAC algorithm provides a flexible approach for tracking the emission, dispersion, chemistry, and deposition of multiple gas- and particle-phase species that are not otherwise included in the model's chemistry mechanisms.

IX.3 Meteorological modeling

This section provides various analysis about meteorological conditions occurring during the MATES V study period compared to the MATES IV period and climatological average conditions. Detailed evaluation on WRF performance against available measurements were discussed as well.

IX.3.1 Comparison of observed meteorological elements during MATES V and past 20-year averages

The meteorological elements including annual average temperature, relative humidity, wind speed and annual total rain at 15 weather stations located in the region were used to evaluate weather patterns during the MATES V period with climatology using data from 2000 to 2019. The 15 weather stations are Los Angeles International Airport (LAX), Santa Monica Municipal Airport (SMO), Hawthorne Municipal Airport (HHR), Torrance Municipal Airport (TOA), Long Beach Airport (LGB), John Wayne Airport (SNA), Fullerton Municipal Airport (FUL), San Gabriel Valley Airport (EMT), Chino Airport (CNO), Ontario International Airport (ONT), Riverside Municipal Airport (RAL), March Air Reserve Base (RIV), Palm Springs International Airport (PSP), Burbank Bob Hope Airport (BUR) and (Van Nuys Airport) VNY. The results are shown in Figures IX-3-1 through IX-3-4.

As shown in Figure IX-3-1, the annual average temperatures during MATES V and the past 20-year average time periods are in reasonable agreement across most of the stations. The largest difference occurs at SMO station where the average temperature during MATES V period is ~0.8°C higher than the past 20-year average temperature. The second largest difference occurs at

VNY station with the MATES V average temperature being ~0.7°C higher than past 20-year average. The minimum difference is seen at HHR station with marginal difference between the two datasets (0.003°C). Of the 15 total stations, there are 5 stations (TOA, EMT, RAL, RIV and BUR) that show a lower temperature during MATES V compared to the past 20-year average.

As seen from Figure IX-3-2, most stations (11 out of 15 stations) have slightly higher relative humidity during the MATES V period compared to the past 20-year average. The largest annual average relative humidity (RH) difference between the two datasets occurs at BUR station where the MATES V period average is 6.6% higher than 20-year average; the minimum difference is seen at SMO station with 20-year average value being only 0.2% higher. The highest and lowest average relative humidity are at the LAX and PSP stations, respectively, according to both datasets.

The wind speed annual averages are also higher during MATES V period at most of the stations (11 out of 15). The ONT station shows the greatest difference where the MATES V average is 0.34 (m/s) higher than the past 20-year average (see Figure IX-3-3).

Among all the meteorological elements, the most notable difference between the two datasets appears to be related to total annual average rainfall (Figure IX-3-4). As shown in Figure IX-3-4, the average annual rainfall during the MATES V period is significantly higher than the 20-year average in all stations. These differences are due to unusually higher amounts of rain during the spring of 2019. The difference between the two datasets ranges from 2.6 inches at ONT station to 8.9 inches at CNO station.

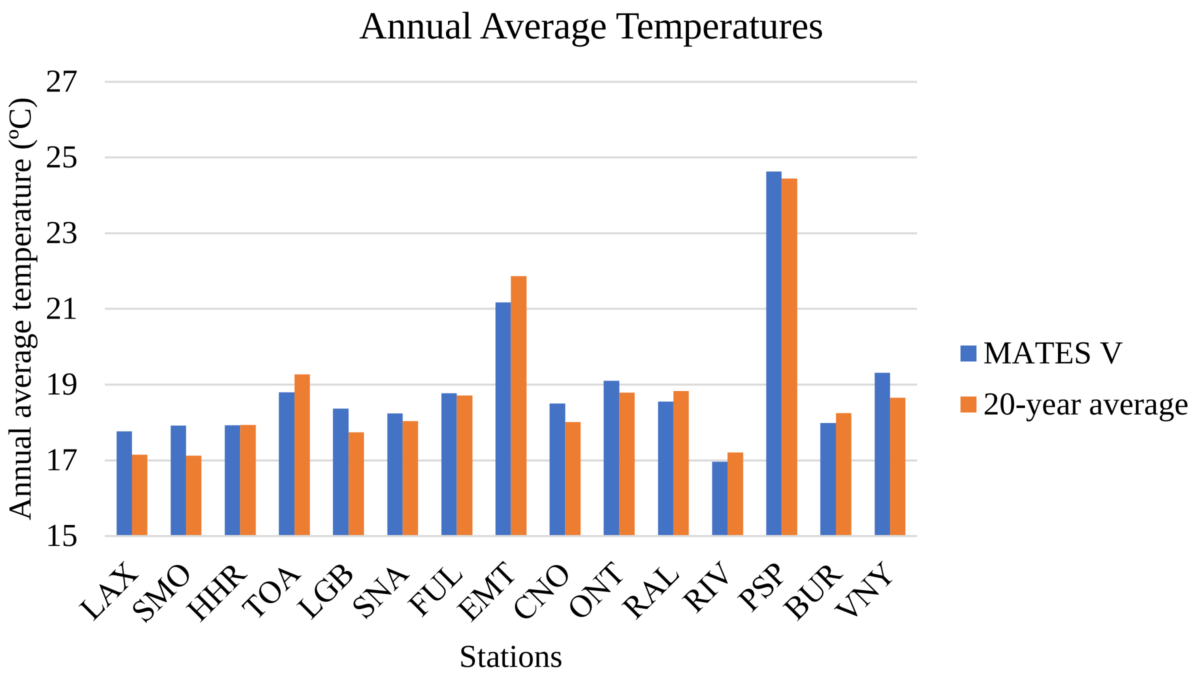


Figure IX-3-1.
Annual average temperature at each station during MATES V and past 20-year averages

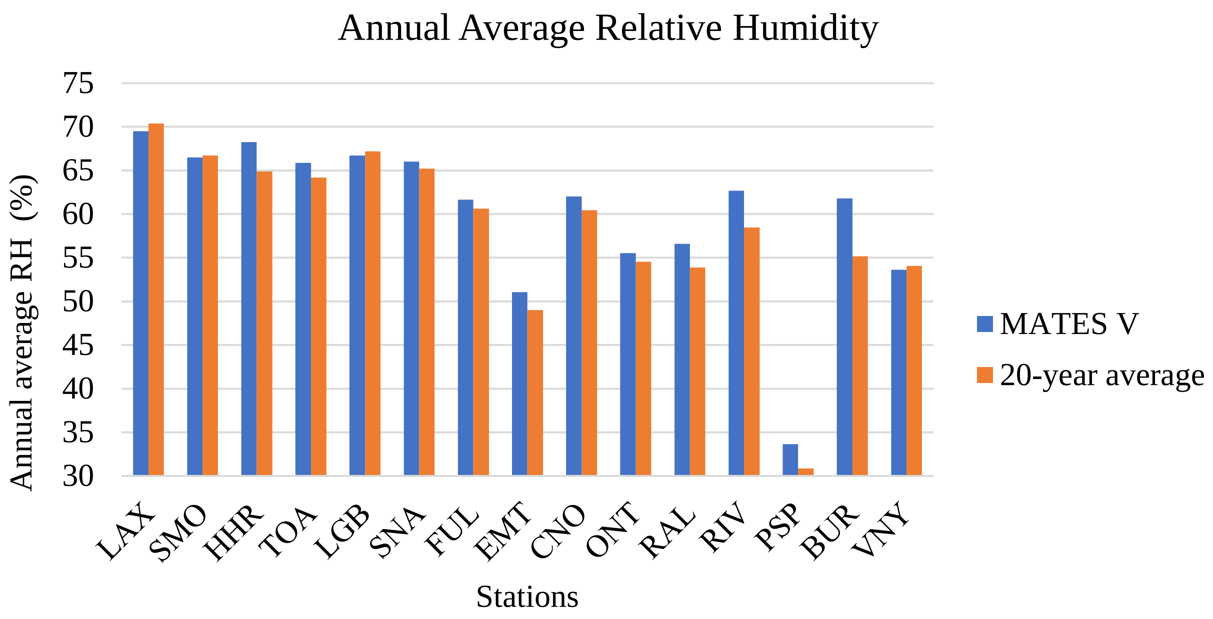


Figure IX-3-2.
Annual average relative humidity at each station during MATES V and past 20-year averages

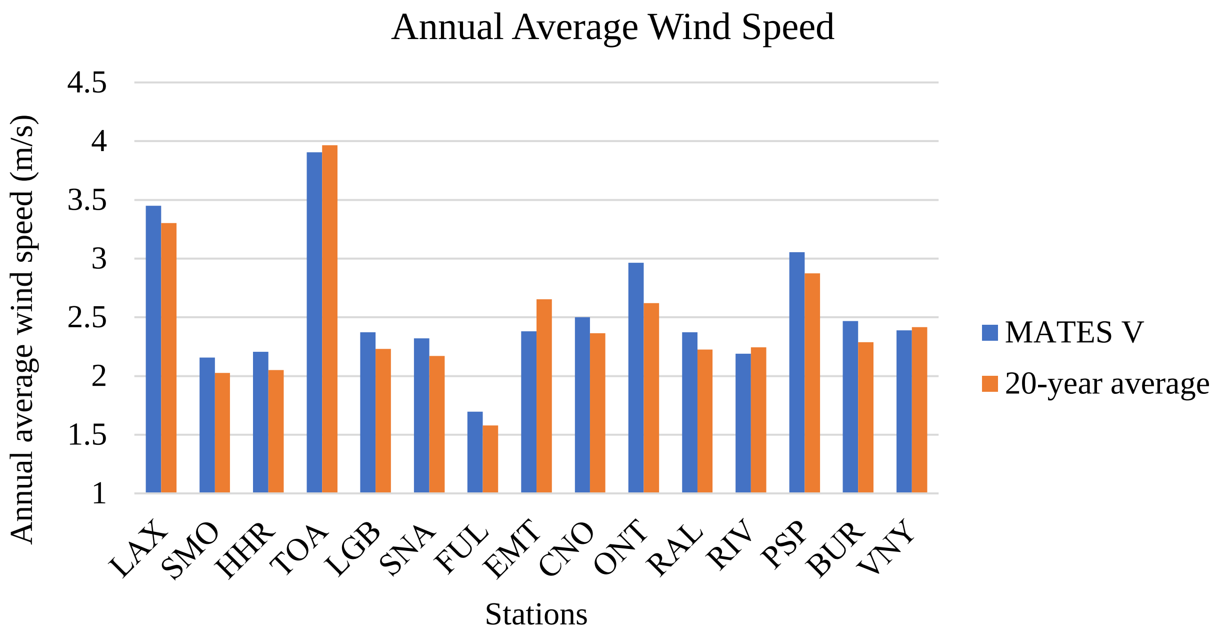


Figure IX-3-3.
Annual average wind speed at each station during MATES V and past 20-year averages

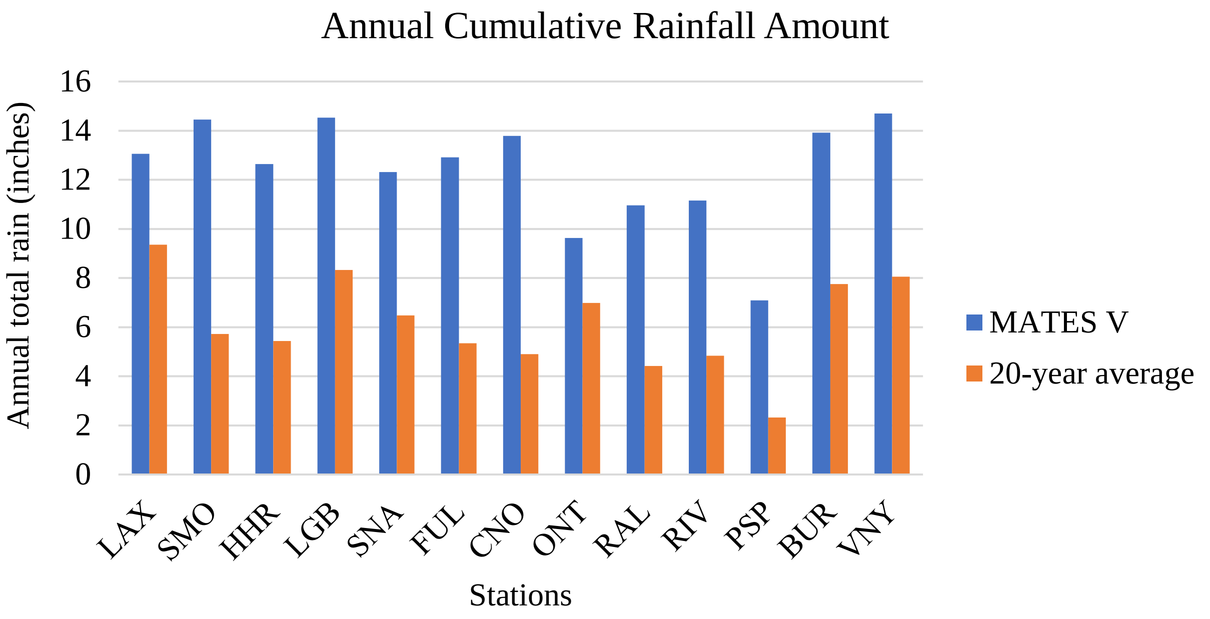


Figure IX-3-4.
Annual cumulative rainfall amount at each station during MATES V and past 20-year averages

IX.3.2 Comparison of meteorological fields between MATES IV and MATES V

Various meteorological parameter averages, including the annual average temperature, relative humidity (RH), wind speed and annual total rain at 15 weather stations in the South Coast Air Basin for the MATES IV and MATES V periods are shown in Figure IX-3-5 through IX-3-8. The MATES IV period (July 2012 through June 2013) is characterized as a dry year based on the observational data analysis in MATES IV report.

The largest difference between the MATES IV and MATES V period averages is related to annual total rain; the MATES V averages show higher values in all stations, as mentioned previously, due to the fact that an unusually high amount of rain occurred during spring 2019. The annual average temperature, annual average RH, and annual average wind speed values do not show significant differences between MATES IV and MATES V. The maximum difference in annual average temperature occurs at BUR station where MATES V is ~0.97 (°C) less than MATES IV. The maximum difference in annual RH occurs at BUR station where MATES V is 8.5 (%) higher than MATES IV. MATES IV averages show higher values for annual average wind speed at most of the stations (Figure IX-3-7); maximum difference occurs at ONT station with MATES V being 0.58 (m/s) higher than MATES IV.

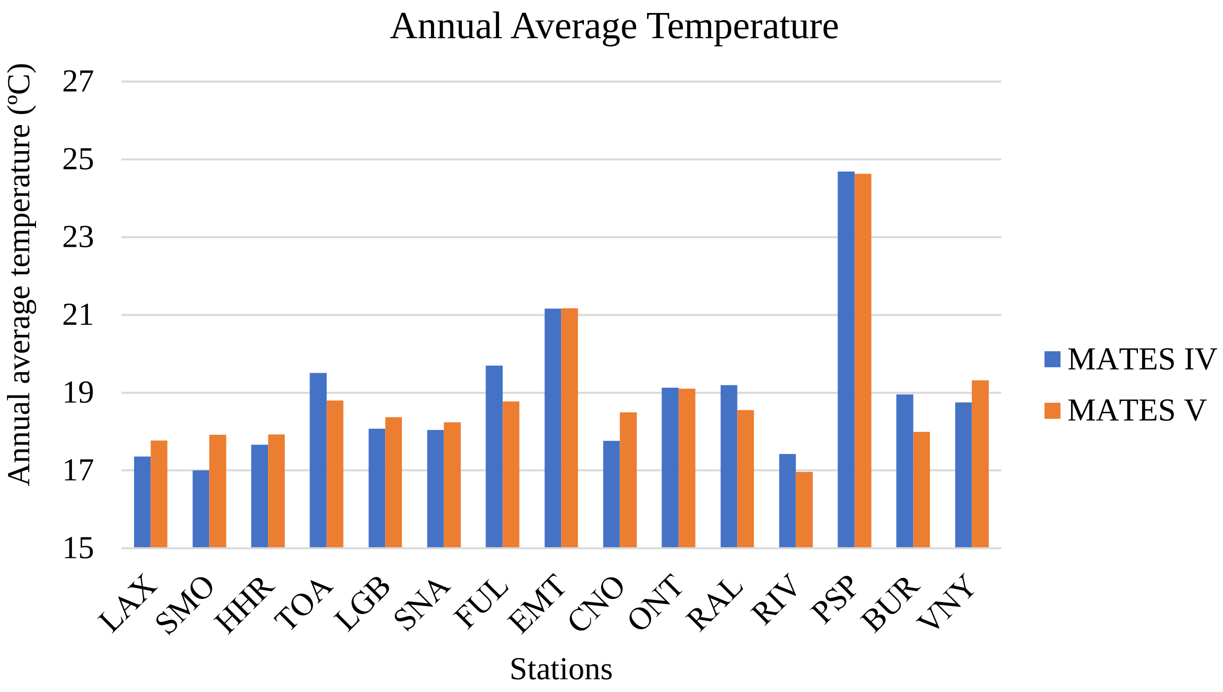


Figure IX-3-5

Annual average temperatures at each station during MATES IV and MATES V

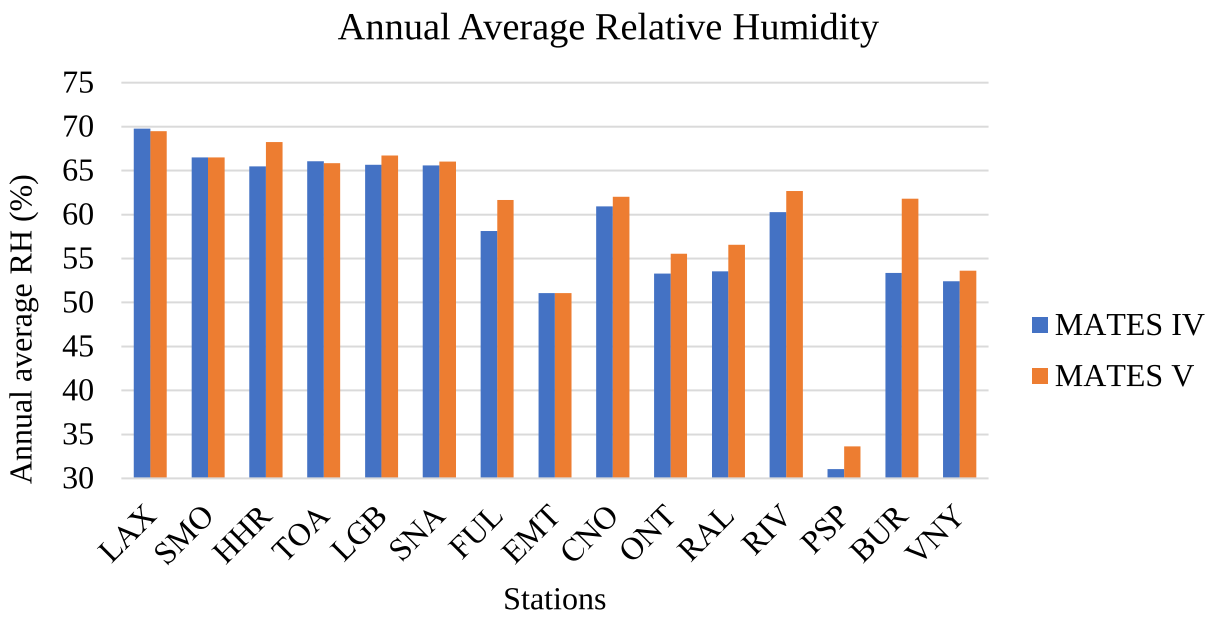


Figure IX-3-6

Annual average relative humidity at each station during MATES IV and MATES V

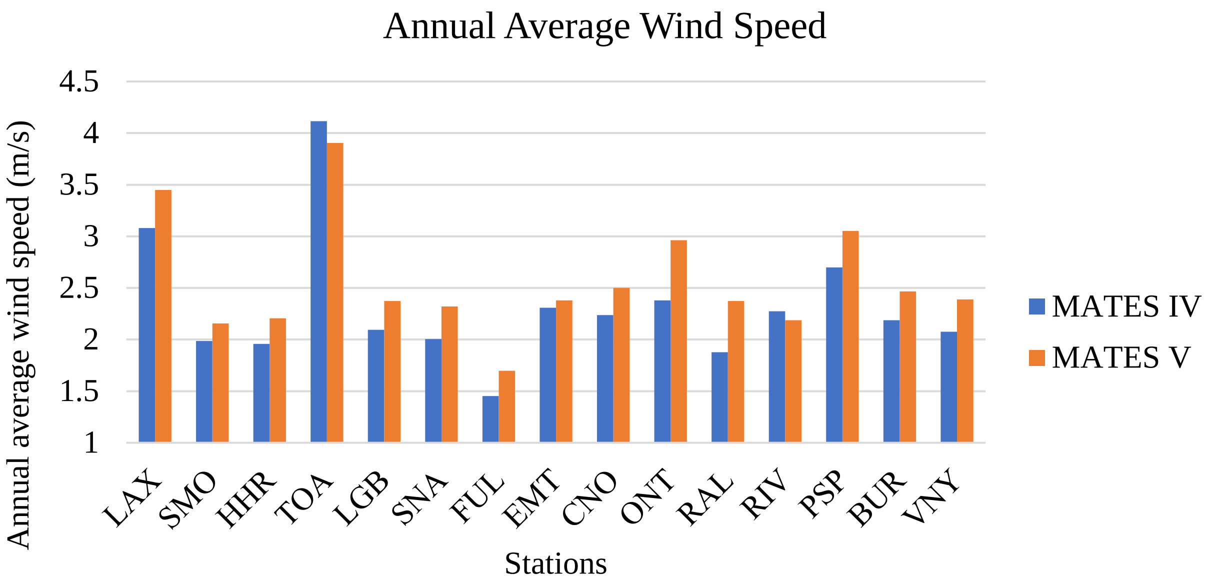


Figure IX-3-7
Annual average wind speed at each station during MATES IV and MATES V

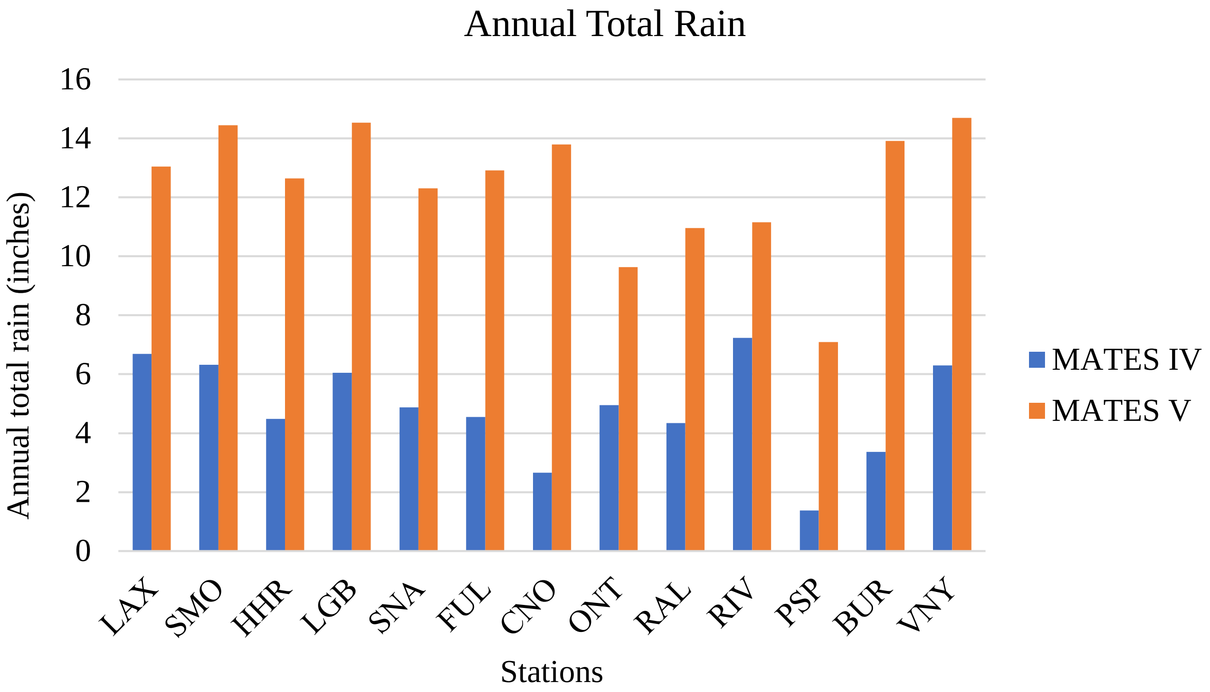


Figure IX-3-8
Annual total rain at each station during MATES IV and MATES V

IX.3.3 Weather Research and Forecasting (WRF) Numerical Model Configuration

The WRF model is one of the most widely used meteorological models that serves a wide range of meteorological applications across scales from tens of meters to thousands of kilometers. WRF has been applied to a wide range of phenomena, such as regional climate, monsoons, baroclinic waves, cyclones, mesoscale fronts, hurricane, deep convection, land-sea breezes, mountain-valley circulations, large eddy simulations, fire event, etc. The model has been in active development and it is a collaborative partnership of the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (represented by the National Centers for Environmental Prediction (NCEP) and the Earth System Research Laboratory), the U.S. Air Force, the Naval Research Laboratory, the University of Oklahoma, and the Federal Aviation Administration (FAA). The WRF system contains two dynamical solvers, referred to as the ARW (Advanced Research WRF) core and the NMM (Nonhydrostatic Mesoscale Model) core. The ARW configuration was chosen for the current modeling analyses. The ARW is primarily developed and maintained by the National Center for Atmospheric Research (NCAR) mesoscale and microscale meteorology laboratory.

The WRF model is a fully compressible and nonhydrostatic model (with a run-time hydrostatic option). Its vertical coordinate is selectable as either a terrain-following or hybrid vertical coordinate hydrostatic pressure coordinate. The grid staggering is the Arakawa C-grid. It uses a time-split small step for acoustic and gravity-wave mode. The dynamics conserves scaler variables. The WRF is designed to be a flexible, state-of-the-art atmospheric simulation system that is portable and efficient on parallel computing platforms.

The WRF simulation domain designed for the MATES V study encompasses the greater Los Angeles and suburban areas, its surrounding mountains, and the sea off the coast of the Basin, as shown in Figure IX-3-9. WRF simulations were conducted with four nested domains at grid resolutions of 36 km, 12 km, 4 km and 2 km. The innermost domain has 187 by 107 grid points in abscissa and ordinate, respectively, which spans 374km by 214 km in east-west and north-south directions, respectively. The figure also shows the relative locations and sizes of the four nested grids. The innermost domain presented in Figure IX-3-10, excluding three boundary columns and rows, served as the CAMx chemical transport modeling domain.

The WRF simulation employed 30 layers vertically with the lowest computational layer being approximately 20 m above ground level (agl) and the top layer at 50 hPa. Four Dimensional Data Assimilation (FDDA) was conducted using grid analysis data that was enhanced with available surface and vertical sounding data. The Sea Surface Temperature (SST) is a critical factor that drives the land-sea breeze and up-slope/down-slope flow. The SST data from the Global Data Assimilation Experiment (GODAE) are used to update the WRF modeling every 6 hours to better represent the sea surface temperature. The Yon-Sei University (YSU) scheme (Hong and Pan, 1996) was used to model the planetary boundary layer (PBL). The WRF simulation with this configuration is referred as "control" simulation. The flowchart (Figure IX-3-11) of WRF simulation shows the meteorology input data, the processing steps, the observation nudging and the one-way nesting for high resolution inner domain.

After careful testing of different WRF physics options, the longwave radiation scheme of Rapid Radiative Transfer Model (RRTM), the shortwave radiation scheme of Dudhia and WRF Single-Moment 3-class scheme of micro physics were chosen for simulations. Kain-Fritsch cumulus schemes were employed to the outer three domains, while no cumulus parameterization was used for the innermost domain. The selections of the land surface model (LSM) scheme, the impacts of vertical and spatial resolution (1km) are discussed further in the next section.

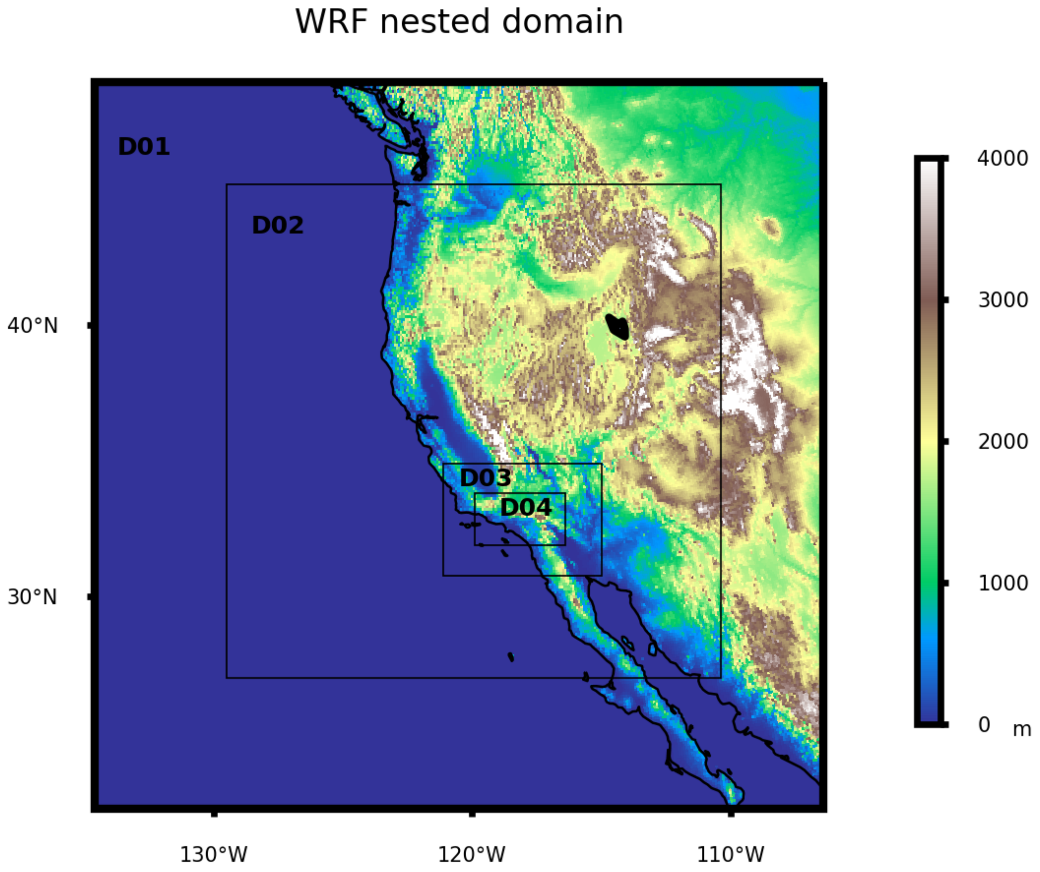


Figure IX-3-9
Four nested WRF modeling domains (36km, 12km, 4km, 2km horizontal resolution). Color scale represents topography

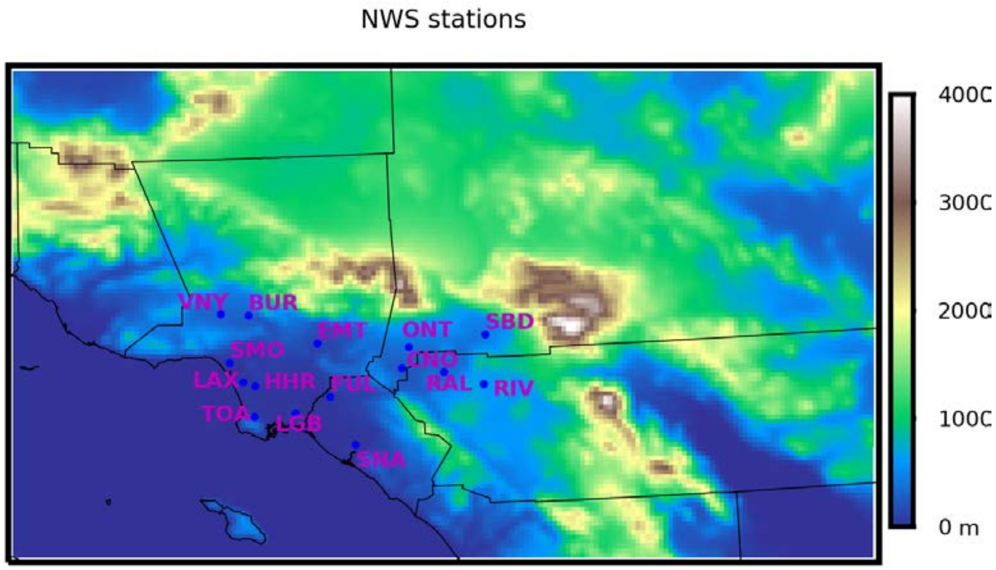


Figure IX-3-10
The inner most WRF simulation domain on the topographic map, and the 15 National Weather Service (NWS) stations used in the model performance evaluation

Table IX-3-1 below provides a summary of the WRF configuration used in MATES V in comparison with MATES IV. Major parameters finalized for MATES V are similar to those used in MATES IV. Sensitivity simulations were performed to evaluate land surface schemes and spatial and vertical resolutions of modeling configuration (Table IX-3-2). Those options identified as critical to describe air pollution episodes are presented.

Table IX-3-1

Overview of WRF configuration for MATES V in comparison with MATES IV

Component	MATES IV (July 2012-June 2013)	MATES V (May 2018-April 2019)
Numerical Platform	WRF version 3.4.1	WRF Version 4.0.3
Number of domains	4 nested domains	
Nested Domain setting	D01: 36 km (71 X 71)	D01: 36 km (83 X 83)
	D02: 12 km (133 X 133)	D02: 12 km (169 X 169)
	D03: 4 km (163 X 115)	
	D04: 2km (167 X 87)	D04: 2km (187 X 107)
Number of vertical layers	30 layers, the lowest layer is at ~ 20 m agl.	
Simulation Length	4 day with 24-hour spin-up	
Initial and boundary values	NCEP NAM* analysis (40 km X 40 km)	NCEP NARR# Re-analysis (32 km X 32 km)
Sea Surface Temperature	GHRSST+	
Boundary layer scheme	YSU (Yon-Sei University) scheme	
Land Surface model	Five-layer soil model	Unified Noah
Cumulus parameterization	Kain-Fritsch for the outer two domains Explicit for inner two domains	Kain-Fritschfor the outer three domains Explicit for the innermost domain
Micro physics	Simple ice	WRF Single-Moment 3-class
Radiation	Cloud radiation	RRTM scheme for longwave, Dudhia scheme for shortwave
Four-dimensional data analysis	Analysis nudging with NWS surface and upper air Measurements	

*NAM - The North American Mesoscale Forecast System

+GHRSST - The Group for High Resolution Sea Surface Temperature (https://www.ghrsst.org/)

#NARR - North American Regional Reanalysis

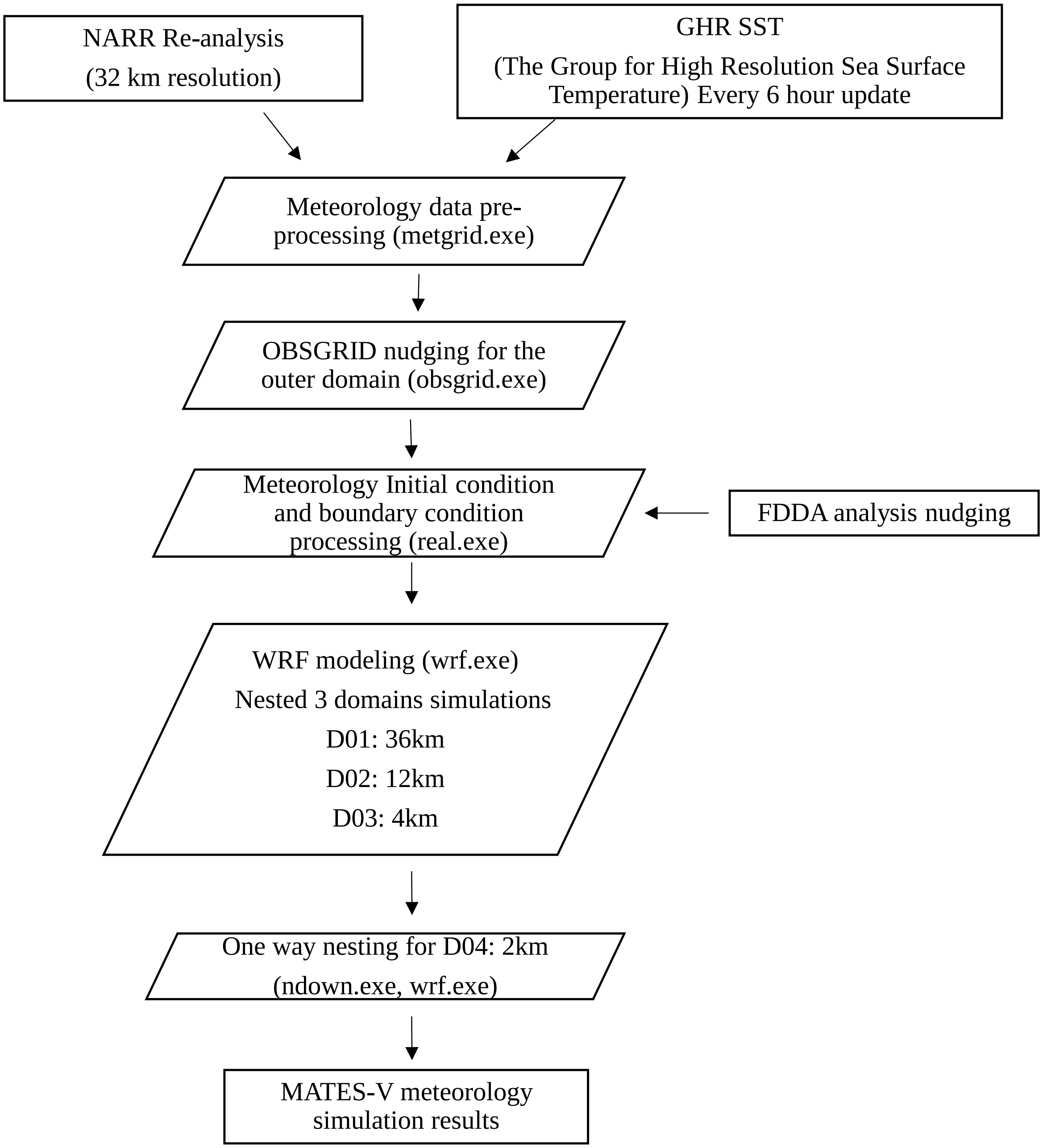


Figure IX-3-11
Flowchart of WRF simulation for MATES V

TABLE IX-3-1

The list of WRF sensitivity simulations

#	Testing Categories	Database
1	Land Surface Scheme	Pleim-Xiu land surface scheme
2	High Spatial Resolution	1km ×1km simulation*
3	High Vertical Resolution	35 layers in total, added 5 more layers between 0.8km – 3 km

*Considering the computational cost, only 4 month simulations (April 2018, July 2018, October 2018 and January 2019) were counducted

IX.3.4 Model Performance Evaluation of Metrological fields– Surface Level

The performance of the control simulations along with other sensitivity testing simulations are summarized in Table IX-3-3 and Table IX-3-4 for the summer season (June, July, and August of 2018) and winter season (December 2018, January and February 2019), respectively. All the results shown in Table IX-3-3 and IX-3-4 are averaged values for the 15 NWS stations. The locations of the NWS stations are shown in Figure IX-3-10. Overall, the WRF simulation for 2018 summer and winter provided representative meteorological fields that well characterized the observed conditions. These fields were used directly in the CAMx joint particulate and ozone simulations.

The performance of WRF control simulations used as transport fields for the CAMx modeling is provided in Figure IX-3-12 through Figure IX-3-20. The model performance was evaluated for each month at the airport stations in the model domain for May 2018 through April 2019. However, only one summer month (July) and one winter month (January) are shown here.

Three NWS stations are selected for surface level model performance evaluation: Hawthorne Municipal Airport (HHR, a coastal site), Fullerton Municipal Airport (FUL, an inland Orange County station), and Chino Airport (CNO, located in mid-Basin). The diurnal variation of temperature, humidity and surface wind are well represented by the WRF control simulations. Temperature and wind speed predictions are more accurate in the summer season than the winter months (Figure IX-12 – Figure IX-17). The observed temperature gradient from the coastal station of HHR to the inland station of CNO is well captured by the WRF model. During summer, the median temperature is 295, 300, and 305 K at HHR, FUL and CNO, respectively, from both WRF simulations and observations. For the inland stations of CNO and FUL, the WRF control simulations show slight underestimation of daily highest temperature during the days in July of 2018. At the near coast station of HHR, the WRF control simulation shows better performance in predicting daily highest values in summer.

During the winter month of January 2019, the WRF-simulated temperature values has better performance at the HHR station compare to the two other stations; the model performance at this station during January 2019 (R = 0.89) is slightly better than in July 2019 (R = 0.87) as well. The model predictions of temperature at CNO and FUL stations during July 2019 are also better than the predictions during January 2019. The daily peak values are in better agreement with observations towards the end of the month of January 2019 at all stations; the model tends to overpredict the minimum values during this month.

The wind speed in summer shows distinct diurnal variation from both the WRF simulation and observation at all three stations with a strong sea breeze in the early afternoon. Daily maximum wind speed values show slight variations during the summer month of July 2019, unlike the winter month of January 2019 (e.g. from 2.5 to 12.5 m s^{-1} during January at CNO station). The model performance in predicting the wind speed is significantly better during summer month of July 2019 compared to the winter month of January 2019 at all stations; R values change from 0.82, 0.73, and 0.78 in July 2019, at CNO, FUL, and HHR stations, respectively, to 0.46,0.41,0.37 in January 2019. The model underestimates the daily peak wind speed values at the HHR station during the entire month of July 2019.

The WRF model has predicted the water vapor mixing ratio trends fairly well at all stations. The observations and predictions are in good agreement during winter with correlation coefficients of 0.83, 0.86, and 0.87 in January 2019 at CNO, FUL, and HHR stations, respectively; the corresponding values for the month of July are 0.61, 0.63, and 0.54. The WRF control run yields comparable magnitude of water vapor mixing ratio in summer without the general underestimation issue that occur in winter months. For both summer and winter months, the WRF control simulation did not capture a few episodes of sudden shift between dryness and wetness.

Table IX-3-3

WRF performance statistics for the seasonal average of June, July and August 2018 at 15 NWS stations

	Control	Pleim-Xiu Land Surface Scheme	High Spatial Resolution	High Vertical Resolution
2m Temperature Mean OBS (K)	299.1	299.1	299.1	299.1
2m Temperature Mean SIM (K)	297.6	297.7	298.9	297.5
2m Temperature Bias (K)	0.3	0.5	-0.1	0.3
2m Temperature Gross Error (K)	1.6	1.5	1.7	1.6
2m Temperature RMSE (K)	2.2	1.9	2.2	2.2
Water vapor mixing ratio Mean OBS (kg/kg)	11.2	11.2	11.2	11.2
Water vapor mixing ratio Mean SIM (kg/kg)	10.9	11.2	11.6	10.9
Water vapor mixing ratio Bias (kg/kg)	0.2	0.5	0.4	0.2
Water vapor mixing ratio Gross Error (kg/kg)	1.4	1.4	1.5	1.4

Water vapor mixing ratio RMSE (kg/kg)	2.4	2.4	2.6	2.4
Wind Speed Mean OBS (m/s)	2.8	2.8	2.8	2.8
Wind Speed Mean PRD (m/s)	2.4	2.4	2.5	2.4
Wind Speed Bias (m/s)	-0.3	-0.4	-0.3	-0.3
Wind Speed Gross Error (m/s)	1.1	1.1	1.2	1.1
Wind Speed RMSE (m/s)	1.5	1.4	1.5	1.5

Table IX-3-4

WRF performance statistics for the seasonal average of December 2018, and January and February 2019 at 15 NWS stations

	Control	Pleim Xiu	High Spatial resolution	High Vertical resolution
2m Temperature Mean OBS (K)	286.7	286.7	286.7	286.7
2m Temperature Mean SIM (K)	286	285	286.5	286
2m Temperature Bias (K)	0	-1	-0.2	0
2m Temperature Gross Error (K)	1.7	1.9	1.9	1.7
2m Temperature RMSE (K)	2.2	2.4	2.5	2.2
Water vapor mixing ratio Mean OBS (kg/kg)	5.9	5.9	5.9	5.9
Water vapor mixing ratio Mean SIM (kg/kg)	4.8	5.2	5	4.9
Water vapor mixing ratio Bias (kg/kg)	-0.8	-0.4	-0.9	-0.7
Water vapor mixing ratio Gross Error (kg/kg)	1.2	1.2	1.2	1.2
Water vapor mixing ratio RMSE (kg/kg)	1.7	1.7	1.6	1.7
Wind Speed Mean OBS (m/s)	2.1	2.1	2.1	2.1
Wind Speed Mean PRD (m/s)	2.1	1.9	2	2.1
Wind Speed Bias (m/s)	0	-0.1	0	0
Wind Speed Gross Error (m/s)	1.4	1.4	1.5	1.5
Wind Speed RMSE (m/s)	1.9	1.9	2	1.9

[*] To save computing time, only 4 month simulations – April 2018, July 2018, October 2018 and January 2019 are counducted for the WRF simulation with 1 X 1 km.

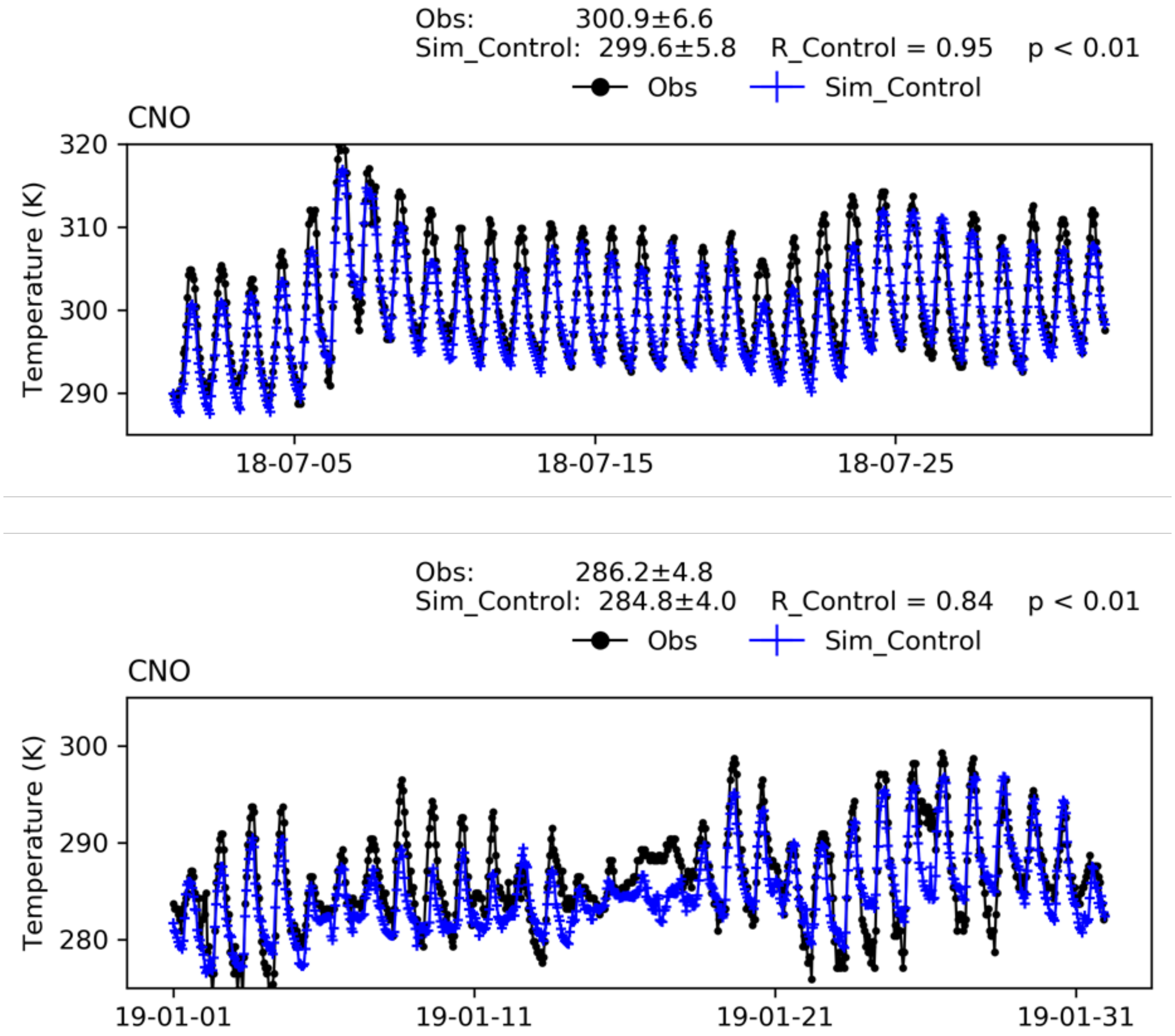
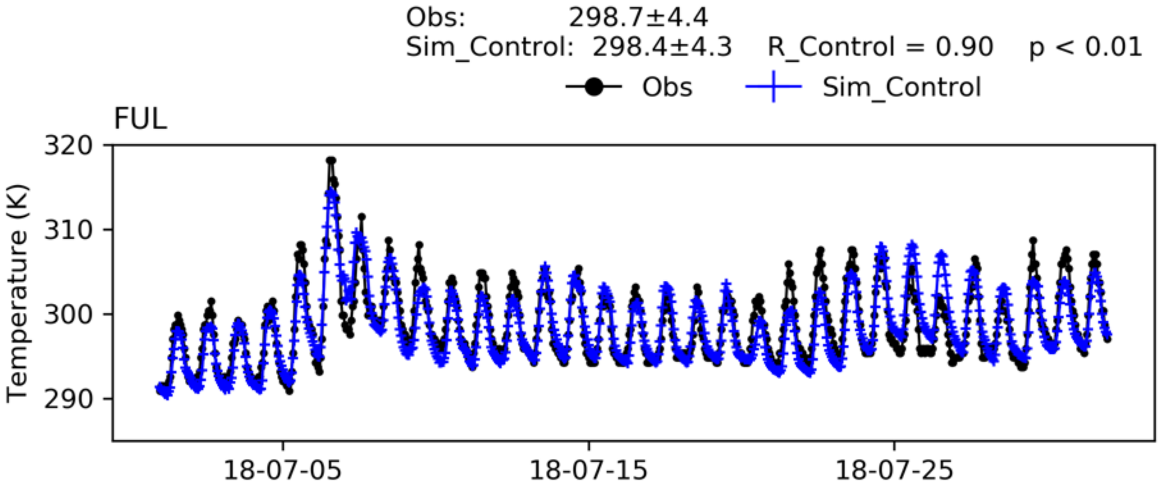


Figure IX-3-12

Time series of hourly temperature from measurement and WRF control simulations at Chino (CNO) station for July 2018 and January 2019



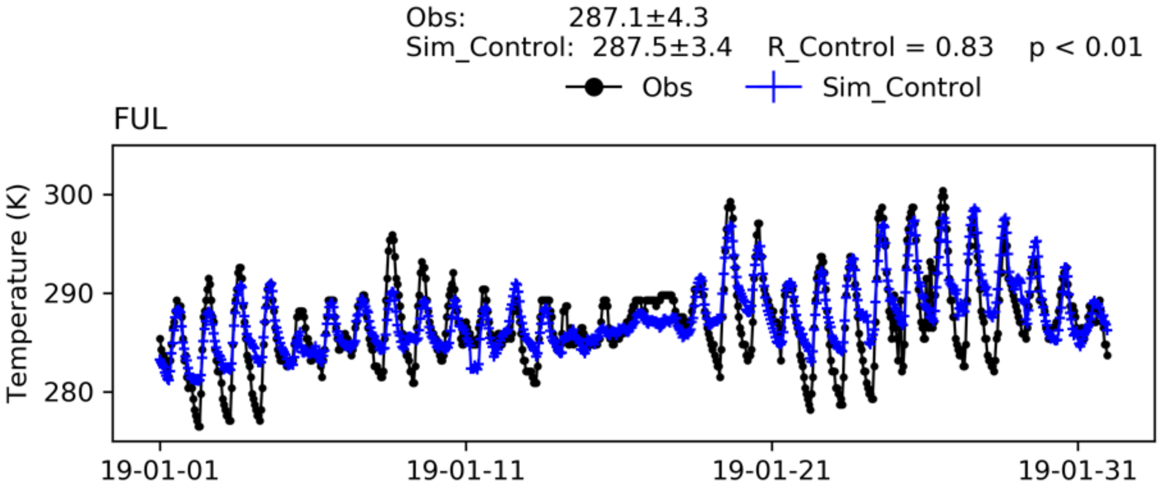


Figure IX-3-13

Time series of hourly temperature from measurements and WRF control simulations at Fullerton (FUL) station for July 2018 and January 2019

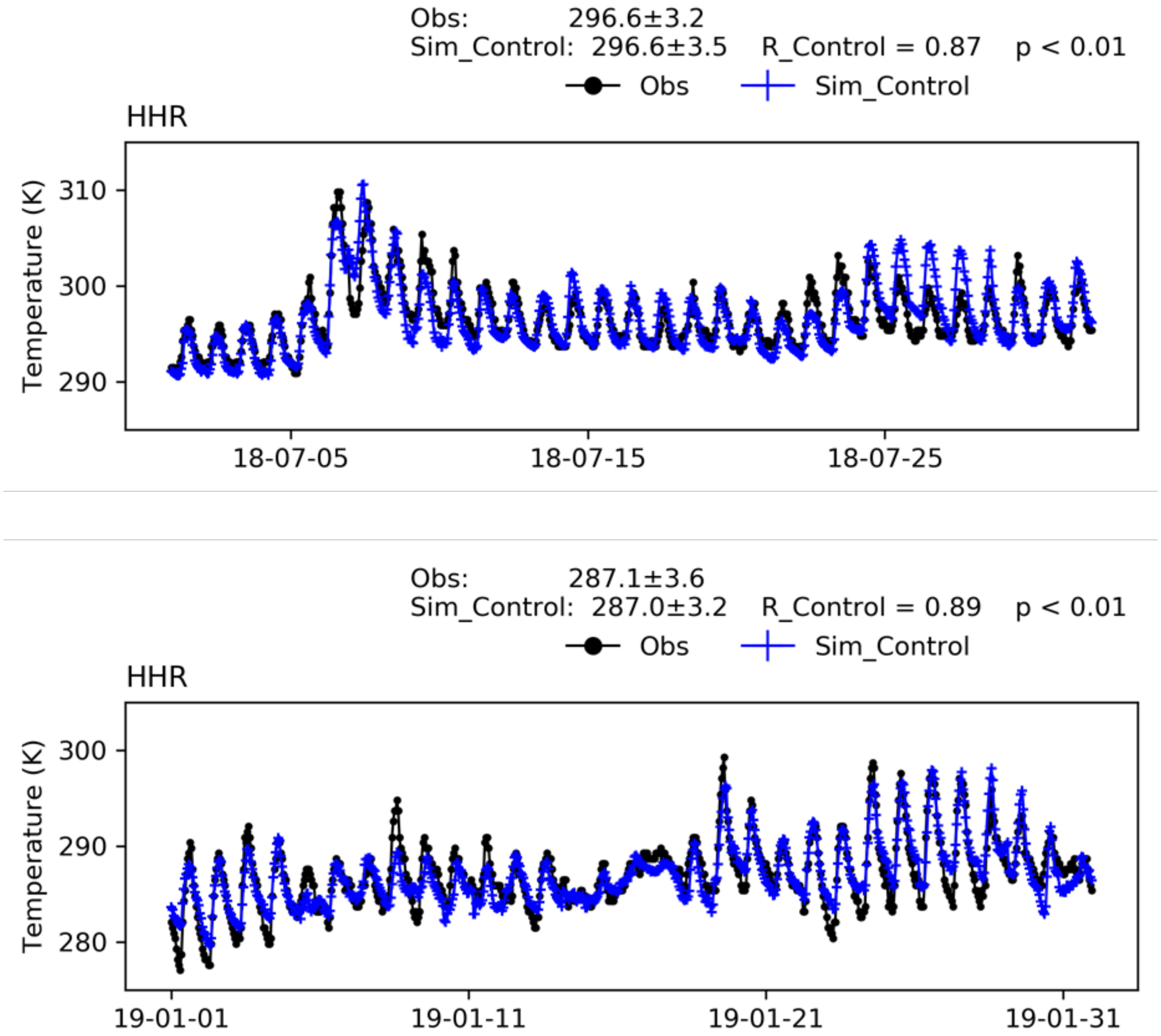


Figure IX-3-14

Time series of hourly temperature from measurements and WRF control simulations at Hawthorne (HHR) station for July 2018 and January 2019

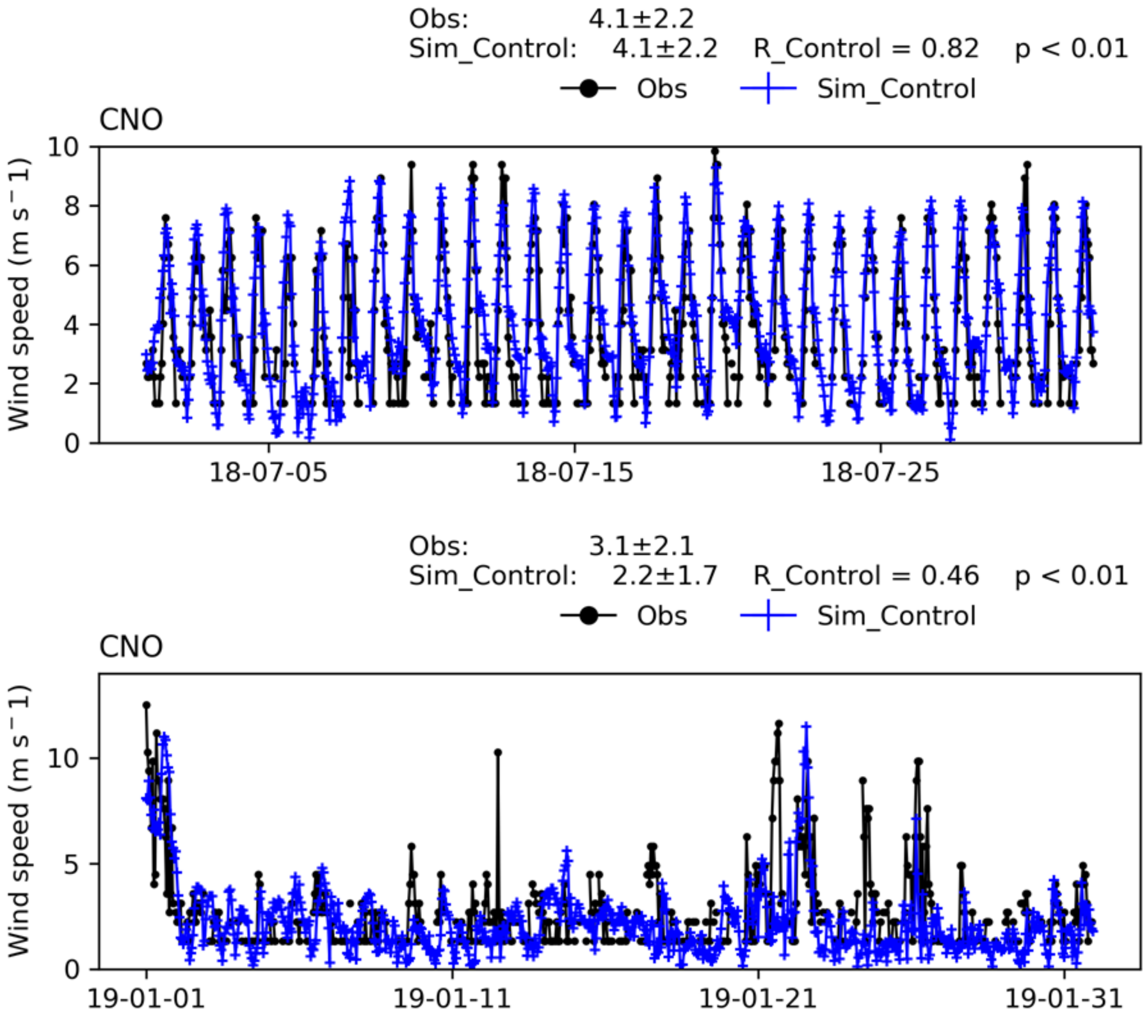


Figure IX-3-15

Time series of hourly wind speed from measurements and WRF control simulations at Chino (CNO) station for July 2018 and January 2019

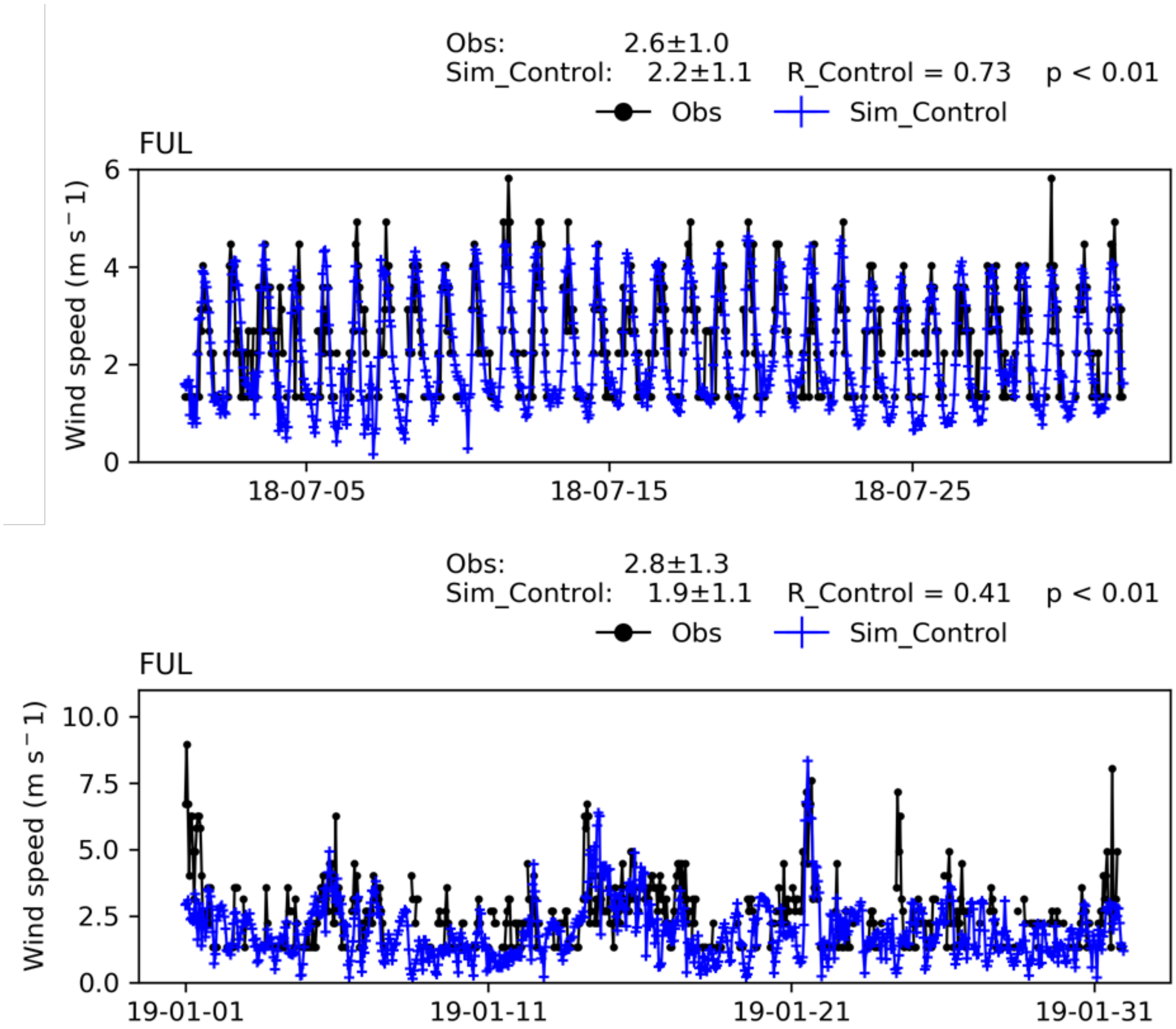


Figure IX-3-16

Time series of hourly wind speed from measurements and WRF control simulations at Fullerton (FUL) station for July 2018 and January 2019

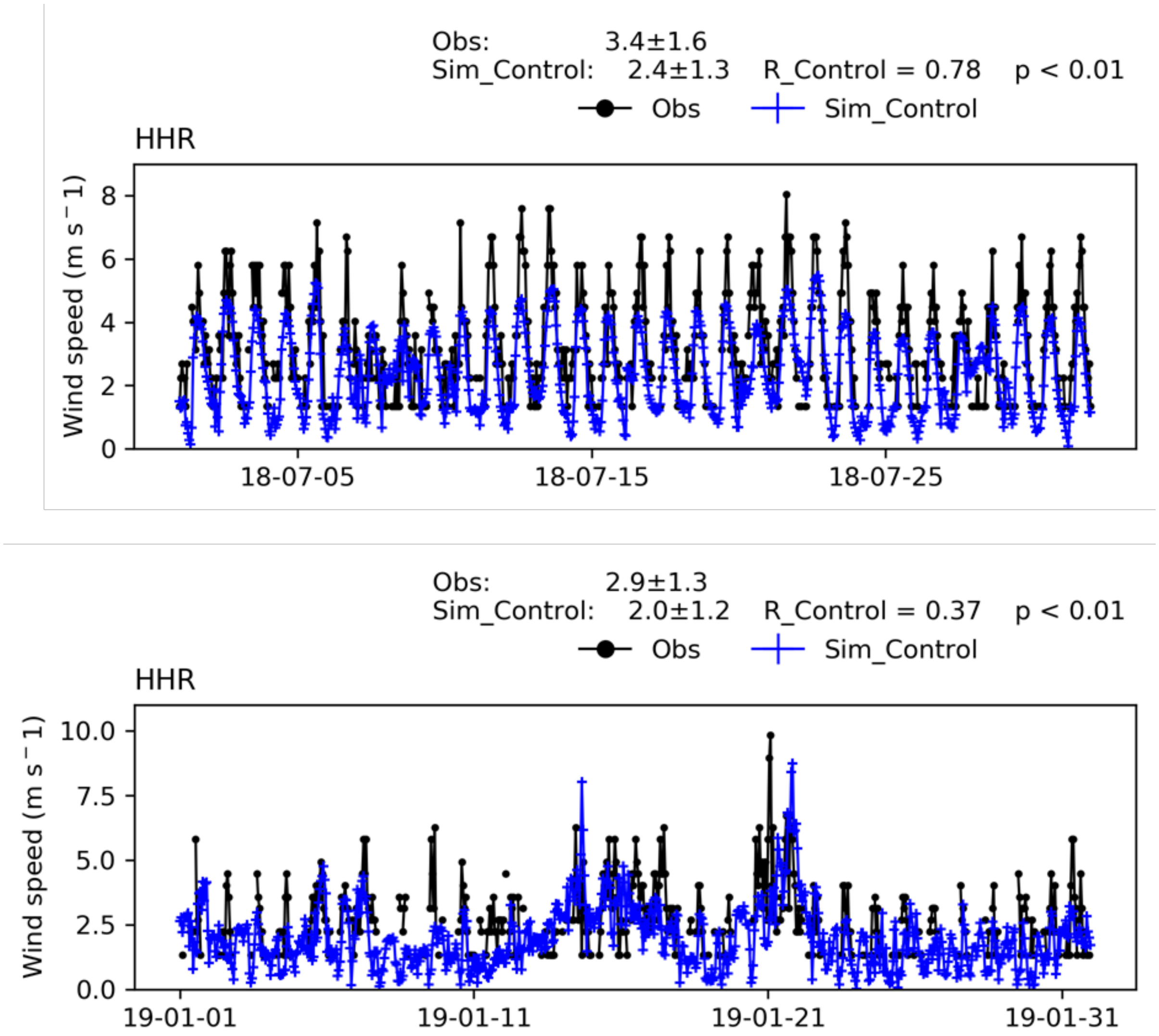


Figure IX-3-17

Time series of hourly wind speed from measurements and WRF control simulations at Hawthorne (HHR) station for July 2018 and January 2019

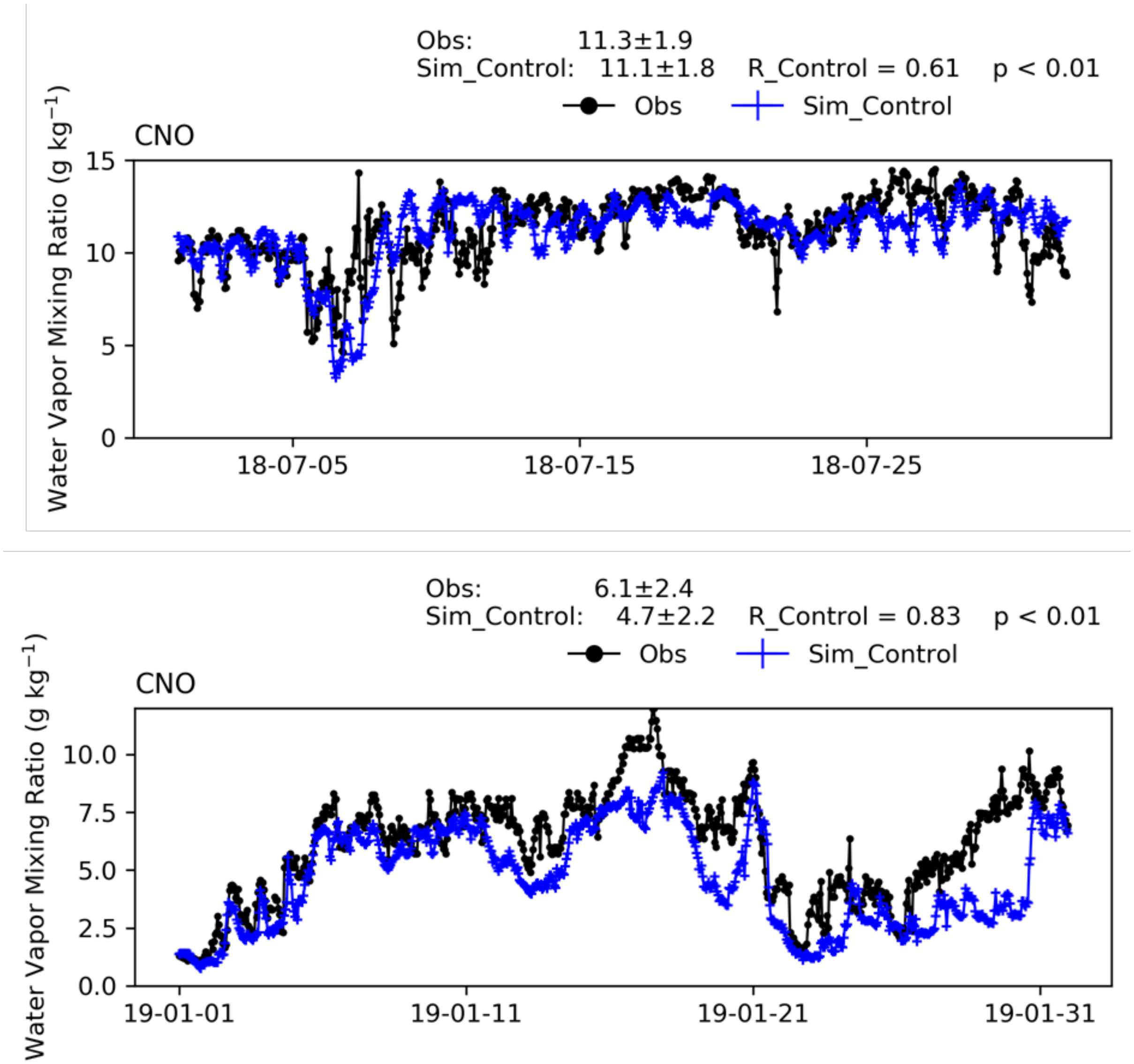


Figure IX-3-18

Time series of hourly water vapor mixing ratio from measurements and WRF control simulations at Chino (CNO) station for July 2018 and January 2019

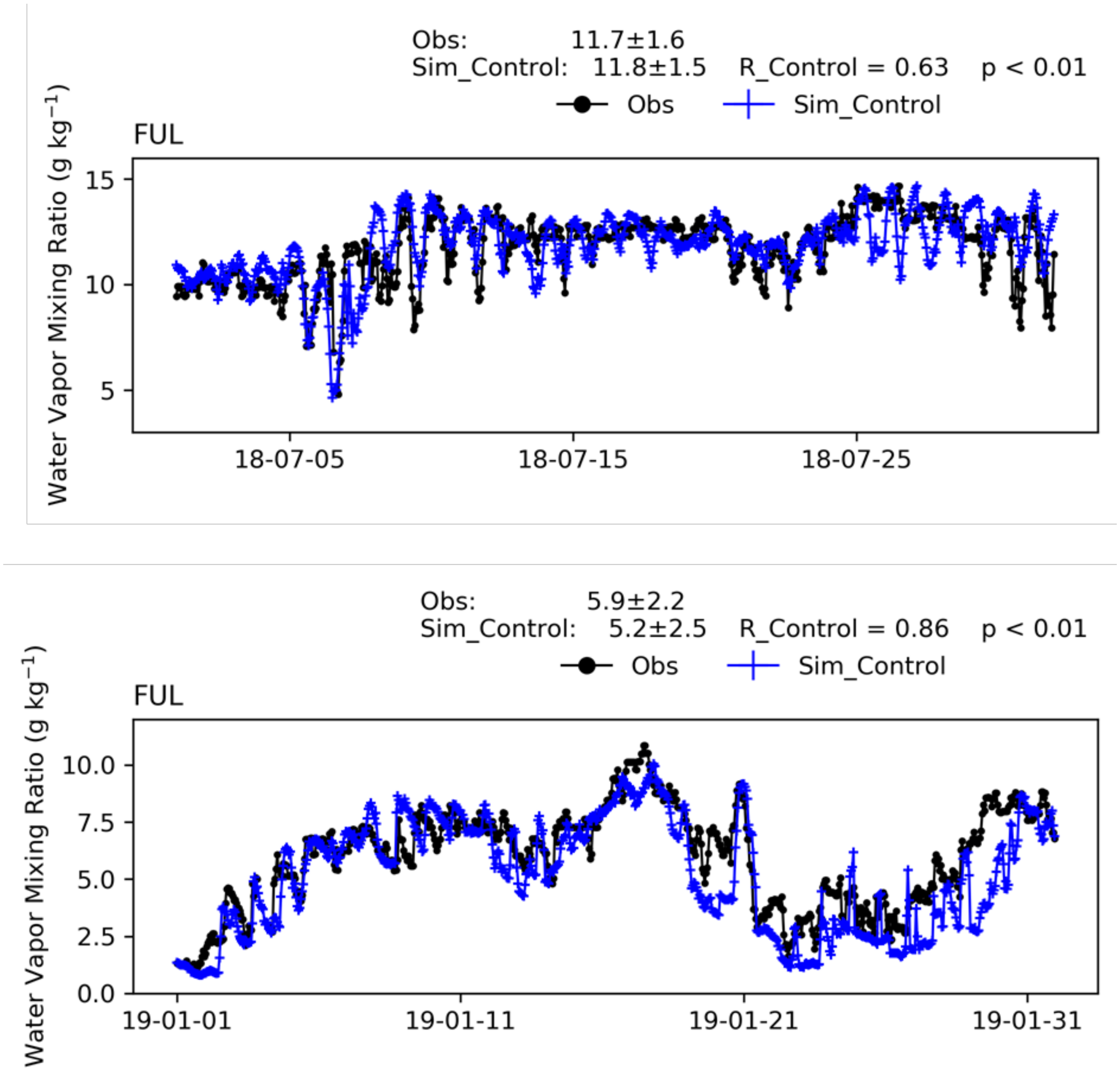


Figure IX-3-19

Time series of hourly water vapor mixing ratio from measurements and WRF control simulations at Fullerton (FUL) station for July 2018 and January 2019

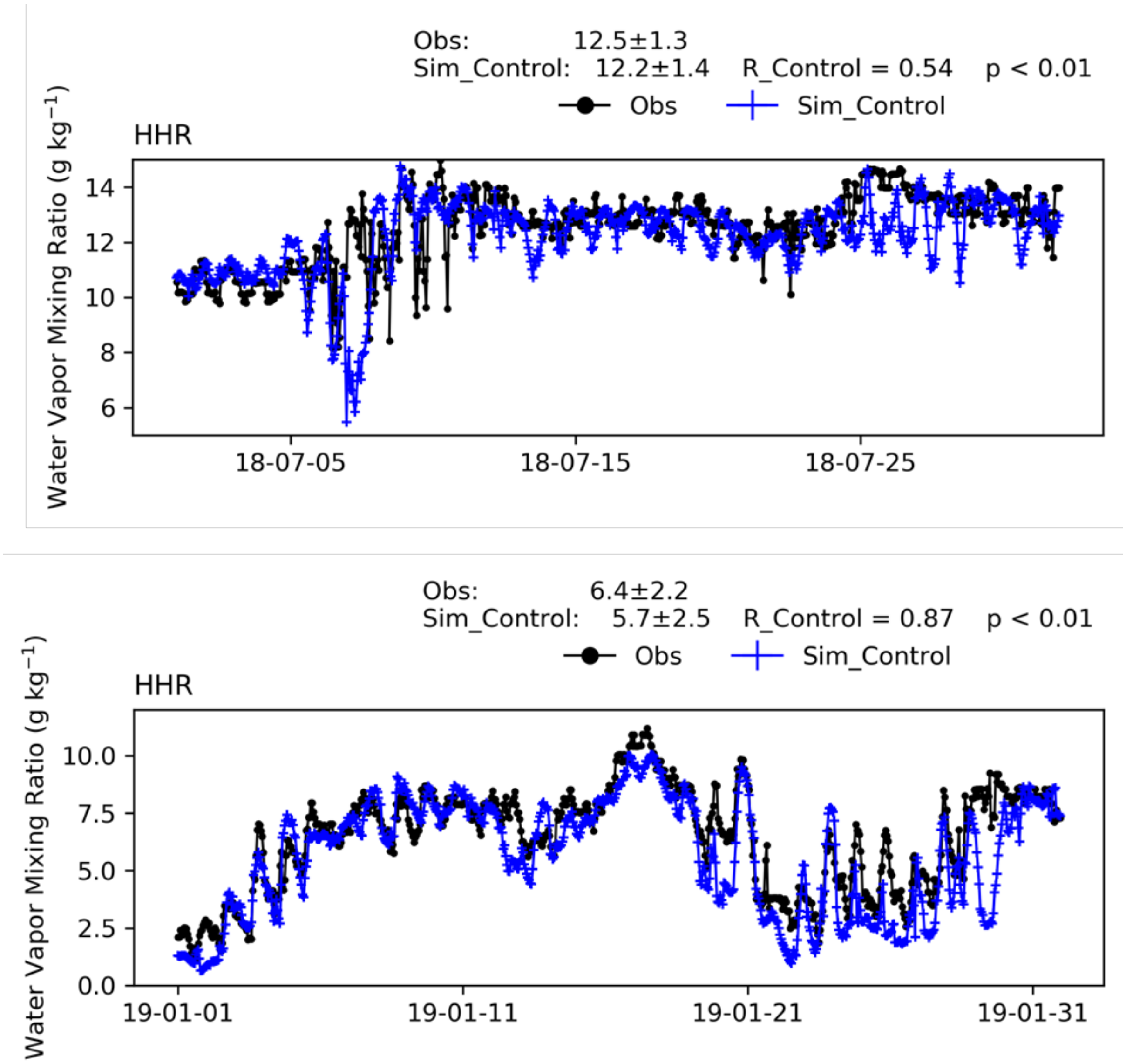


Figure IX-3-20

Time series of hourly water vapor mixing ratio from measurements and WRF control simulations at Hawthorne (HHR) station for July 2018 and January 2019

IX.3.5 Model Performance Evaluation of Meteorological fields – Diurnal variations

Monthly average diurnal variations of simulated temperature and water vapor mixing ratio were compared against measurements at three locations as provided in Figures IX-3-21 - IX-3-22. The seasonal differences between summer and winter, as represented by July and January, respectively, and the diurnal variations were well reproduced in the WRF control simulation. For example, the daily highest temperature occurs at around 14:00 local time for both summer (~305 K) and winter (~292 K). The water vapor mixing ratio does not exhibit distinct diurnal variation as does the temperature, but it does show a slight dryness in the early afternoon such as between 13:00 – 15:00 local time during summer.

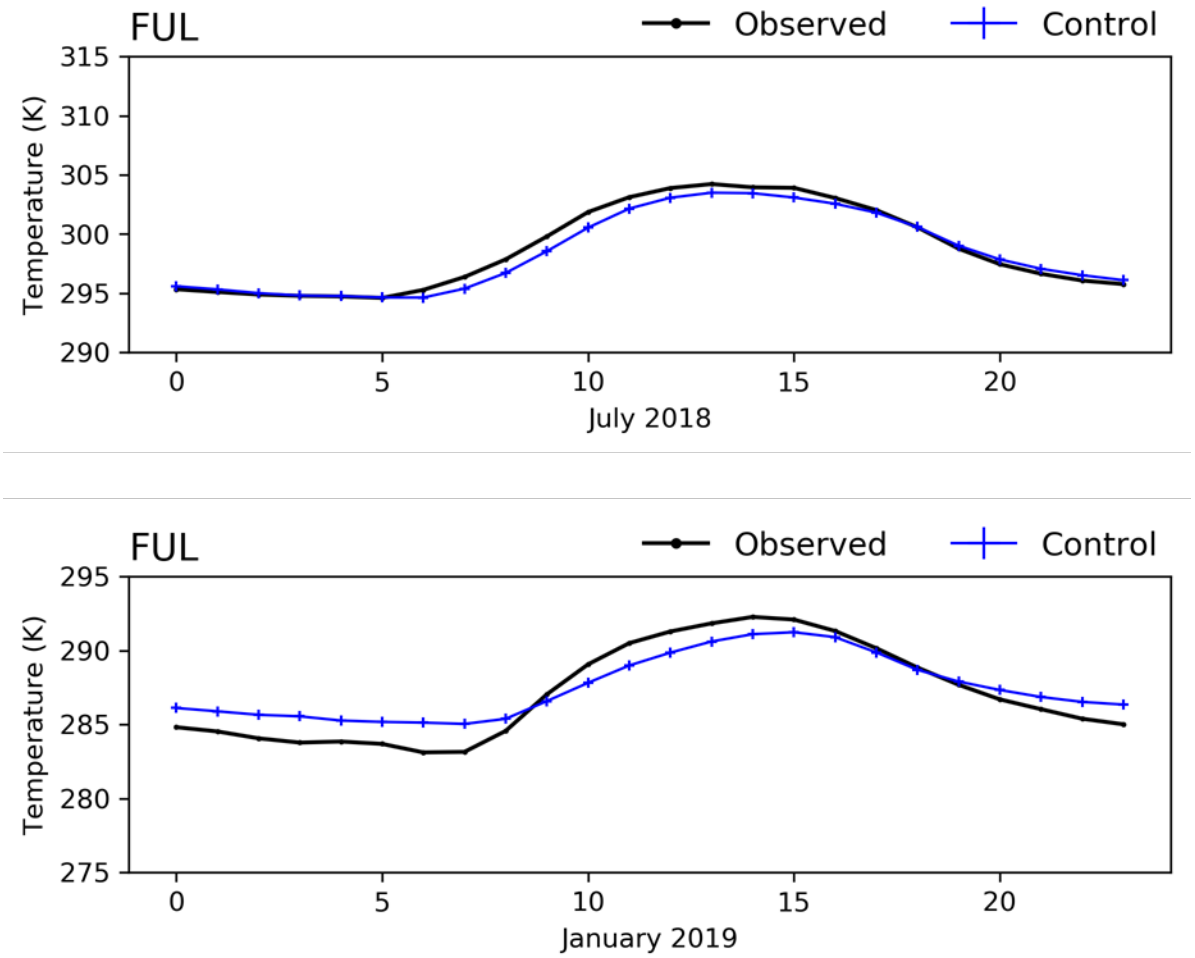


Figure IX-3-21

Measured vs simulated composite diurnal temperature variation at Fullerton (FUL) station for July 2018 and January 2019

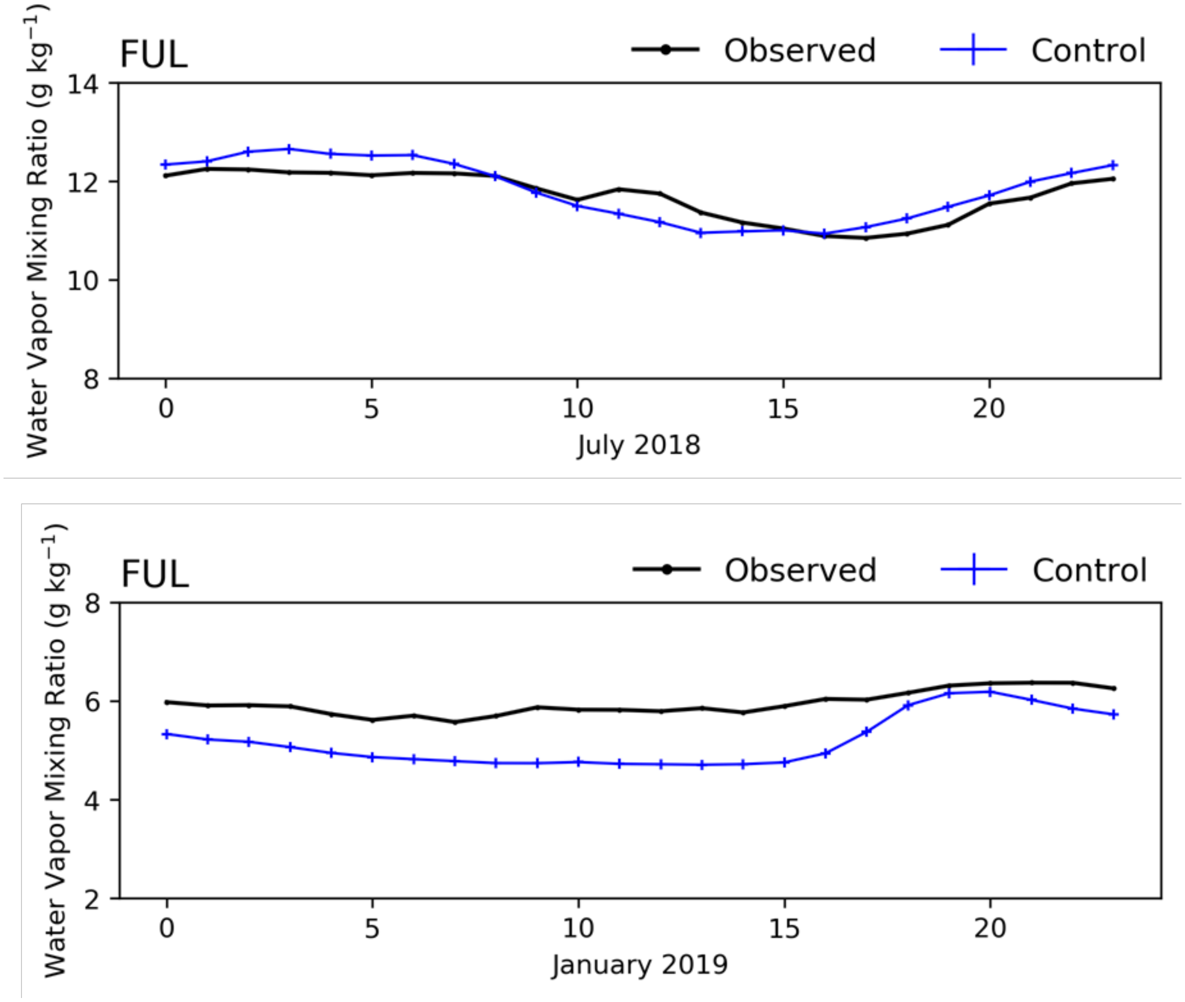
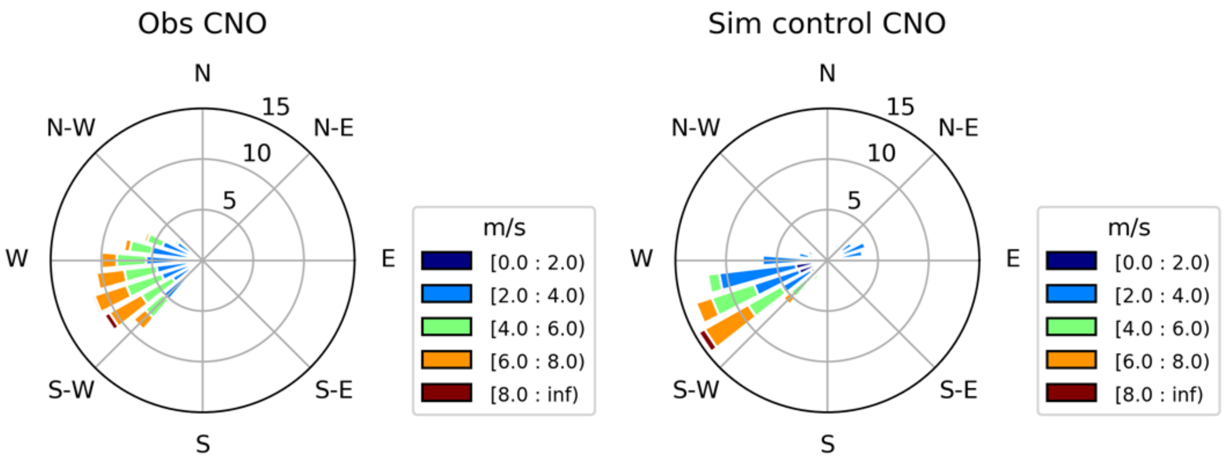


Figure IX-3-22

Water vapor mixing ratio at Fullerton (FUL) station from measurement and WRF control simulation for July 2018 and January 2019

IX.3.6 Meteorological Model Performance – Wind Rose

The measured and WRF control simulated wind rose at each station for 1-year period of May 2018– April 2019 are shown in Figure IX-3-23 – Figure IX-3-27. The wind rose plots for 5 stations are presented. In general, the control simulations reproduce the dominant wind direction as the measurement at each station. For example, the station of CNO, FUL, HHR and ONT all have southwest wind as prevailing wind direction showed from both observations and simulations. The wind direction is mostly from the southeast at the BUR station, as presented in both observations and simulations. For the wind speed, among the five stations, the FUL and BUR stations have calm winds, mostly under 6 m/s, while other stations showed stronger wind between 6 - 8 m/s. In general, the WRF control simulation underestimates the observed wind speed at HHR and ONT stations.

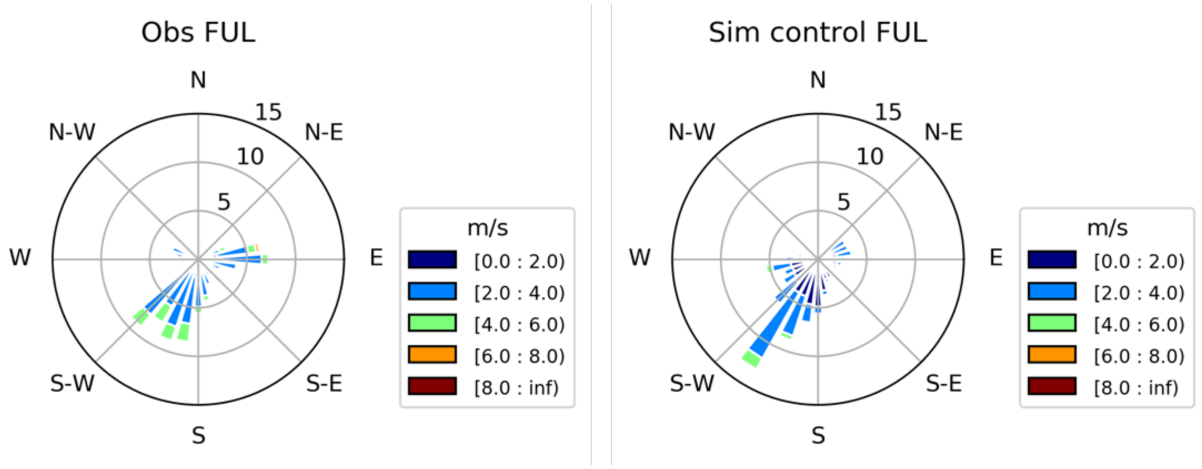


Obs CNO

Sim control CNO

Figure IX-3-23

Wind rose from measurement and WRF control simulation at Chino (CNO) station during MATES V



Obs FUL

Sim control FUL

Figure IX-3-24

Wind rose from measurement and WRF control simulation at Fullerton (FUL) station during MATES V

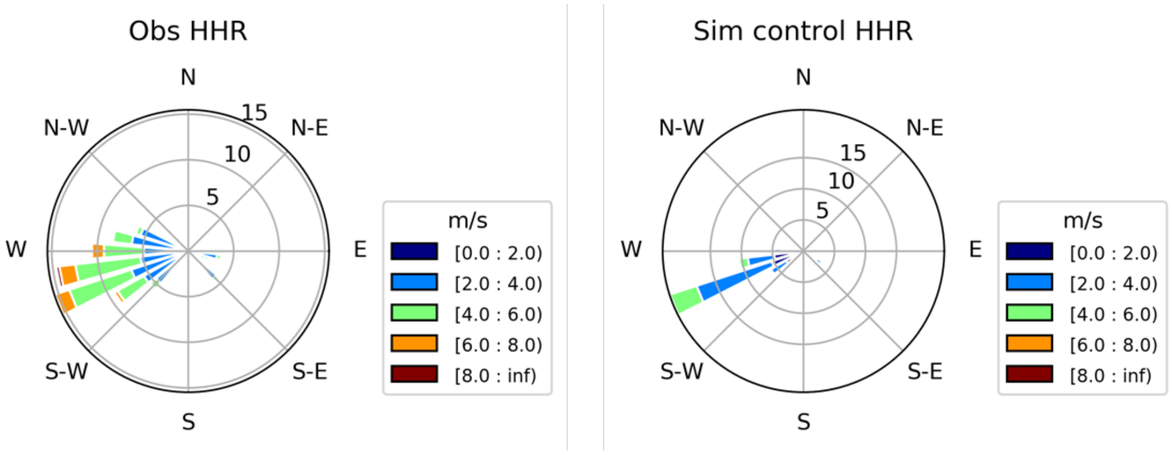


Figure IX-3-25

Wind rose from measurement and WRF control simulation at Hawthorne (HHR) station during MATES V

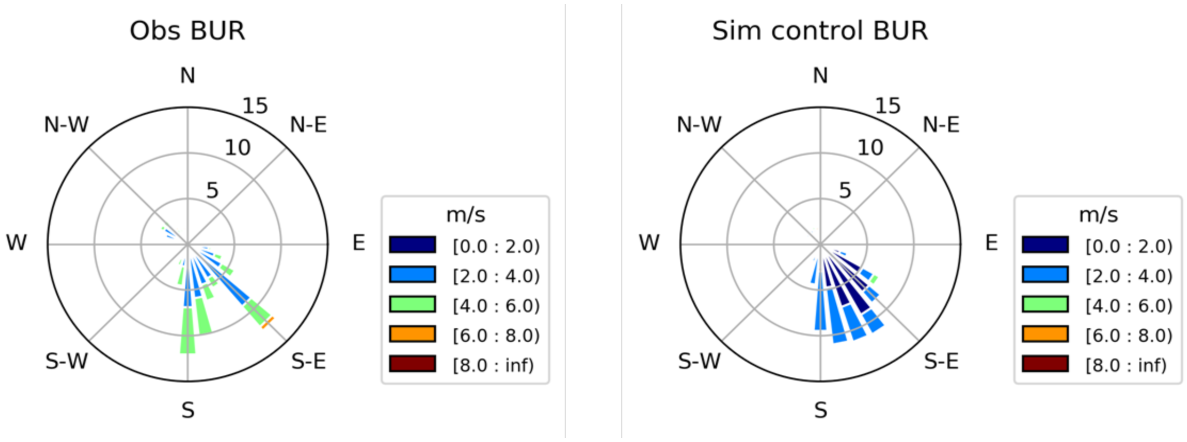


Figure IX-3-26

Wind rose from measurement and WRF control simulation at Burbank (BUR) station during MATES V

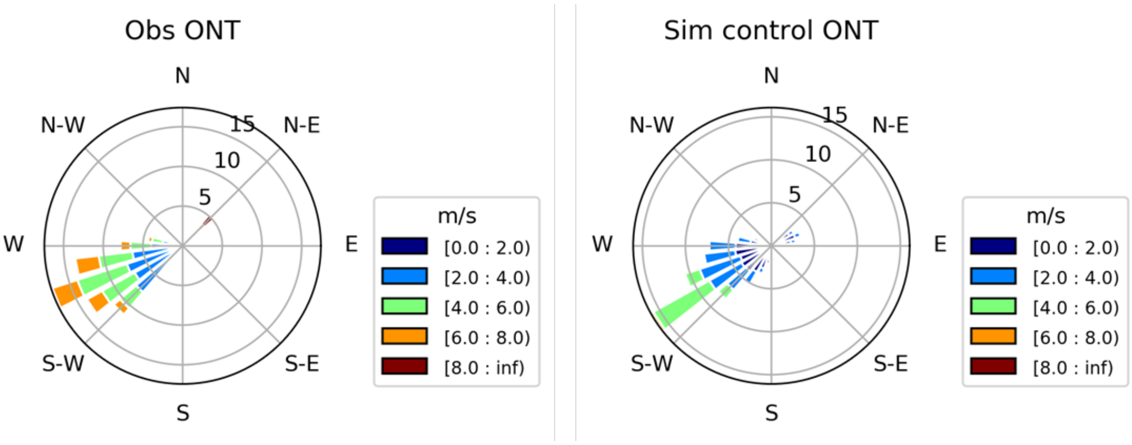


Figure IX-3-27

Wind rose from measurement and WRF control simulation at Ontario (ONT) station during MATES V

IX.3.7 Meteorological Model Performance – Planetary Boundary Layer Height (PBLH)

Time series of hourly PBLH from Ceilometer measurements and WRF control simulations for July 2018 at ONT and IRV are shown in Figure IX-3-28. The simulations match very well with the Ceilometer PBL height in general except the Ceilometer reported several very high values such as values higher than 2 km. The very high PBL values from the Ceilometer might be caused by some contamination from clouds. Time series of seasonal composed PBLH diurnal variation from measurement and the WRF control simulations for summer season (June, July and August of 2018) at ONT and IRV shown in Figure IX-3-29. The PBL height development processes from midnight through daytime toward late night are well captured by the simulations. For example, at ONT, the PBL height is lowest (~200 m) during early morning and develops to higher values of ~800 m around noon time because convection and vertical mixing are stronger, then slowly decays to the lower heights during the late afternoon and early night.

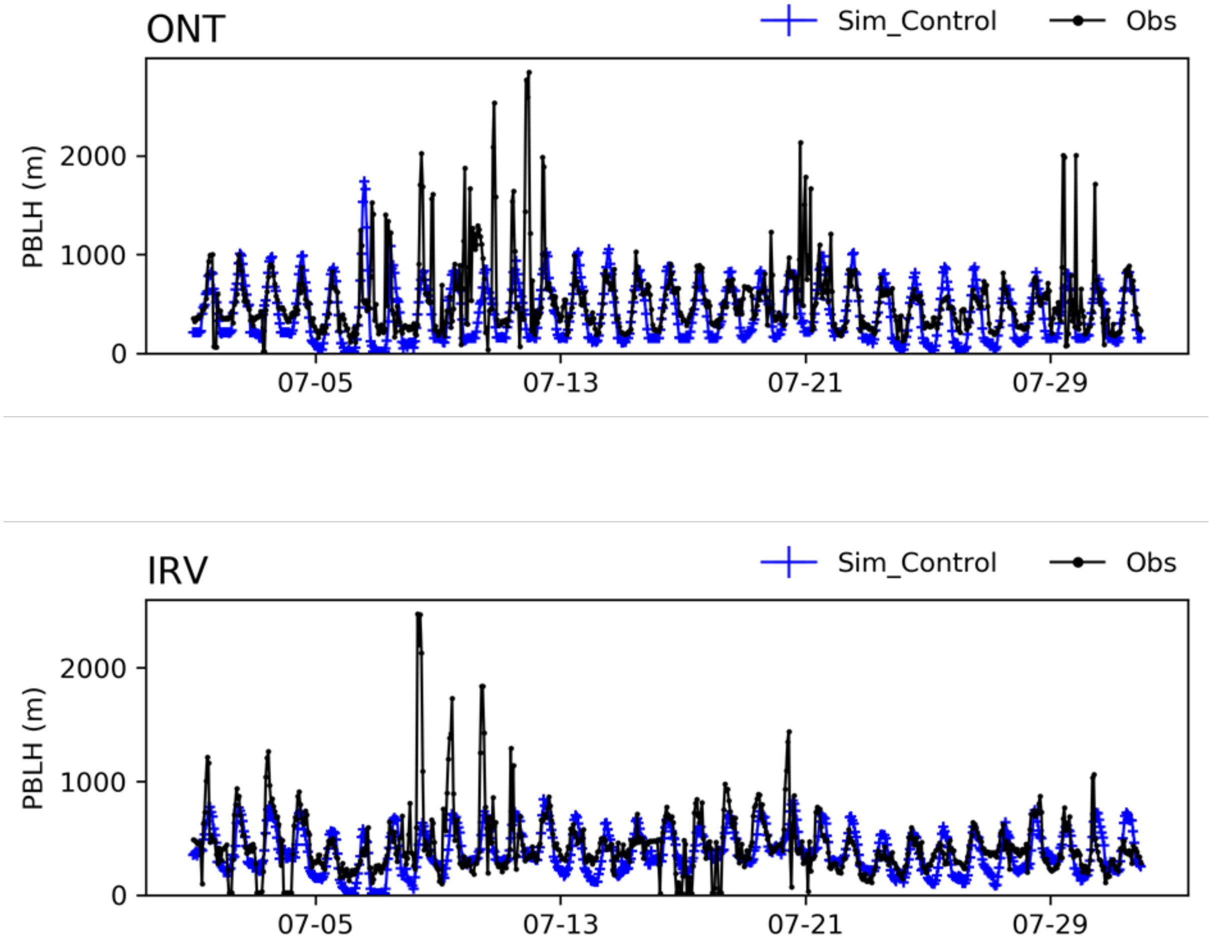


Figure IX-3-28

Time series of hourly PBLH from ceilometer measurement and WRF control simulations for July of 2018 at Ontario (ONT) station and at Irvine (IRV) station

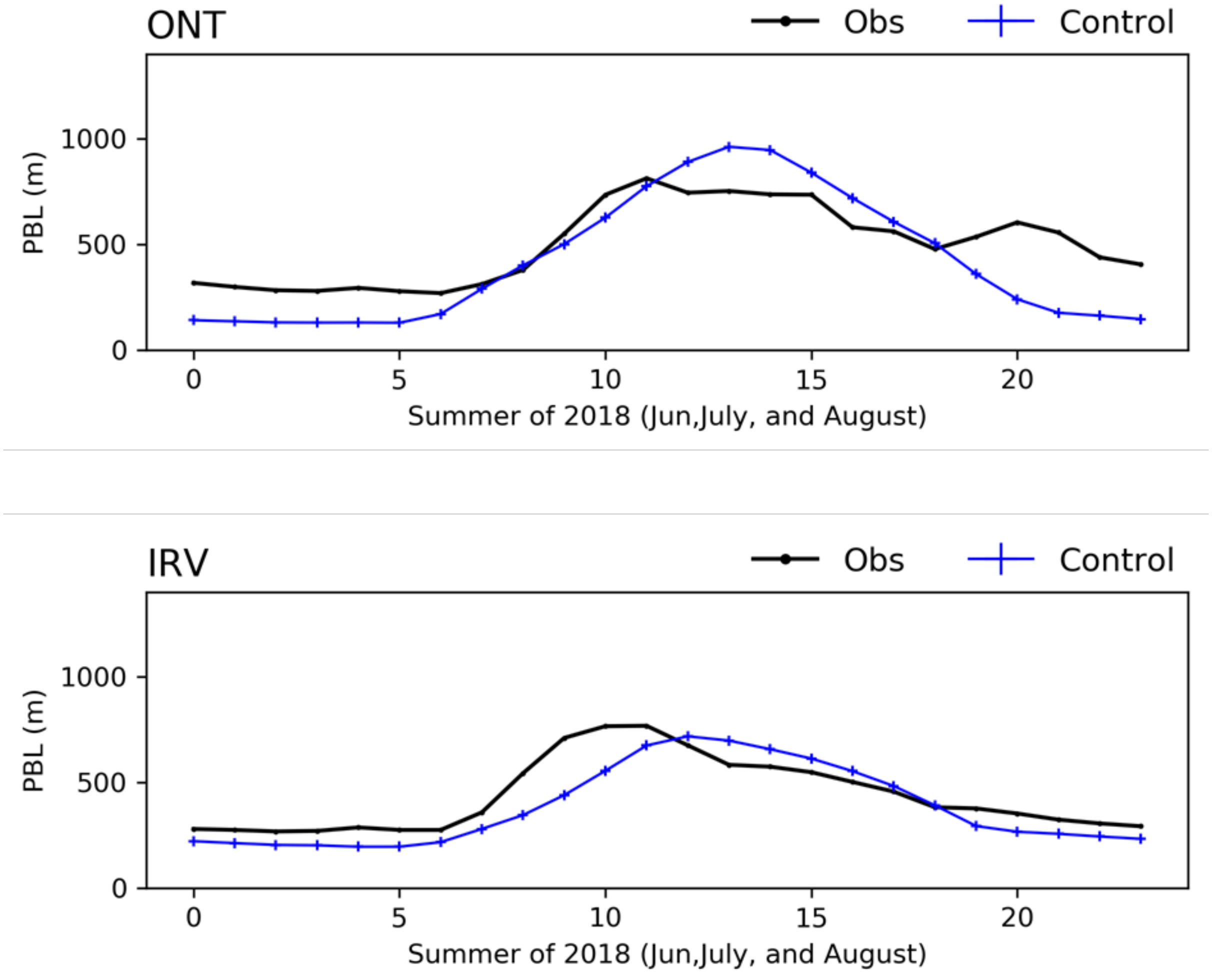


Figure IX-3-29

Time series of seasonal composed PBLH diurnal variation from ceilometer measurement and WRF control simulations for summer season (Jun, July and August of 2018) at Ontario (ONT) station and Irvine (IRV) station

IX.3.8 Vertical Dispersion

The WRF output was converted to the CAMx reactive tracer (RTRAC) format using ‘wrfcamx_v.7’ software. Vertical diffusivity (*Kv*), which is critical in vertical dispersion, was computed using CMAQ vertical diffusivity scheme with a minimum value of 1.0 m^2/sec. The number of vertical layers was reduced to 18 layers from the 30-layer configuration used in the WRF. The layers whose height was below 2 km from the ground level were remained unchanged. The layers above 2 km were collapsed to four layers in order to reduce computation cost. The vertical structure was chosen carefully to optimize computational efficiency and numerical accuracy based on an extensive sensitivity study evaluating the impact of vertical layer structure using various numbers of computational layers.

There are three *Kv*-patch options: 1) Land use-based patch to enhance mixing over urban areas; 2) the OB70 patch applies the O'Brien 70 [OB70] (O'Brien, 1970) profile through a user specified surface layer depth. Its purpose is to maintain higher vertical diffusivity during nighttime hours to help reduce over predictions in the buildup of NOx; 3) the cloud patch extends the daytime PBL vertical diffusivity profile through capping cloud tops as a means to prohibit artificial collapse of the boundary layer when convection develops and to include convective venting to the free troposphere. Since the SoCAB is mostly under stable atmosphere especially during pollution episodes, it is recommended to avoid using the cloud patch. In all, after careful evaluation of various sensitivity analyses, the vertical dispersion profile used in the final MATES V CAMx RTRAC simulations relied on a 16-layer structure using the CMAQ diffusivity scheme overlaid with the *Kv*-patch option. The land use-based patch and OB79 patch are applied with the minimum vertical diffusivity of 1.0 m^2/sec. In the current study, the first and second computational layers, which are centered approximately 20 m and 40 m above ground level, respectively, were subject to the direct modification of the *Kv* through the *Kv* patch.

IX.4 MATES V CAMx Modeling Emissions

An updated version of the 2016 AQMP emissions inventory for the year 2018 provided mobile and stationary source input for the MATES V CAMx RTRAC simulations. On-Road mobile source emissions were updated based the most recent CARB model, EMFAC2017 (CARB, 2017) and adjusted for time-of-day and day-of-week travel patterns based on CalTrans Performance Monitoring System (PeMS) and weigh-in-motion data profiles. The updated inventory also included 2018 reported point source emissions and updated OGV emissions. Table IX-4-1 lists the annual average day emissions for 2018. (A comprehensive breakdown of the planning VOC, NOx, CO, SO2 and particulate emissions for 2018 used in the MATES V simulation is provided in Chapter 3 and Appendix VIII). Table IX-4-1 also includes the MATES IV total suspended particulate matter (TSP) and $PM_{2.5}$ diesel emissions for 2012 for comparison.

Table IX-4-1

Annual Average Diesel/EC Emissions in the SCAB (TPD)

Compound	MATES IV 2012		MATES V 2018	
	$PM_{2.5}$	TSP	$PM_{2.5}$	TSP
EC	11.58	14.74	5.05	7.85
Total Diesel Particulate Matter (DPM)	9.43	10.24	4.53	4.85
DPM per Major Source Category				
On-road	4.97	5.40	2.00	2.11
Off-road	2.94	3.20	1.81	1.98
Ships	0.74	0.78	0.29	0.31
Trains	0.56	0.61	0.30	0.32
Stationary	0.22	0.25	0.14	0.14
Total DPM	9.43	10.24	4.53	4.85

A comparison of the MATES V 2018 $PM_{2.5}$ diesel emissions shows a 52% reduction in emissions from the 2012 emissions used in MATES IV. The most significant area of diesel particulate matter emissions reduction occurs in the on-road categories due to significant DPM reductions from CARB’s Truck and Bus Regulation.

Figures IX-4-1a through IX-4-1x provide the grid-based average modeling emissions for selected toxic pollutant and precursor emissions categories.

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 for 2018 developed for the 2016 RTP/SCS, 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 projected annual emissions from ocean-going vessels (OGV) for 2018 from the CARB 2018 SIP update (CARB, 2018) were also used. Emissions from OGV and commercial harbor craft (CHC) were spatially and temporally resolved using Automatic Identification System (AIS) data. OGV emissions are 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 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.

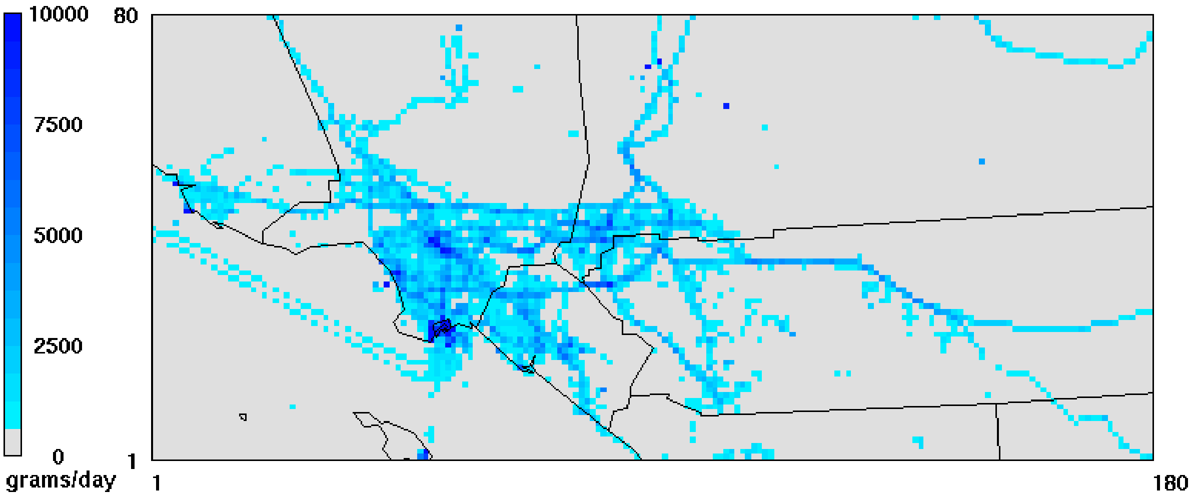


Figure IX-4-1a

Average emissions pattern for diesel PM from all source categories

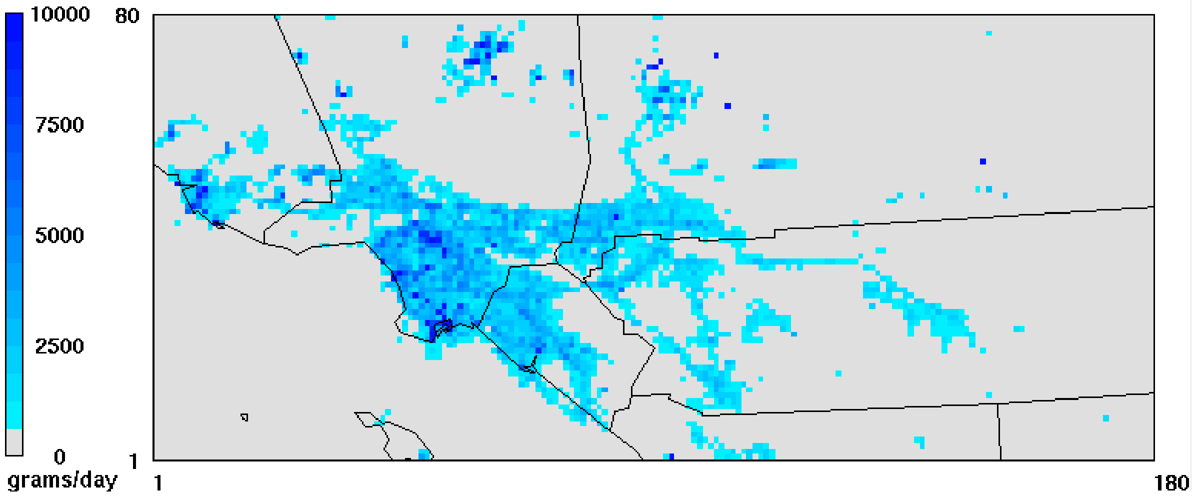


Figure IX-4-1b

Average emissions pattern for elemental carbon

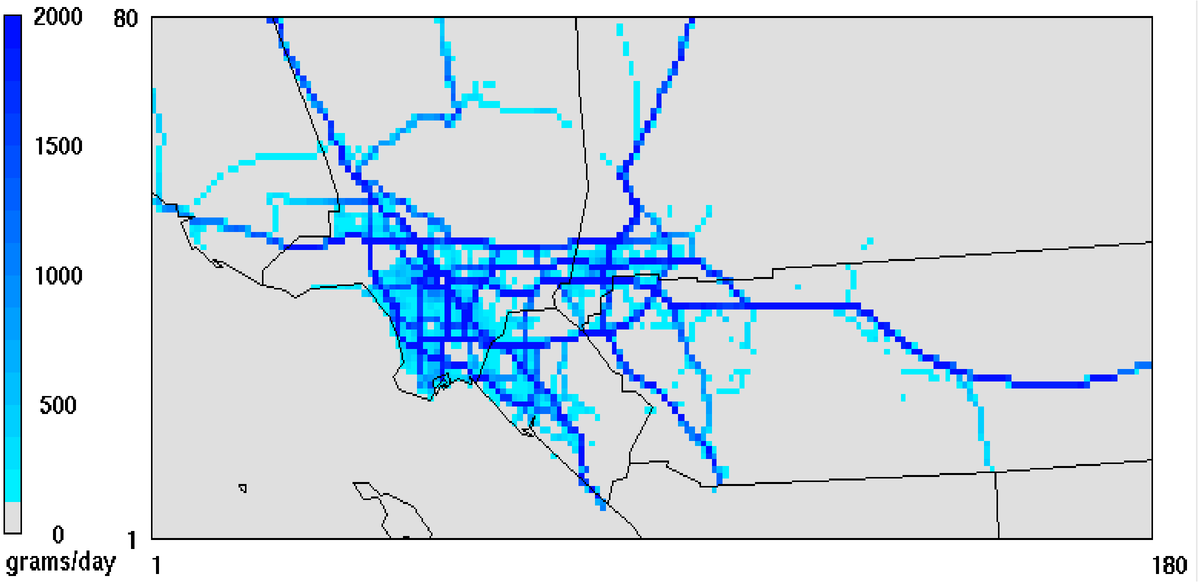


Figure IX-4-1c

Average emissions pattern of on-road diesel PM

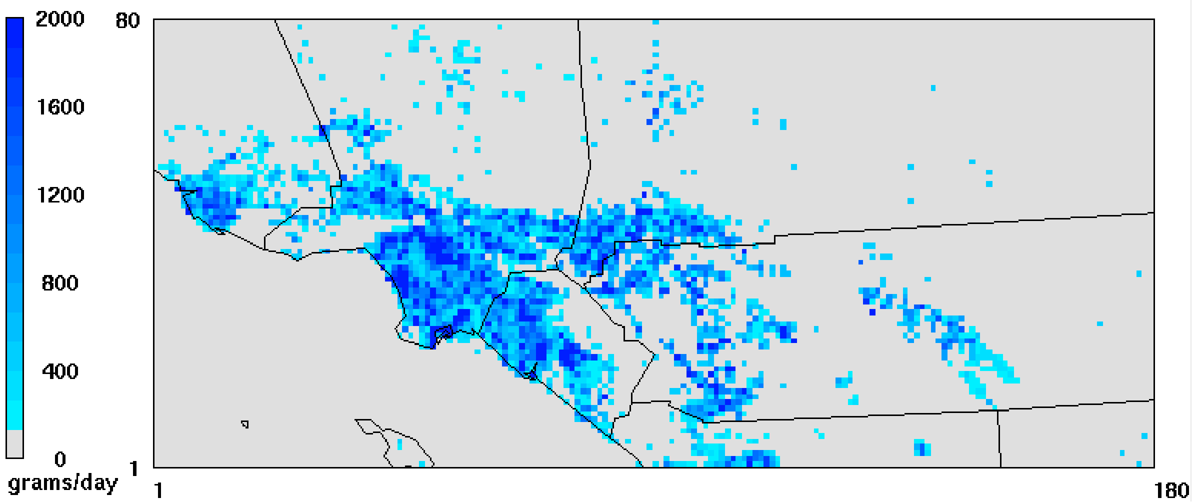


Figure IX-4-1d

Average emissions pattern of off-road diesel PM

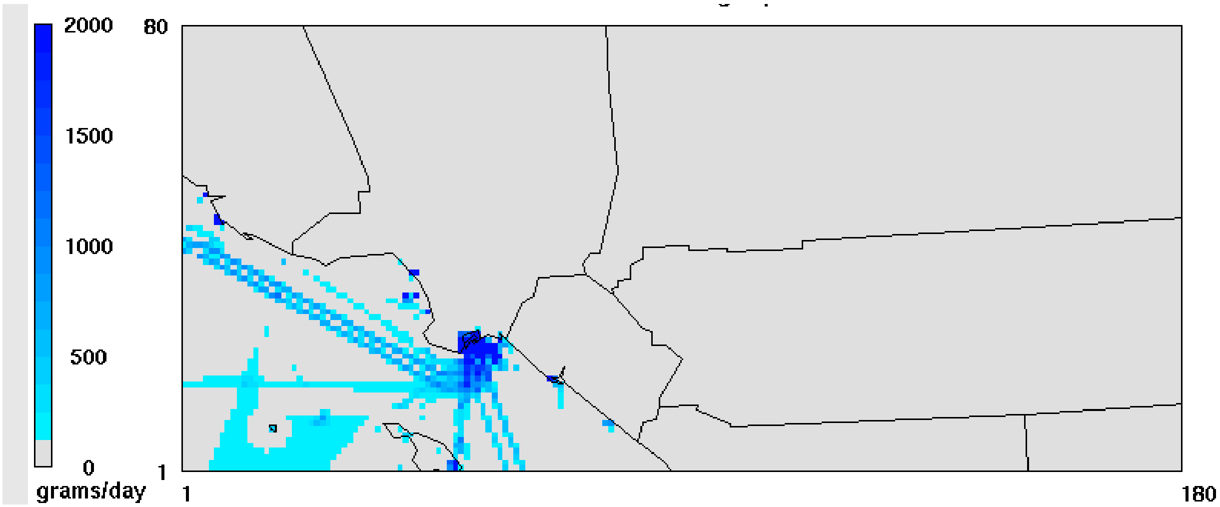


Figure IX-4-1e
Average emissions pattern of diesel PM from OGV and CHC.

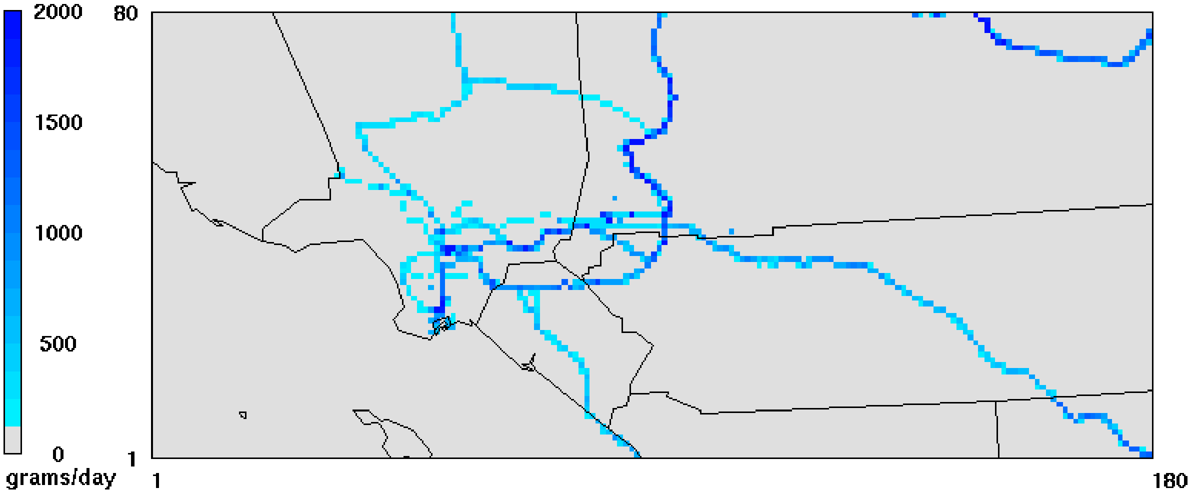


Figure IX-4-1f
Average emissions pattern of diesel PM from trains

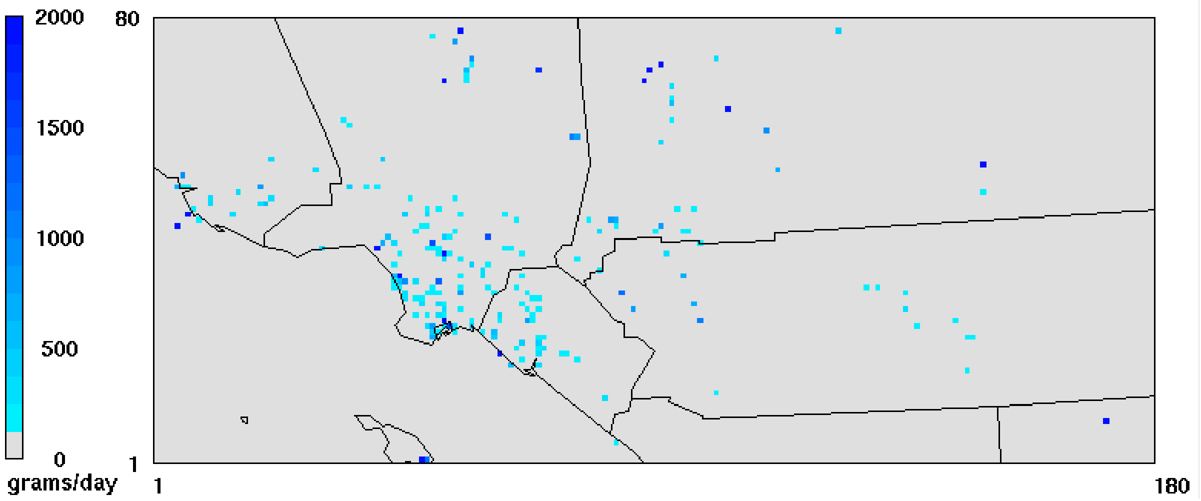


Figure IX-4-1g

Average emissions pattern Diesel PM from stationary sources

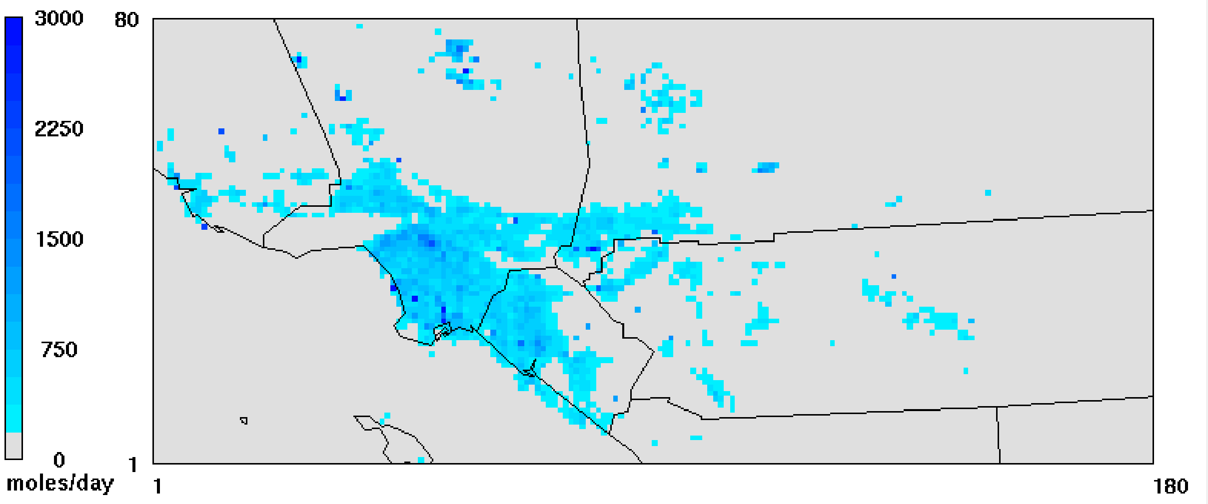


Figure IX-4-1h

Average VOC emissions pattern from all source categories

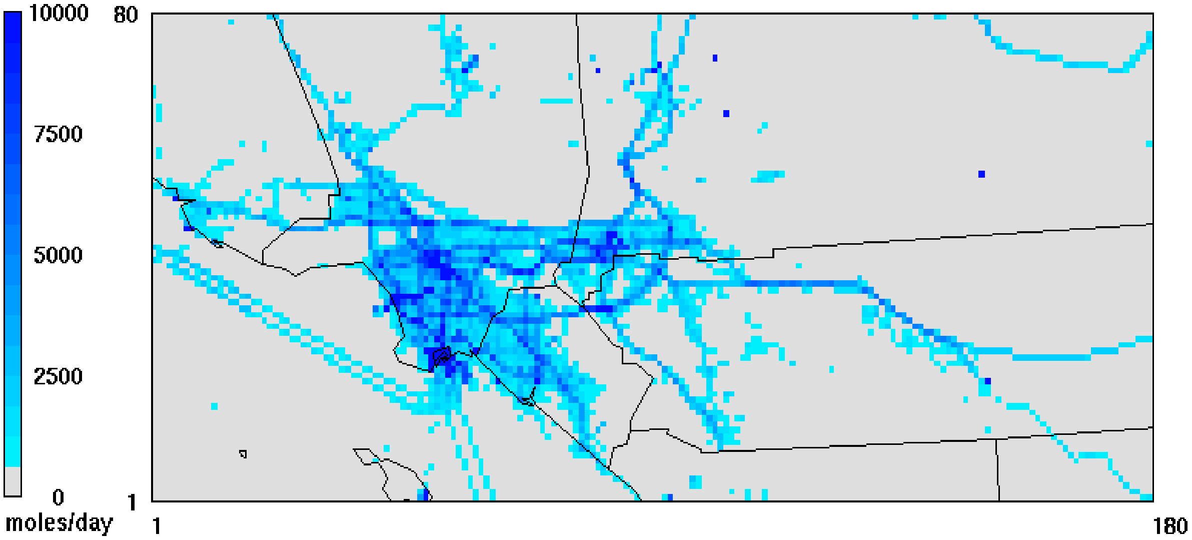


Figure IX-4-1i

Average NOx emissions pattern from all source categories

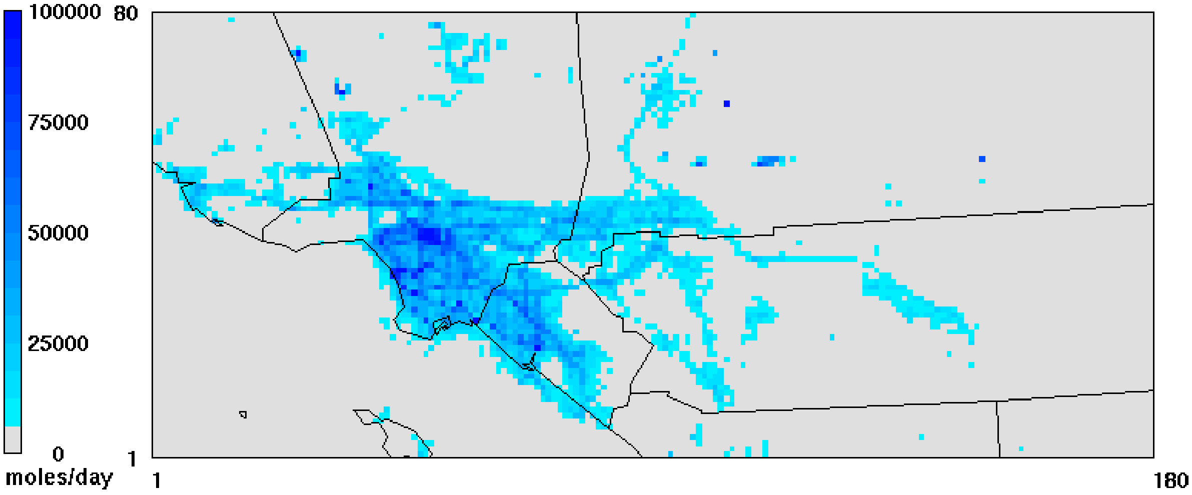


Figure IX-4-1j

Average CO emissions pattern from all source categories

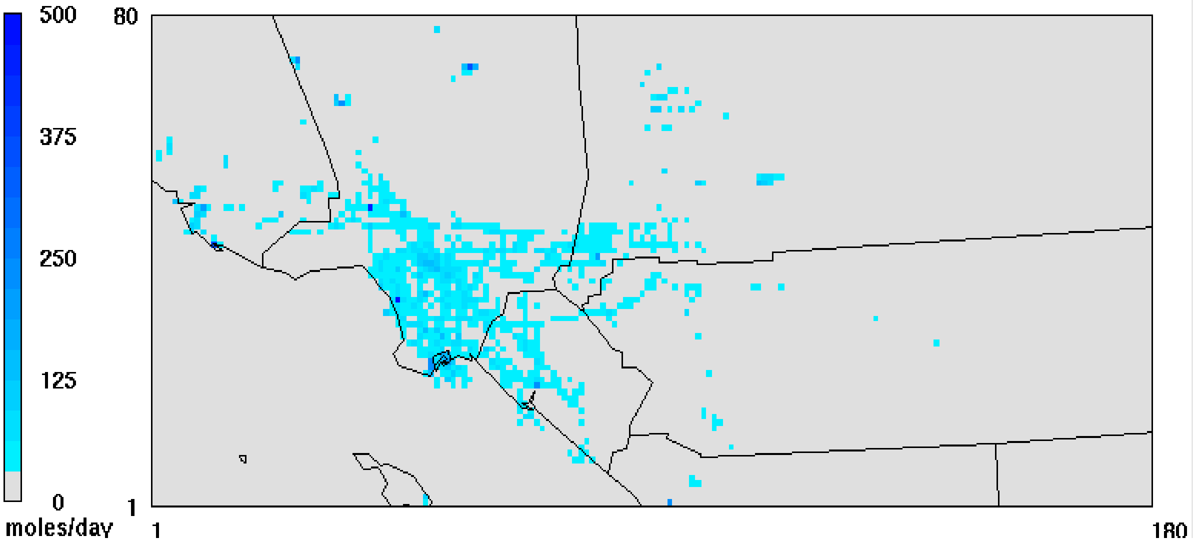


Figure IX-4-1k

Average emissions pattern for Acetaldehyde from all source categories

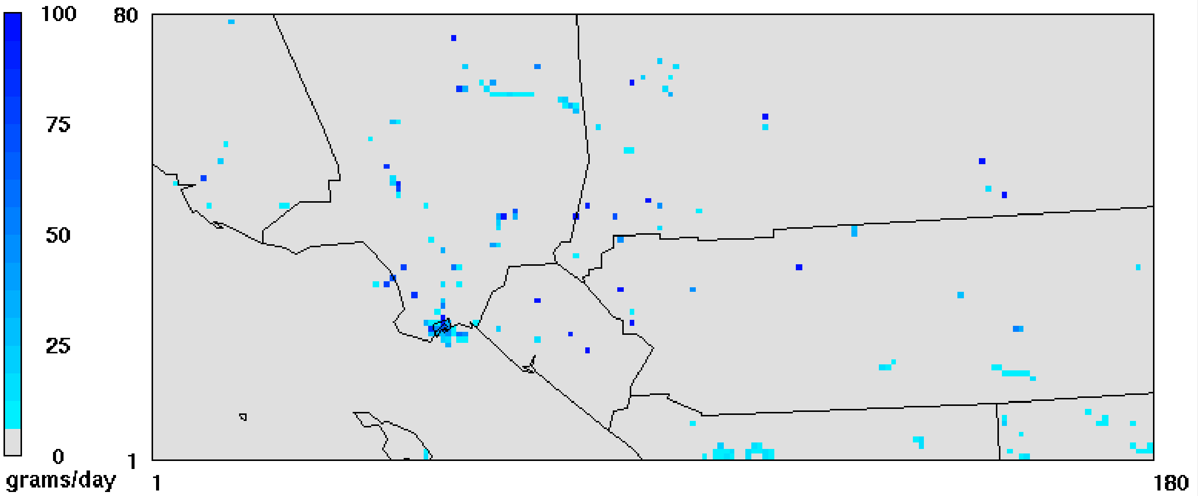


Figure IX-4-1l

Average Arsenic emissions pattern from all source categories

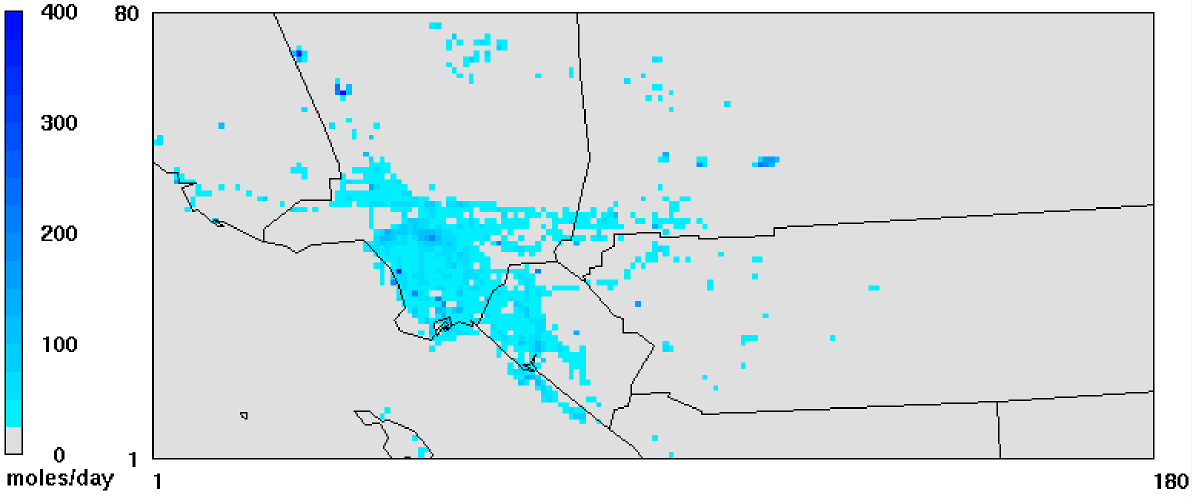


Figure IX-4-1m
Average Benzene emissions pattern from all source categories

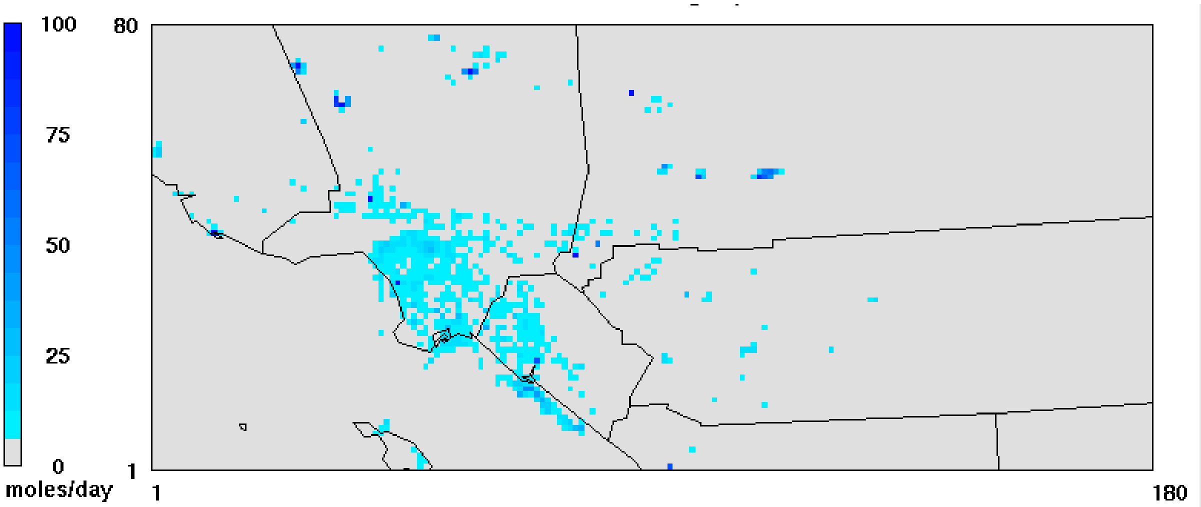


Figure IX-4-1n
Average 1,3-Butadiene emissions pattern from all source categories

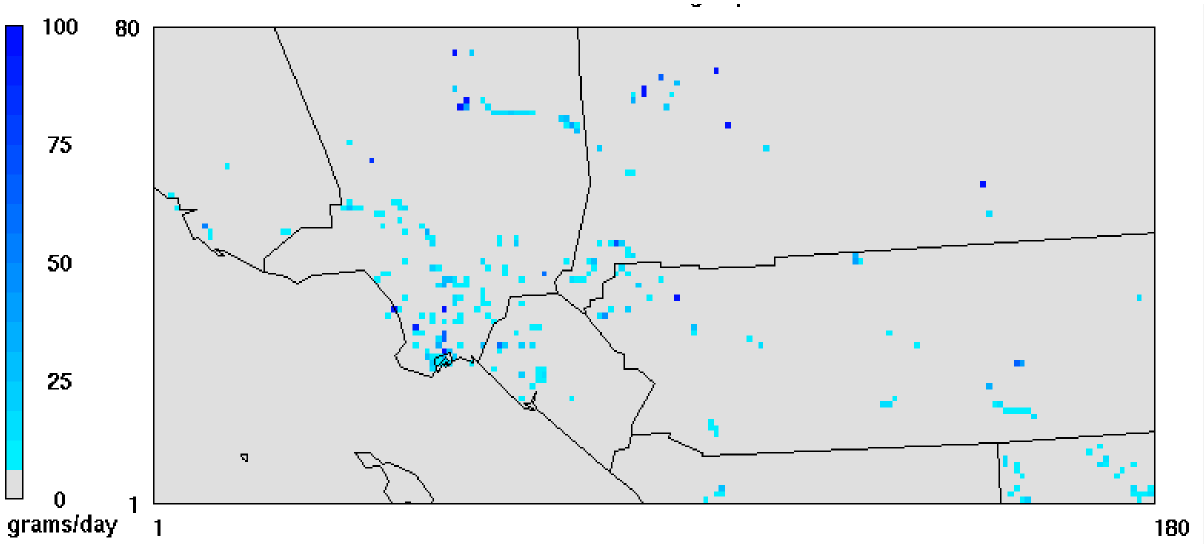


Figure IX-4-1o

Average Cadmium emissions pattern from all source categories

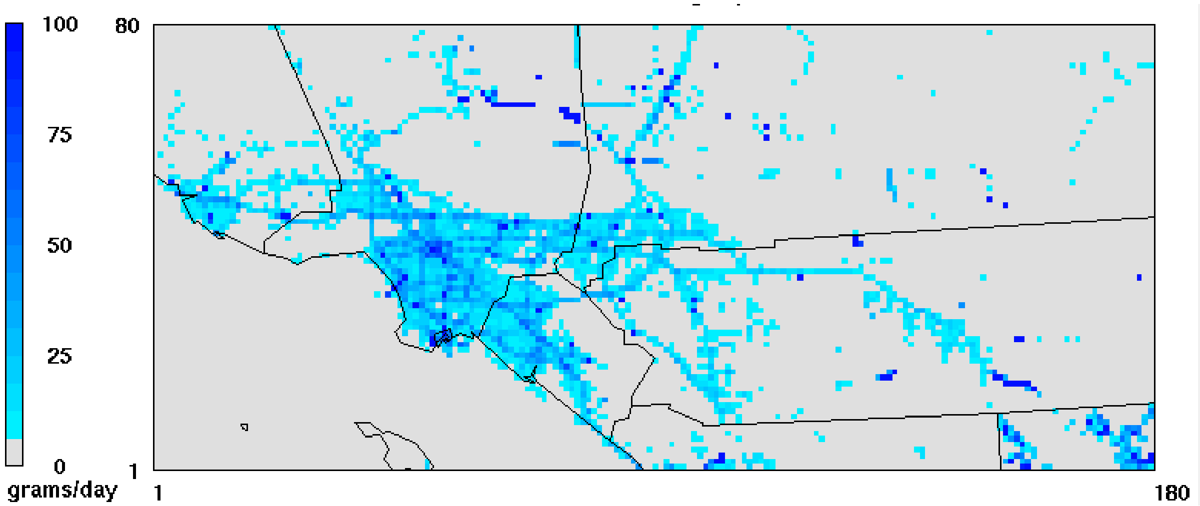


Figure IX-4-1p

Average Total Chromium emissions pattern from all source categories

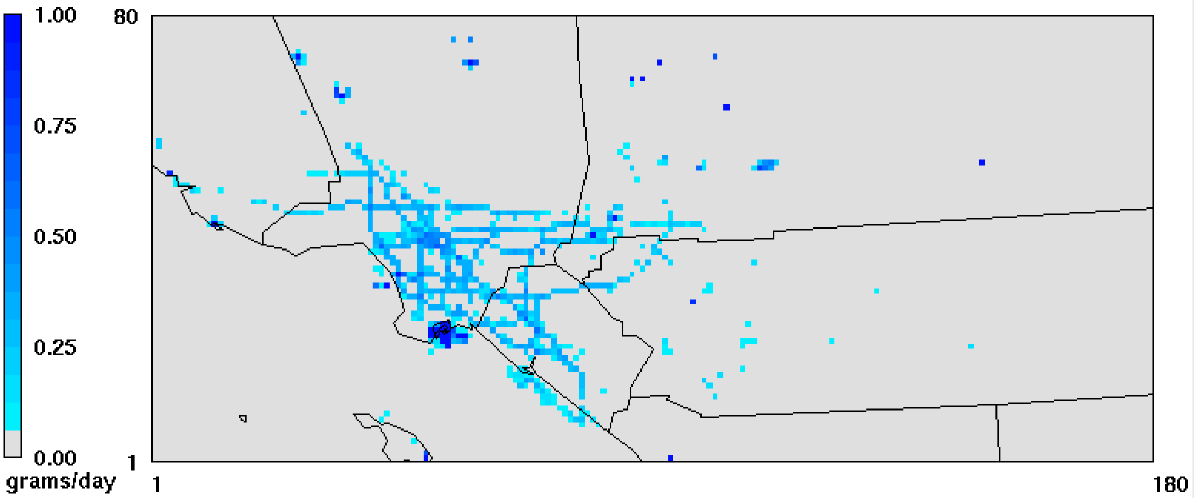


Figure IX-4-1q

Average Hexavalent Chromium emissions pattern from all source categories

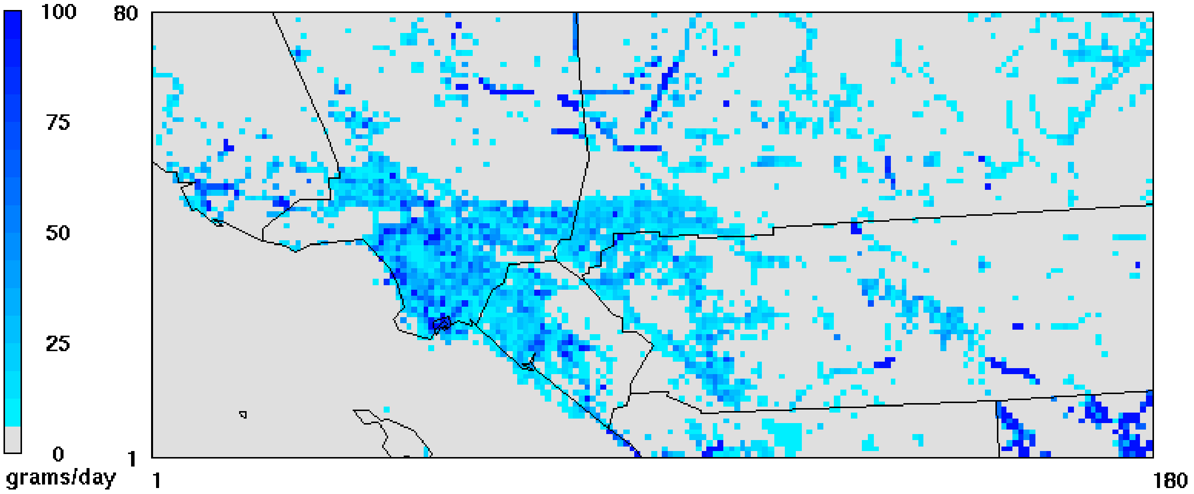


Figure IX-4-1r

Average Lead emissions pattern from all source categories

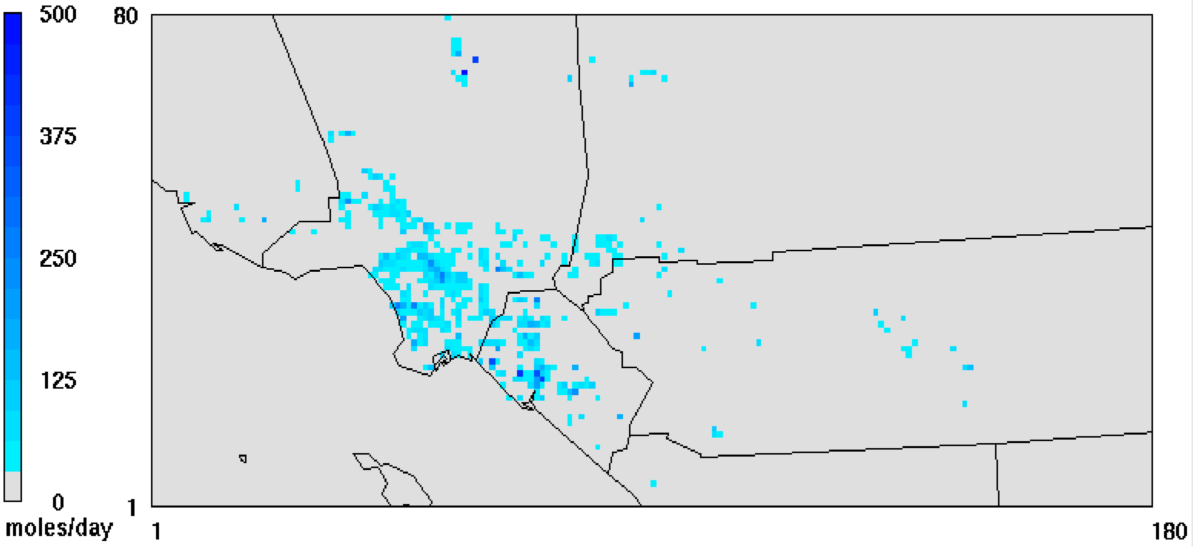


Figure IX-4-1s
Average Methylene Chloride emissions pattern from all source categories

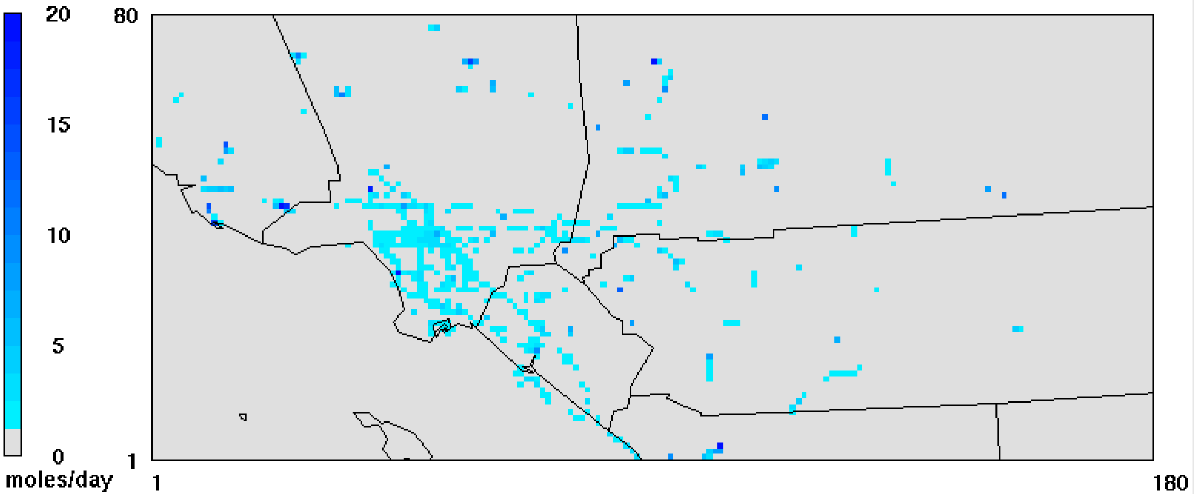


Figure IX-4-1t
Average Naphthalene emissions pattern from all source categories

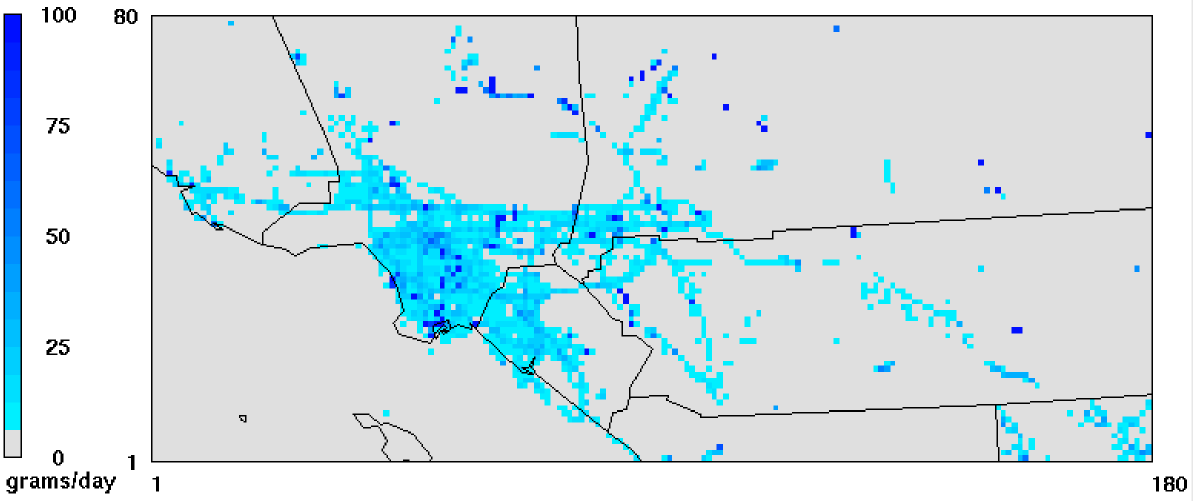


Figure IX-4-1u

Average Nickel emissions pattern from all source categories

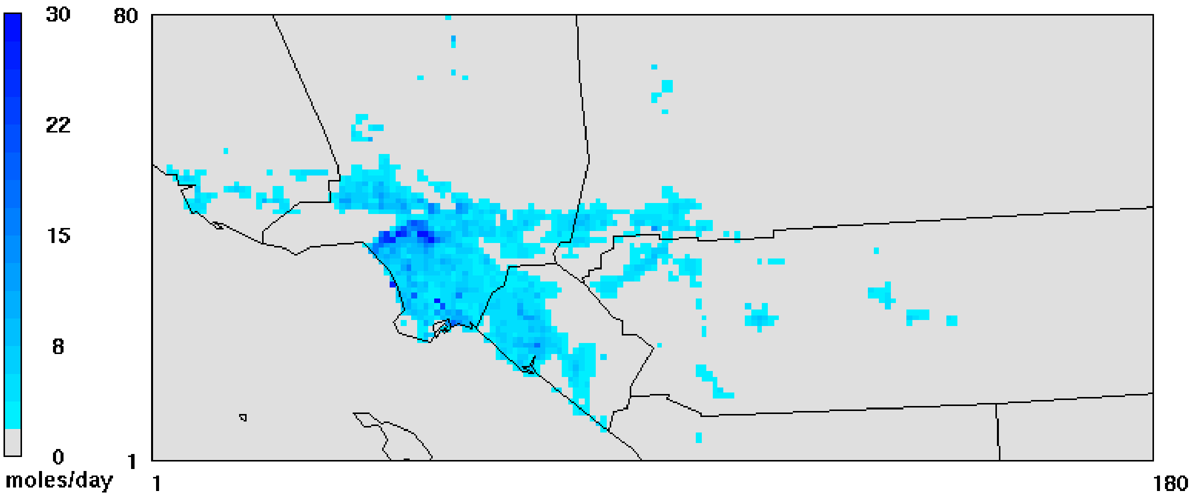


Figure IX-4-1v

Average p-Dichlorobenzene emissions pattern from all source categories

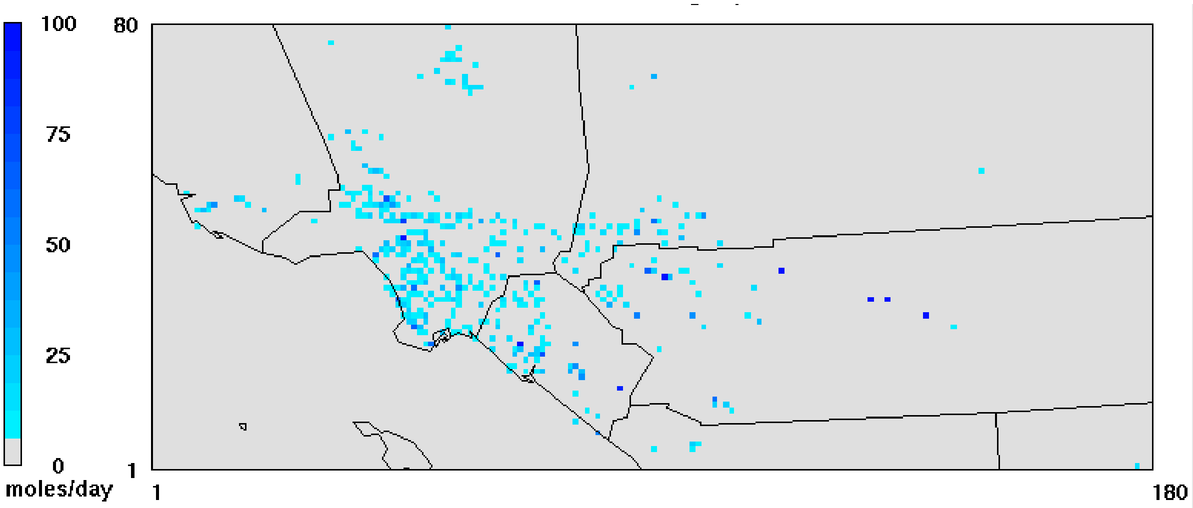


Figure IX-4-1w

Average Perchloroethylene emissions pattern from all source categories

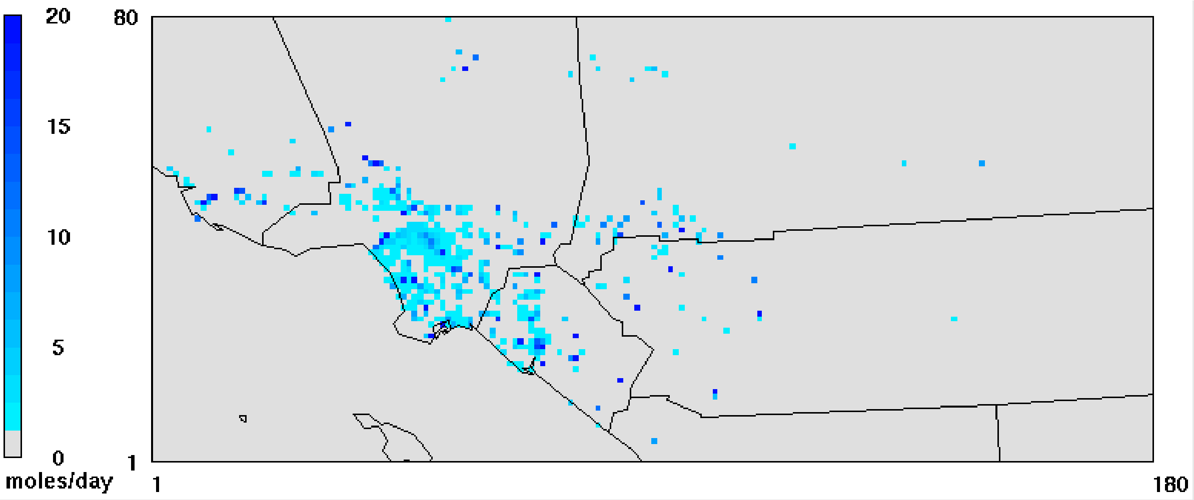


Figure IX-4-1x

Average Trichloroethylene emissions pattern from all source categories

IX.5 Modeling Setup

The MATES V regional modeling analyses relies 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 strives to use the best information and modeling tools available at the time for its MATES modeling analyses. Table IX-5-1 summarizes the major components in the air toxics modeling and provides a comparison between the MATES V and MATES IV analyses.

Table IX-5-1
Summary and Comparison of Key Modeling Considerations Between
MATES IV and MATES V

Parameter	MATES IV	MATES V
Meteorological Modeling Year	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 Caltrans/SCAG Model Uniform day of week and hourly distributions by Caltrans District	EMFAC2017/2016 RTP Caltrans PeMS/WIM data and SCAG model Day-specific spatial and temporal distributions
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 except OGV	2012 Projection from 2008 (2012 AQMP)	2018 Projection from 2012 (2016 AQMP)

IX.6 Boundary and Initial Conditions

The day-specific boundary condition files were prepared by extracting values at boundary grids from the 2016 AQMP modeling domain, which spans 90 by 40 grids in the east-west and the north-south direction, respectively, with 4 km grid space (2016 AQMP, Appendix V, Figure V-2-2).The CMAQ modeling domain covers the South Coast Air Basin as well as adjacent counties in Southern California. SAPRC07 were chosen as the gaseous species mechanism and AERO6 were chosen as aerosol module in the CMAQ modeling (South Coast AQMD, 2020). In total, 171 modeled gaseous and aerosol species were extracted from the CMAQ hourly simulation outputs using the BCON m3conc utility. For the unmodeled toxic gaseous and metal components required in the MATES V modeling, the boundary values were scaled based on the resolved CMAQ surrogate concentrations. The corresponding days in the 2018 CMAQ modeling values were used for the boundary conditions extraction during the January to April 2019 MATES modeling period. In order to minimize the impact of the unrealistic low CMAQ simulated benzene concentrations to MATES V domain, a fixed value as 0.1 ppbV were replaced for the lateral boundary condition.

The initial condition files were prepared using the *icbcprep* utility included in the CAMx standard package. The utility prepares uniform boundary and initial conditions with prescribed values. The initial values turn out to be not significant in the annual modeling, since the footprint of the initial values typically disappear in approximately 7 to 10 days of time integration, depending on grid size and chemical mechanism. In the MATES V simulations, 7 days were used as initial spin-up.

IX.7 CAMx Modeling Results

CAMx modeling results, CAMx modeling performance evaluation, and cancer risk estimation based on model predicted air toxics concentrations, OEHHA's cancer potency factor and population were presented in this section. The estimated cancer risk based on CAMx modeling results were compared with measurement-based cancer risk and those from MATES IV to evaluate the progress in improving air quality for the South Coast Air Basin and Coachella Valley.

IX.7.1 Overall Model Performances

The performance of the CAMx regional modeling simulation is summarized through statistical and graphical analysis, including time series of key pollutant concentrations. Summarized in Table IX-7-1 are the measurements and model predictions of toxic components during the sampling period. Prediction Accuracy (PA), defined as the percentage difference between the mean observed and simulated concentrations, is given as an indicator for the model performance.

For the MATES V period, the model simulated concentrations of particulate matter species, such as $EC_{2.5,}$ and TSP metals, compared favorably with measurement results. Concentrations of some air toxic species, such as perchloroethylene, p-dichlorobenzene, trichloroethylene, and naphthalene have become low enough that model performances for those pollutants are immaterial. Concentrations of 1,3-butadiene was underpredicted by the modeling. Emissions of 1,3-butadiene are primarily from gasoline combustion. Recently, CARB updated emissions from small off-road engines (CARB, 2020). This update is expected to increase 1,3-butadiene emissions marginally and to help reduce some of the underprediction, and is not incorporated in this modeling. Benzene and methylene were relatively well-simulated. Compared to MATES IV, ambient concentrations of formaldehyde and acetaldehyde increased in MATES V. These increases were incongruent with the expected emission decreases between the two MATES periods. Consequently, the model underpredicted the formaldehyde and acetaldehyde concentrations.

Simulated annual average $EC_{2.5}$ was used to assess overall model performance for the MATES V period. Tables IX-7-2 summarizes the MATESV $EC_{2.5}$ performance.

EPA guidance (U.S. EPA, 2006) recommends evaluating gaseous and particulate modeling performance using measures of prediction bias and error. 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 previous modeling attainment demonstrations.

As shown in the Tables IX-7-2, eight of the 10 MATES V sites meet the $PM_{2.5}$ PA goal. In general, the model underpredicts annual average concentrations at the Rubidoux, Inland Valley San Bernardino, Compton and Pico Rivera stations, consistent with what was observed in our past modeling effort. Concentrations in locations such as Burbank Area, Long Beach and Anaheim are overpredicted. Overall, modeled $EC_{2.5}$ concentrations were 5% lower than the measurements, which were likely driven by the CAMx not being able to predict extreme high events (See Figures IX-7-1).

Table IX-7-3 provides the CAMx RTRAC performance for benzene at the 7 MATES V monitoring sites. Benzene model performance is included in the evaluation because of the confidence in the benzene measurement data based on the long-term monitoring conducted in the Basin and throughout California. With the exception of the Burbank Area site (25% over), the annual average benzene concentrations are underpredicted with Compton showing the largest low bias (36%). Overall, the model underpredicted benzene concentrations by 13%. Therefore, the overall model performance for benzene is reasonable.

The time series fit of the simulated $EC_{2.5}$ concentrations to measurements for each station is depicted in Figures IX-7-1a through IX-7-1j. As evident in the plots, variations of modeled concentrations matched well with measurements. As expected, the model has difficulty in predicting extreme high and low concentrations.

Table IX-7-1

Station Observed and CAMx Simulated MATES V Average Concentrations

Compound	Units	Anaheim			Burbank Area			Compton			Inland Valley San Bernardino		
		Obs	Model	PA	Obs	Model	PA	Obs	Model	PA	Obs	Model	PA
1,3-Butadiene	ppb	N/A	-	N/A	0.036	0.018	-50	0.095	0.017	-82	0.051	0.014	-72
Acetaldehyde	ppb	N/A	-	N/A	1.77	0.70	-61	1.48	0.55	-63	2.15	0.65	-70
As (2.5)	ng/m^3	N/A	0.17	N/A	N/A	0.13	N/A	N/A	0.28	N/A	N/A	0.22	N/A
As (TSP)	ng/m^3	0.36	0.31	-14	0.46	0.33	-28	0.44	0.59	34	0.89	0.52	-42
Benzene	ppb	N/A	-	N/A	0.22	0.27	23	0.38	0.24	-36	0.23	0.22	-4
Cd (2.5)	ng/m^3	N/A	0.43	N/A	N/A	0.39	N/A	N/A	0.80	N/A	N/A	0.59	N/A
Cd (TSP)	ng/m^3	0.24	0.49	104	0.19	0.47	147	0.25	0.86	244	0.31	0.78	151
Cr6 (TSP)	ng/m^3	0.038	0.022	-42	0.032	0.028	-13	0.061	0.029	-52	0.038	0.081	125
$EC_{2.5}$	µg/m^3	0.47	0.55	17	0.50	0.67	34	0.80	0.66	-18	0.78	0.63	-19
Formaldehyde	ppb	N/A	-	N/A	3.73	1.72	-54	2.47	1.48	-40	4.47	1.67	-63
Methylene Chloride	ppb	N/A	-	N/A	0.16	0.22	36	0.19	0.17	-10	0.19	0.15	-21
Naphthalene	ppb												
Ni (2.5)	ng/m^3	N/A	1.77	N/A	N/A	1.96	N/A	N/A	3.55	N/A	N/A	3.55	N/A
Ni (TSP)	ng/m^3	2.17	2.62	20	2.01	3.26	62	2.93	5.02	71	6.31	5.14	-19
Pb (2.5)	ng/m^3	N/A	1.11	N/A	N/A	1.56	N/A	N/A	1.36	N/A	N/A	2.24	N/A
Pb (TSP)	ng/m^3	2.72	2.46	-10	6.98	3.93	-44	4.81	3.12	-53	7.66	4.93	-36
p-Dichlorobenzene	ppb	N/A	-	N/A	0.023	0.037	61	0.030	0.023	-23	0.020	0.018	-10
Perchloroethylene	ppb	N/A	-	N/A	0.021	0.032	52	0.049	0.023	-53	0.052	0.024	-54
Trichloroethylene	ppb	N/A	-	N/A	0.024	0.019	-21	0.020	0.012	-40	0.018	0.015	-17

Table IX-7-1 (Continued)

Station Observed and CAMx Simulated MATES V Annual Average Concentrations

Compound	Units	Huntington Park			North Long Beach			Central Los Angeles			Pico Rivera		
		Obs	Model	PA	Obs	Model	PA	Obs	Model	PA	Obs	Model	PA
1,3-Butadiene	ppb	0.074	0.022	-70	0.051	0.017	-67	N/A	-	N/A	0.055	0.012	-78
Acetaldehyde	ppb	1.63	0.62	-62	1.24	0.50	-60	N/A	-	N/A	1.39	0.64	-54
As (2.5)	ng/m^3	N/A	0.24	N/A	N/A	0.46	N/A	N/A	0.20	N/A	N/A	0.18	N/A
As (TSP)	ng/m^3	0.45	0.46	2	0.38	0.69	82	0.42	0.43	2	0.66	0.41	-39
Benzene	ppb	0.31	0.26	-16	0.32	0.24	-23	N/A	-	N/A	0.25	0.23	-6
Cd (2.5)	ng/m^3	N/A	0.82	N/A	N/A	0.58	N/A	N/A	0.43	N/A	N/A	0.41	N/A
Cd (TSP)	ng/m^3	0.46	0.90	96	0.09	0.66	633	0.15	0.52	246	0.14	0.49	250
Cr6 (TSP)	ng/m^3	0.057	0.024	-58	0.034	0.029	-15	0.044	0.036	-18	0.035	0.023	-34
EC$_{2.5}$	µg/m^3	0.68	0.66	-3	0.52	0.61	17	0.71	0.78	10	0.74	0.62	-16
Formaldehyde	ppb	2.56	1.61	-37	2.08	1.42	-32	N/A	-	N/A	3.00	1.56	-48
Methylene Chloride	ppb	0.17	0.27	59	0.16	0.14	-14	N/A	-	N/A	0.16	0.17	4
Naphthalene	ppb							0.013	0.007	-46			
Ni (2.5)	ng/m^3	N/A	3.01	N/A	N/A	2.91	N/A	N/A	2.94	N/A	N/A	2.47	N/A
Ni (TSP)	ng/m^3	2.64	4.25	61	3.64	4.23	16	2.00	4.50	125	3.00	3.81	27
Pb (2.5)	ng/m^3	N/A	1.41	N/A	N/A	1.56	N/A	N/A	1.64	N/A	N/A	1.36	N/A
Pb (TSP)	ng/m^3	4.42	3.56	-19	3.19	3.18	0	5.09	4.53	-11	4.73	3.35	-29
p-Dichlorobenzene	ppb	0.033	0.028	-15	0.029	0.025	-14	N/A	-	N/A	0.026	0.021	-19
Perchloroethylene	ppb	0.032	0.028	-13	0.023	0.017	-26	N/A	-	N/A	0.031	0.021	-32
Trichloroethylene	ppb	0.022	0.015	-32	0.020	0.011	-45	N/A	-	N/A	0.014	0.012	-14

Table IX-7-1 (Continued)

Station Observed and CAMx Simulated MATES V Average Concentrations

Compound	Units	Rubidoux			West Long Beach		
		Obs	Model	PA	Obs	Model	PA
1,3-Butadiene	ppb	N/A	-	N/A	0.062	0.022	-65
Acetaldehyde	ppb	N/A	-	N/A	1.16	0.51	-56
As (2.5)	ng/m^3	N/A	0.09	N/A	N/A	0.80	N/A
As (TSP)	ng/m^3	0.67	0.26	-61	0.47	1.11	136
Benzene	ppb	N/A	-	N/A	0.30	0.27	-10
Cd (2.5)	ng/m^3	N/A	0.22	N/A	N/A	0.88	N/A
Cd (TSP)	ng/m^3	0.59	0.30	-49	0.77	0.94	22
Cr6 (TSP)	ng/m^3	0.026	0.012	-54	0.035	0.037	6
$EC_{2.5}$	$\mu g/m^3$	0.69	0.42	-39	0.72	0.71	1
Formaldehyde	ppb	N/A	-	N/A	2.33	1.64	-30
Methylene Chloride	ppb	N/A	-	N/A	0.16	0.13	-19
Naphthalene	ppb	0.008	0.003	-100			
Ni (2.5))	ng/m^3	N/A	1.11	N/A	N/A	4.64	N/A
Ni (TSP)	ng/m^3	2.41	1.88	-22	4.32	6.84	58
Pb (2.5)	ng/m^3	N/A	0.88	N/A	N/A	1.87	N/A
Pb (TSP)	ng/m^3	4.47	2.63	-41	4.14	3.50	-15
p-Dichlorobenzene	ppb	N/A	-	N/A	0.026	0.024	8
Perchloroethylene	ppb	N/A	-	N/A	0.024	0.017	-29
Trichloroethylene	ppb	N/A	-	N/A	0.030	0.012	-60

Table IX-7-2

MATES V $EC_{2.5}$ Model Performance

Location	Observed (µg/m^3)	*Modeled (µg/m^3)	Prediction Accuracy	Mean Bias (µg/m^3)	Mean Error (µg/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	0.62	-16	-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

Table IX-7-3

MATES V Simulation Performance Statistics for Benzene

Location	Observed (ppb)	Samples	Predicted (ppb)	PA	Mean Bias (ppb)	Mean Error (ppb)	Normalized Mean Bias	Normalized Mean Error
Anaheim								
Burbank Area	0.22	60	0.27	23	-0.06	0.08	0.33	0.41
Compton	0.38	61	0.24	-36	-0.14	0.20	0.09	0.52
Inland Valley San Bernardino	0.23	61	0.22	-4	-0.01	0.06	0.07	0.27
Huntington Park	0.31	60	0.26	-17	-0.05	0.11	0.08	0.35
North Long Beach	0.32	58	0.24	-24	-0.08	0.15	0.28	0.61
Central L.A.								
Pico Rivera	0.25	53	0.23	-8	-0.02	0.08	0.14	0.37
Rubidoux								
West Long Beach	0.30	58	0.27	-8	-0.03	0.13	0.35	0.61
All Stations	0.29	411	0.25	-13	-0.04	0.12	0.19	0.45

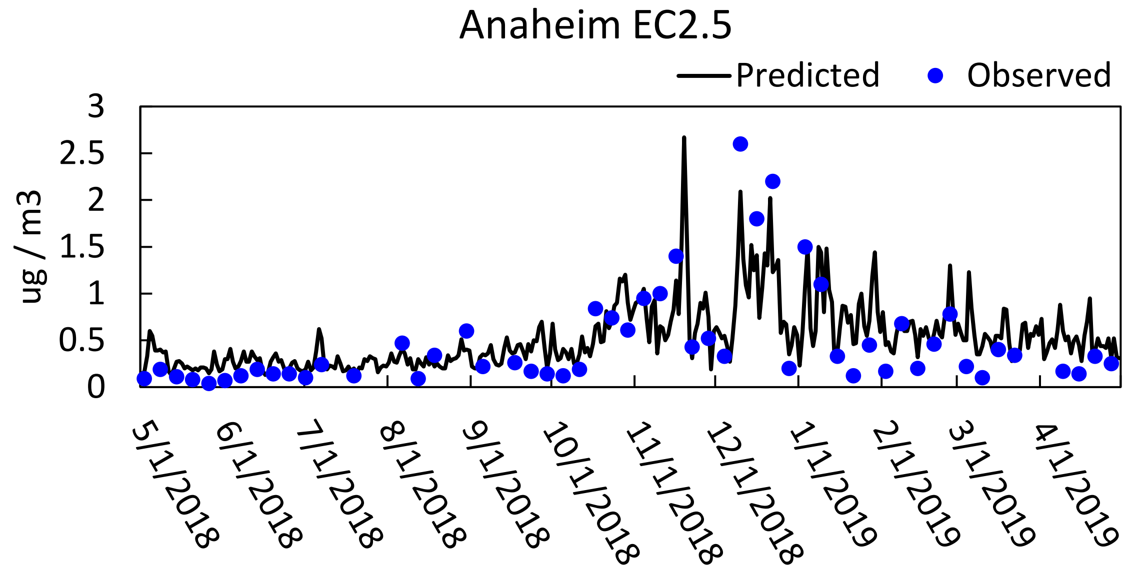


Figure IX-7-1a
$EC_{2.5}$ Time Series: Simulated vs. Measured at Anaheim

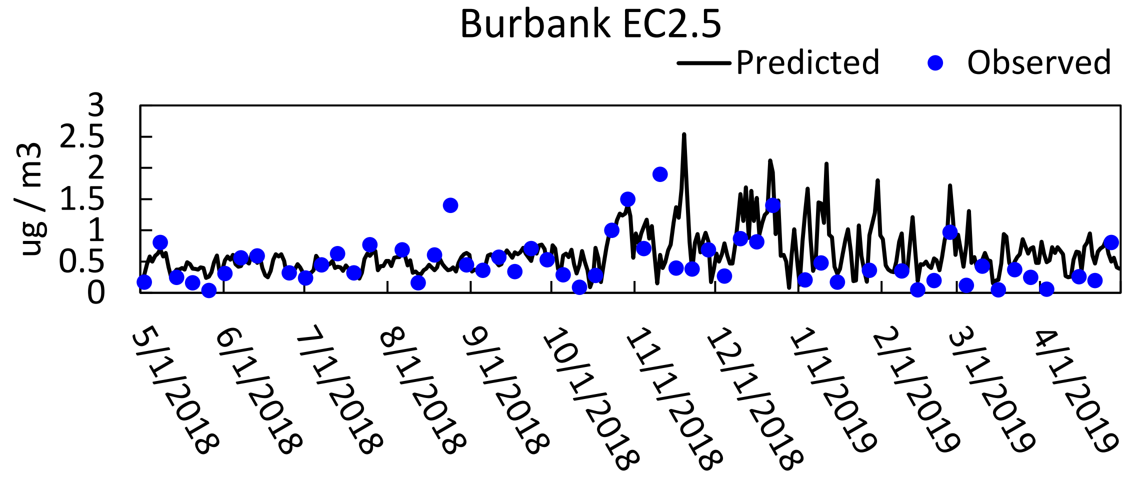


Figure IX-7-1b
$EC_{2.5}$ Time Series: Simulated vs. Measured at Burbank Area

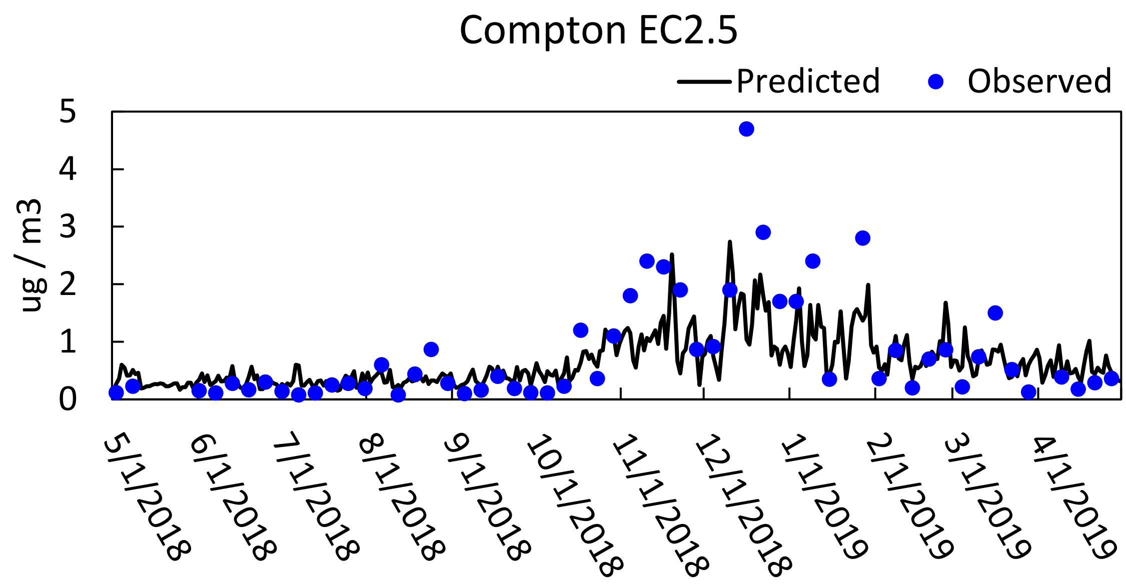


Figure IX-7-1c
$EC_{2.5}$ Time Series: Simulated vs. Measured at Compton

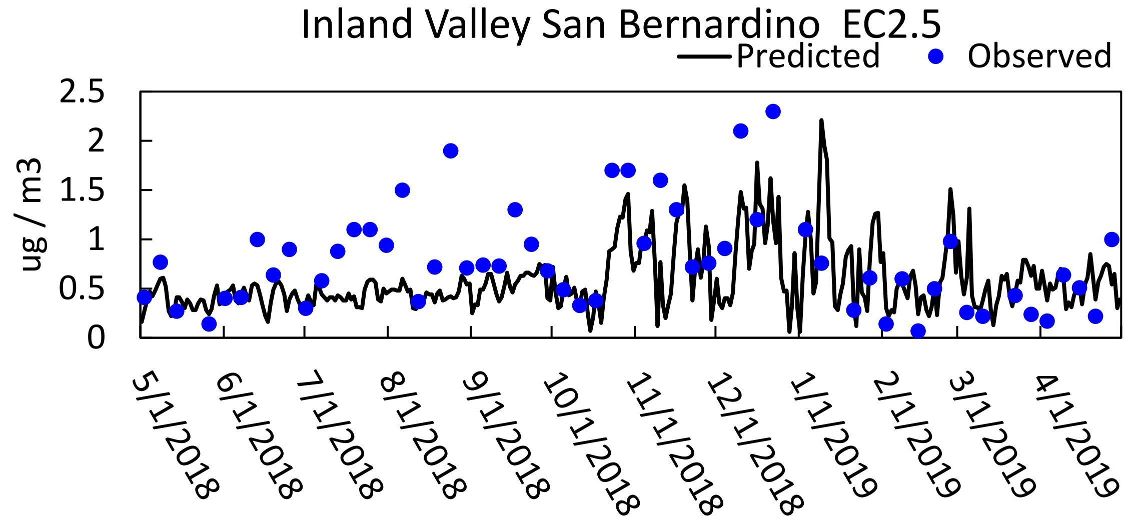


Figure IX-7-1d
$EC_{2.5}$ Time Series: Simulated vs. Measured at Inland Valley San Bernardino

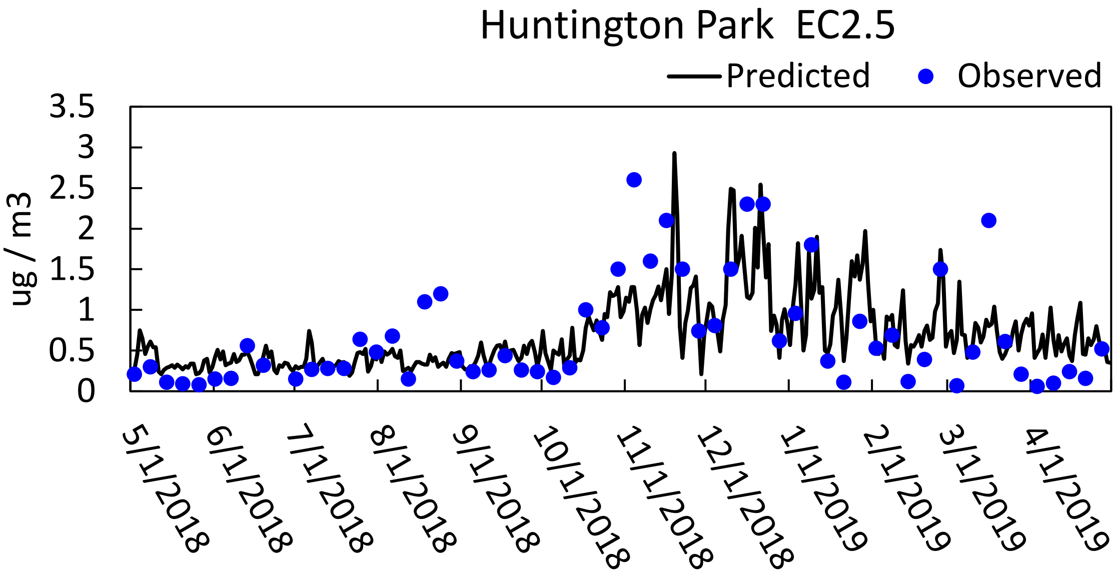


Figure IX-7-1e

$EC_{2.5}$ Time Series: Simulated vs. Measured at Huntington Park

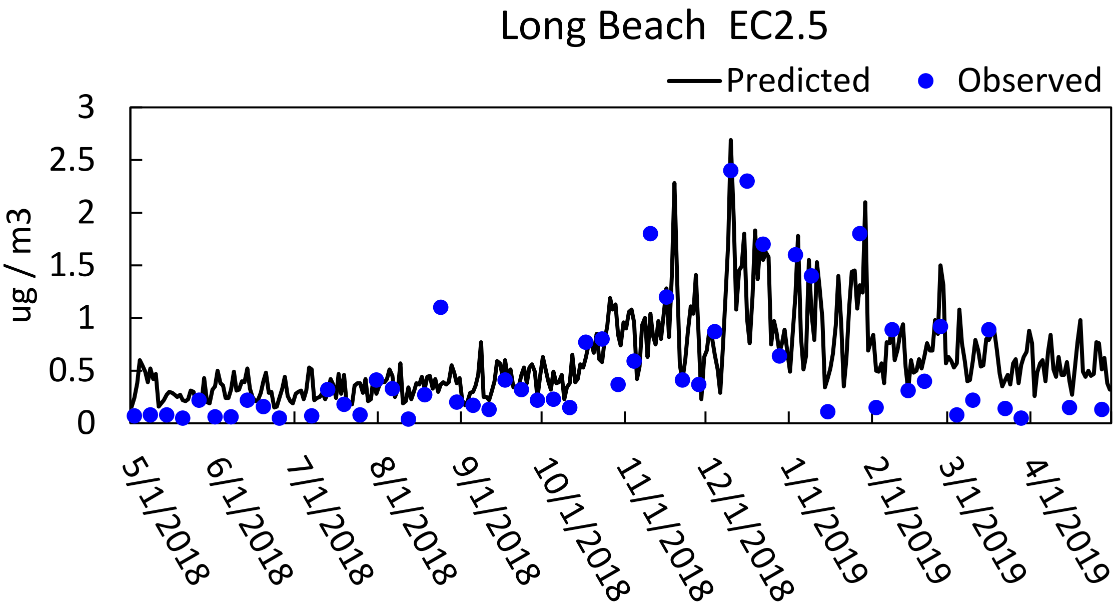


Figure IX-7-1f

$EC_{2.5}$ Time Series: Simulated vs. Measured at Long Beach

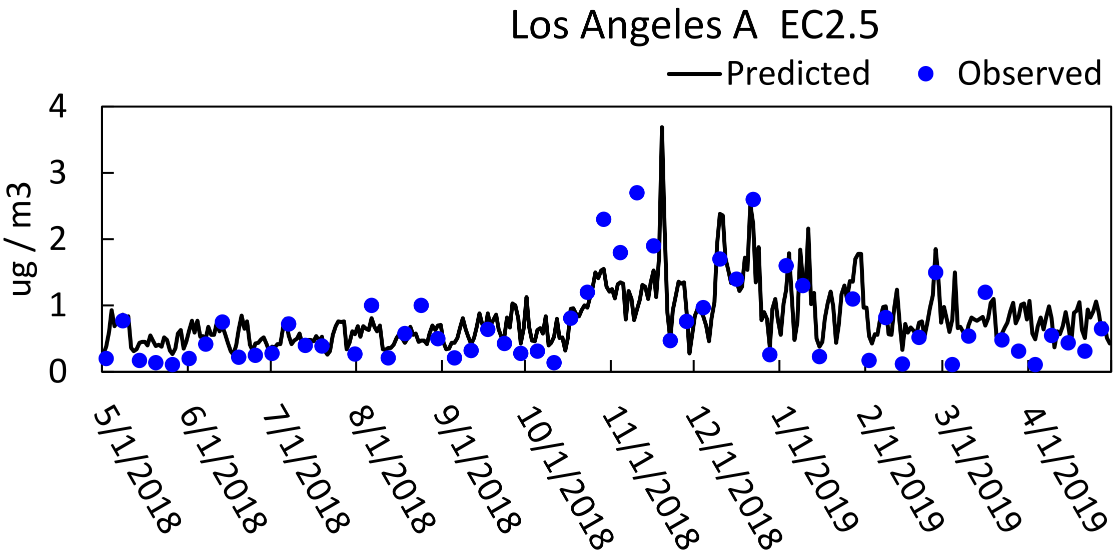


Figure IX-7-1g

$EC_{2.5}$ Time Series: Simulated vs. Measured at Central Los Angeles

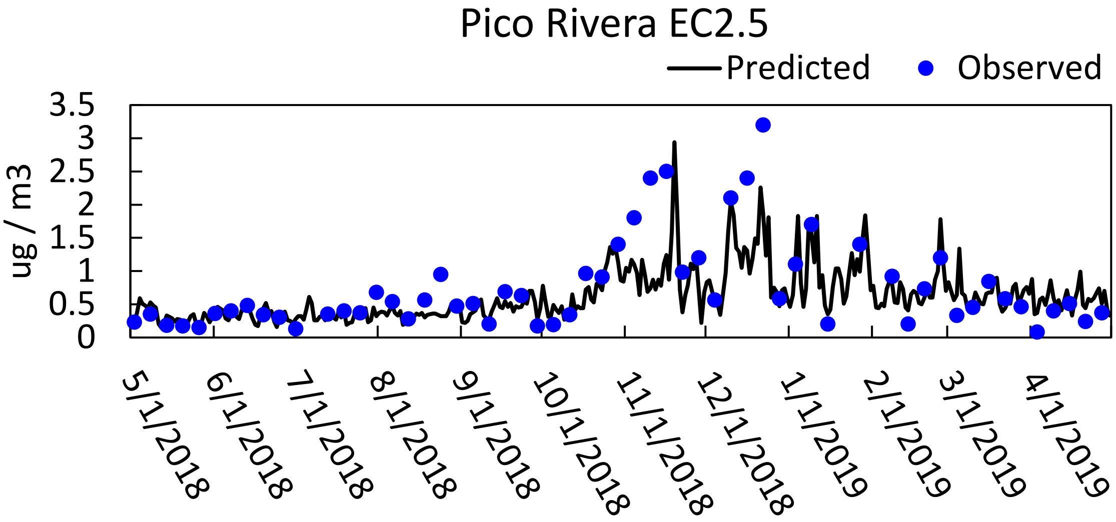


Figure IX-7-1h

$EC_{2.5}$ Time Series: Simulated vs. Measured at Pico Rivera

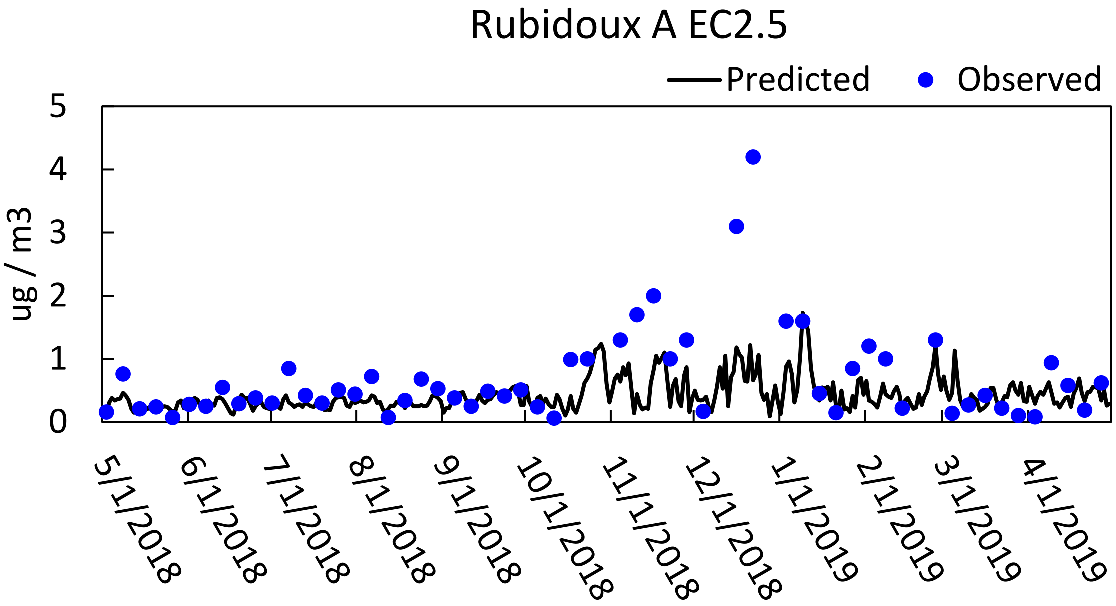


Figure IX-7-1i

$EC_{2.5}$ Time Series: Simulated vs. Measured at Rubidoux

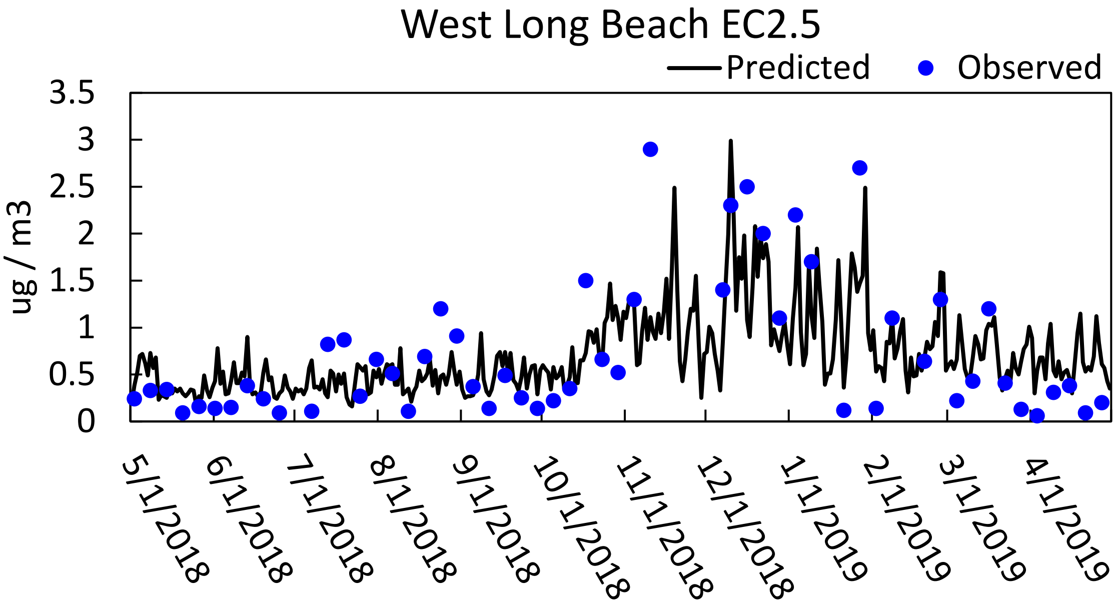


Figure IX-7-1j

$EC_{2.5}$ Time Series: Simulated vs. Measured at West Long Beach

IX.7.2 Comparison with MATES IV Simulation

Tables IX-7-4 and IX-7-5 provide a comparison of the 2018-2019 MATES V and 2012-2013 MATES IV model performance for $EC_{2.5}$ and benzene, respectively. Listed in each table are PA, bias, and mean error. As presented in tables, compared to MATES IV modeling, where modeling exhibited an overall tendency to overpredict $EC_{2.5}$. MATES V modeling does not show a significant under or over prediction tendencies. Historically, regional modeling in the SCAB showed under predictions in the Rubidoux and Burbank areas, as evidenced by the MATES IV results. MATES V modeling, while still shows underprediction in the Rubidoux area, it no longer underpredicts the Burbank Area, indicating changes in the behavior of meteorological modeling. Overall, the MATES V model performance is on par or better compared to MATES IV.

Table IX-7-4

Comparative Simulation Performance Statistics for **$EC_{2.5}$**

	MATES IV (2012-2013)					MATES V (2018-2019)				
Location	Observed Days (µg/m^3)	Modeled Sampling Days (µg/m^3)	PA	Bias (µg/m^3)	Mean Error (µg/m^3)	Observed Days (µg/m^3)	Modeled Sampling Days (µg/m^3)	PA	Bias (µg/m^3)	Mean Error (µg/m^3)
Anaheim	0.90	1.10	22	0.20	0.56	0.47	0.55	16	0.08	0.21
Burbank Area	1.32	1.19	-9	-0.12	0.64	0.50	0.67	33	0.17	0.33
Compton	1.06	1.48	39	0.42	0.76	0.80	0.66	-17	-0.14	0.42
Inland Valley San Bernardino	1.38	1.13	-18	-0.25	0.46	0.78	0.63	-20	-0.15	0.33
Huntington Park	1.30	1.70	31	0.40	0.67	0.68	0.66	-2	-0.02	0.32
Long Beach	0.91	1.45	59	0.53	0.80	0.52	0.62	19	0.10	0.28
Central L.A.	1.23	1.81	47	0.58	0.70	0.71	0.78	9	0.07	0.27
Pico Rivera	1.39	1.30	-6	-0.09	0.48	0.74	0.62	-16	-0.13	0.25
Rubidoux	1.11	0.98	-12	-0.13	0.40	0.69	0.42	-40	-0.27	0.35
West Long Beach	1.13	1.88	67	0.75	1.00	0.72	0.71	-2	-0.01	0.38

Table IX-7-5

Comparative Simulation Performance Statistics for Benzene

	MATES IV (2012-2013)					MATES V (2018-2019)				
Location	Observed Days (ppb)	Modeled Sampling Days (ppb)	PA	Bias (ppb)	Mean Error (ppb)	Observed Days (ppb)	Modeled Sampling Days (ppb)	PA	Bias (ppb)	Mean Error (ppb)
Anaheim	0.33	0.28	-14	-0.05	0.16					
Burbank Area	0.46	0.28	-38	-0.17	0.22	0.22	0.27	23	-0.06	0.08
Compton	0.50	0.28	-43	-0.21	0.26	0.38	0.24	-36	-0.14	0.20
Inland Valley San Bernardino.	0.29	0.22	-24	-0.07	0.09	0.23	0.22	--4	-0.01	0.06
Huntington Park	0.53	0.33	-38	-0.20	0.22	0.31	0.26	-17	-0.05	0.11
Long Beach	0.33	0.30	-10	-0.03	0.10	0.32	0.24	-24	-0.08	0.15
Central L.A.	0.40	0.37	-8	-0.03	0.12					
Pico Rivera	0.35	0.27	-21	-0.07	0.12	0.25	0.23	-8	-0.02	0.08
Rubidoux	0.28	0.21	-24	-0.07	0.10					
West Long Beach	0.36	0.41	15	0.05	0.20	0.30	0.27	-8	-0.03	0.13

IX.7.3 Simulation Evaluation Averaged Over the Monitoring Network

For this comparison, the monitored data for ten stations are combined to provide an estimate of average Basin-wide conditions for the two sampling periods. Table IX-7-6 summarizes the network average measured and predicted pollutant concentrations. For gaseous species concentrations, measurement data from Anaheim, Central Los Angeles and Rubidoux were missing, so only the data from the remaining seven monitoring sites were presented. Measured concentrations of naphthalene were available for Central Los Angeles, and Rubidoux. Each of the four counties is represented by at least one station. The stations' measured and simulated average concentrations provide an estimate of the regional profile but with a bias towards impacts to the coastal communities in the heavily transited areas of the Basin. Moreover, the assessment provides a direct comparison for model performance evaluation.

For MATES V, the model simulated concentrations of particulate matter species, such as $EC_{2.5}$ and TSP metals were consistent with measured data. The model was unable to predict the increased carbonyl concentrations, formaldehyde and acetaldehyde, compared to MATES IV. Concentrations of perchloroethylene, p-dichlorobenzene, trichloroethylene, 1,3-butadiene and naphthalene have become low enough that model performances for those pollutants are immaterial. Benzene and methylene concentrations were well simulated.

Table IX-7-6

Toxic Compounds Simulated and Measured Ten-Station Annual Average Concentrations For MATES IV and MATES V periods using CAMX RTRAC

Compound	Units	2012-2013 MATES IV		2018-2019 MATES V	
		Measured Annual Average	Simulated Annual Average***	Measured Annual Average	Simulated Annual Average***
$EC_{2.5}$	μg/m^3	0.96	1.39	0.66	0.63
Cr 6 (TSP)	ng/m^3	0.05	0.18	0.040	0.032
As (2.5)	ng/m^3	N/A	0.66	N/A	0.27
As (TSP)	ng/m^3	0.44	1.07	0.52	0.51
Cd (2.5)	ng/m^3	N/A	0.38	N/A	0.55
Cd (TSP)	ng/m^3	0.13	0.56	0.32	0.64
Ni (2.5))	ng/m^3	N/A	4.58	N/A	2.83
Ni (TSP)	ng/m^3	2.98	6.64	3.14	4.15
Pb (2.5)	ng/m^3	N/A	2.10	N/A	1.52
Pb (TSP)	ng/m^3	4.69	5.26	4.80	3.51

Benzene*	ppb	0.33	0.29	0.29	0.25
Perchloroethylene*	ppb	0.03	0.08	0.03	0.02
p-Dichlorobenzene*	ppb	0.02	0.04	0.03	0.03
Methylene Chloride*	ppb	0.46	0.24	0.17	0.18
Trichloroethylene*	ppb	0.02	0.04	0.02	0.01
1,3-Butadiene*	ppb	0.09	0.04	0.06	0.02
Formaldehyde*	ppb	1.78	1.91	2.95	1.59
Acetaldehyde*	ppb	0.71	0.95	1.55	0.60
Naphthalene**	ppb	0.02	0.01	0.01	0.01

* Seven station average
** Two station average
*** Average of days with measurements

IX.7.4 Simulation Estimated Spatial Concentration Fields

Figures IX-7-2a through IX-7-2u depict the CAMx projected annual average concentration distributions of selected toxic compounds as well as the impacts of five emissions categories of diesel particulates in the Basin. The highest concentration (1.13 $\mu g/m^3$) 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, due in a large part to emission reductions in various categories of on-road and other mobile sources. Figures IX-7-2h and IX-7-2i provide the distributions of benzene and 1,3-butadiene, respectively, whereby the toxic compounds are almost uniformly distributed throughout the Basin, reflecting patterns of light-duty vehicles fuel consumption since benzene and 1,3-butadiene emissions are mostly from gasoline combustion. Benzene emissions are primarily from on- and off-road mobile sources, with some 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 (at Burbank Area) to 0.38 ppb (at Compton), with a 7-station average of 0.29 ppb. Model prediction at those stations ranges from 0.21 to 0.28 ppb with a 7-station average of 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 IX-7-2j 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. It is also possible that uncertainties in emissions inventory and air quality modeling could contribute to the discrepancy. The modeled concentrations from the 7 monitoring stations averaged at 1.61 ppb, lower than the measured values averaged at 2.95 ppb.

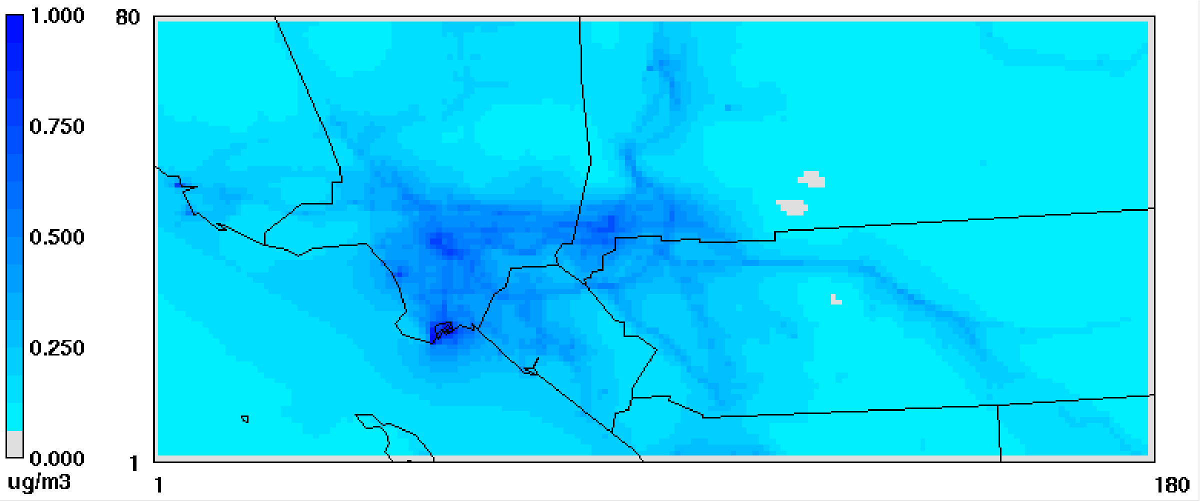


Figure IX-7-2a
CAMx simulated 2018 annual average Diesel PM

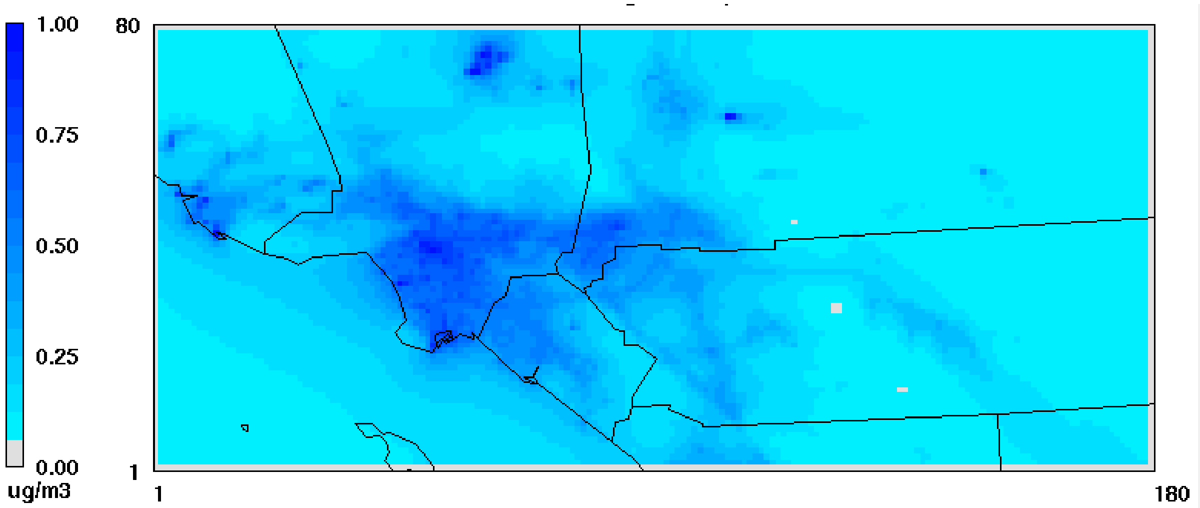


Figure IX-7-2b
CAMx simulated 2018 annual average Elemental Carbon $PM_{2.5}$

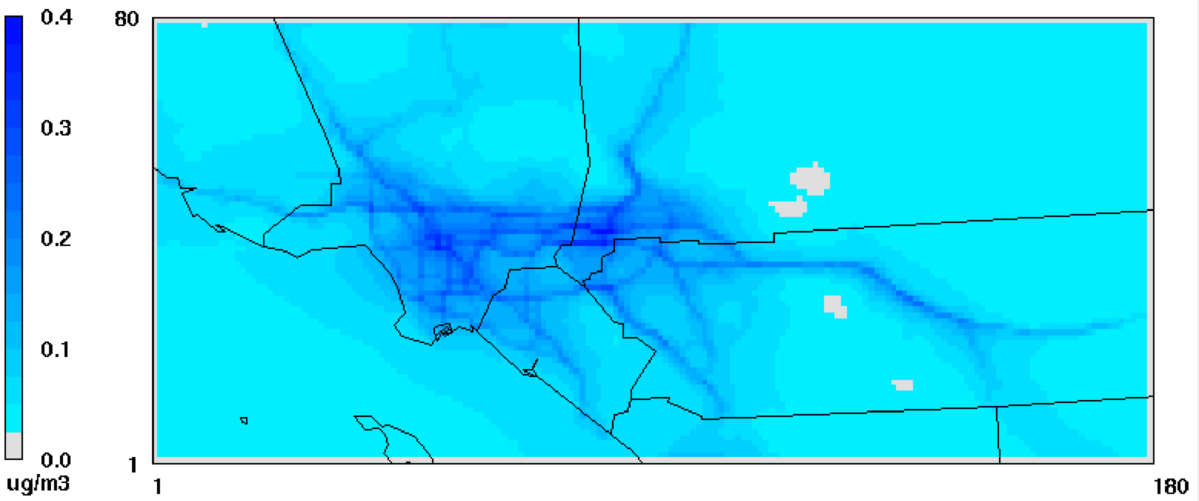


Figure IX-7-2c
CAMx simulated 2018 annual average On-Road Diesel PM

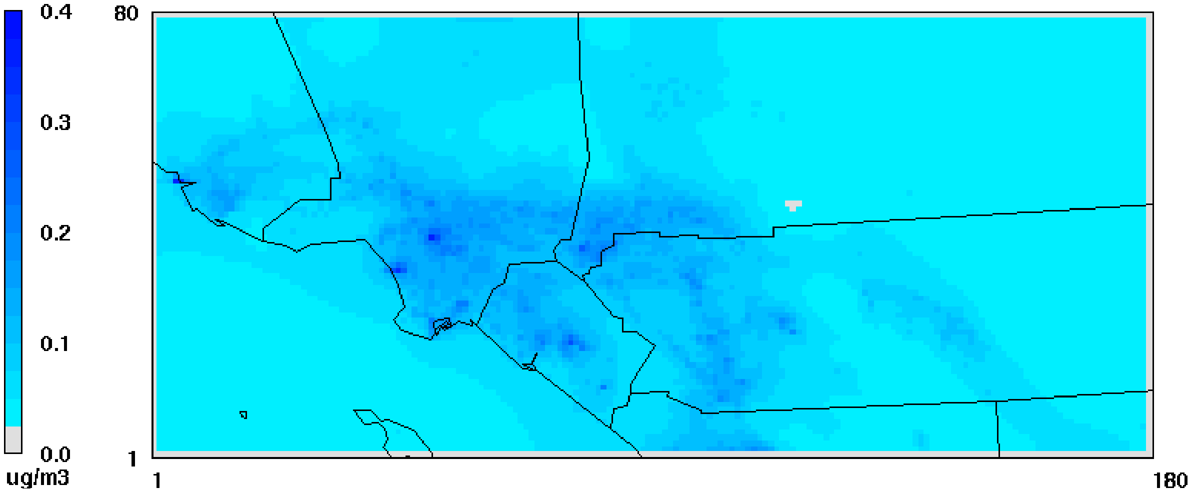


Figure IX-7-2d
CAMx simulated 2018 annual average Off-Road Diesel PM

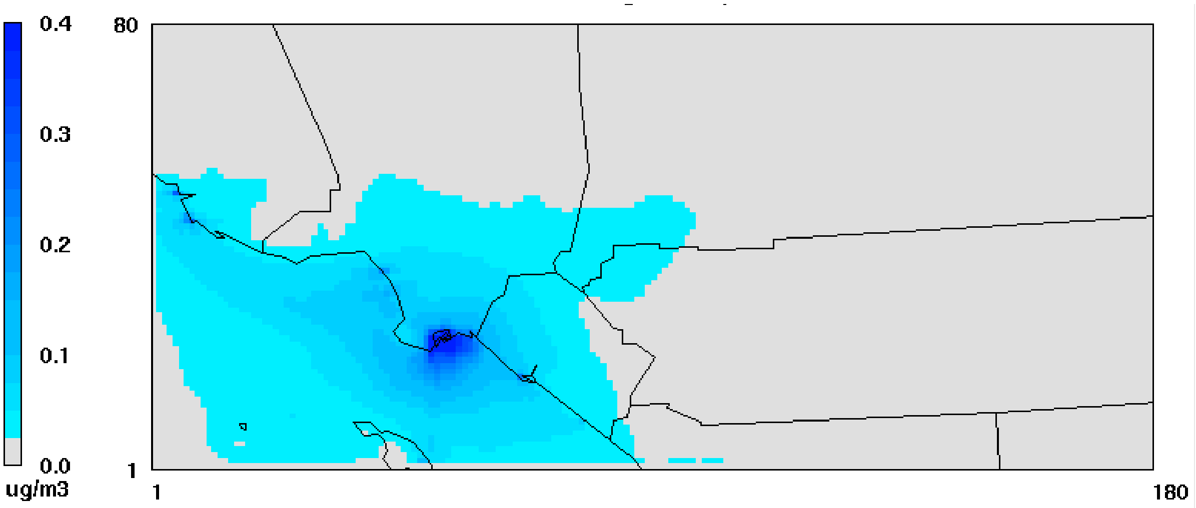


Figure IX-7-2e
CAMx simulated 2018 annual average Diesel PM from OGV and CHC

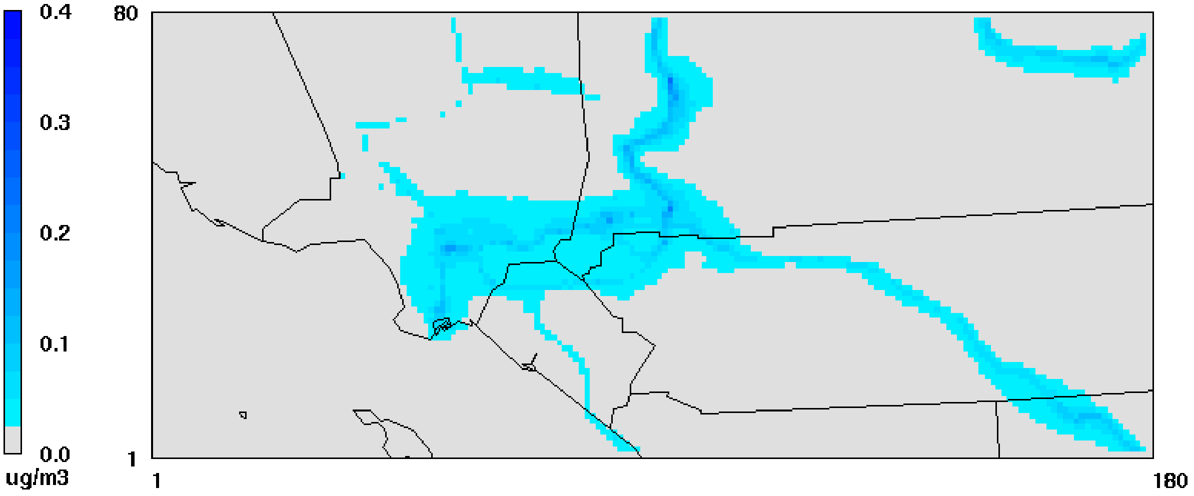


Figure IX-7-2f
CAMx simulated 2018 annual average Diesel PM from Trains

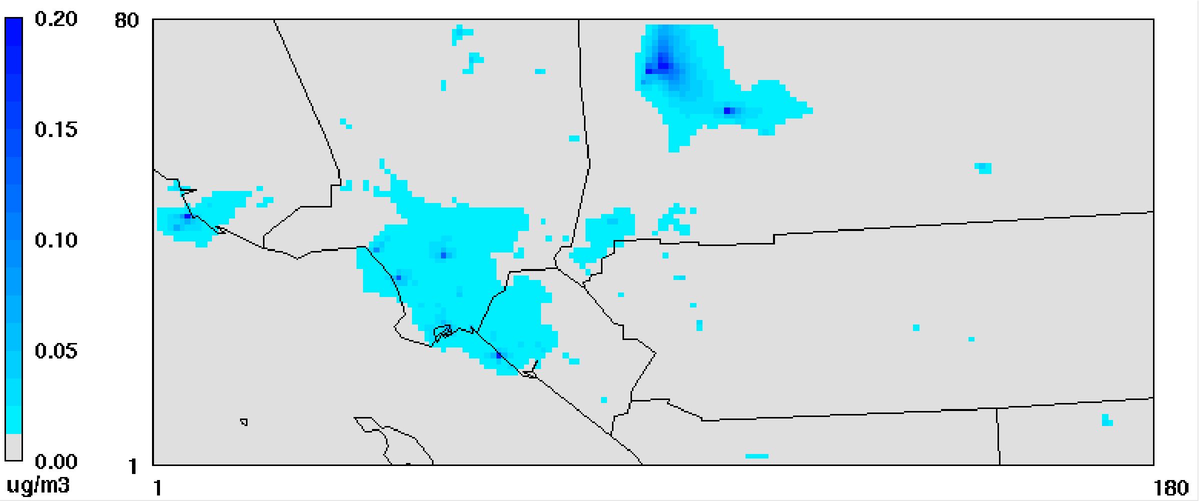


Figure IX-7-2g

CAMx simulated 2018 annual average diesel PM from stationary sources.

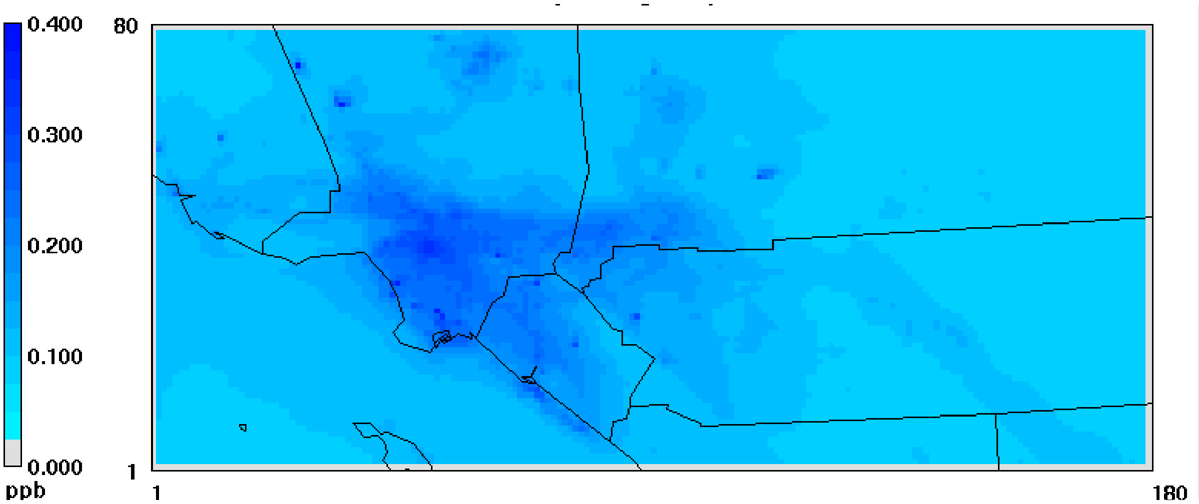


Figure IX-7-2h

CAMx simulated 2018 annual average benzene

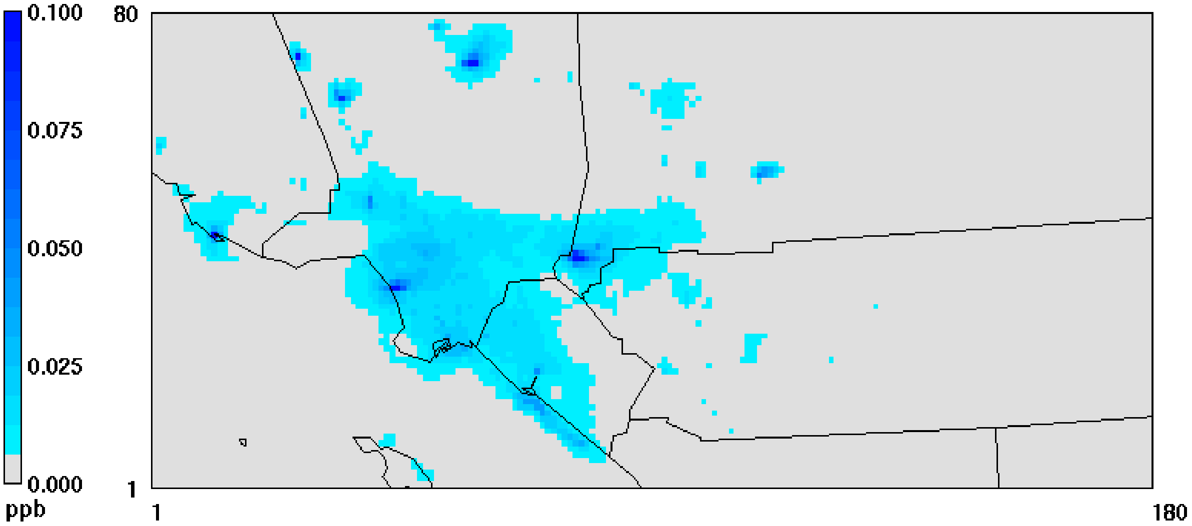


Figure IX-7-2i

CAMx simulated 2018 annual average 1,3-butadiene

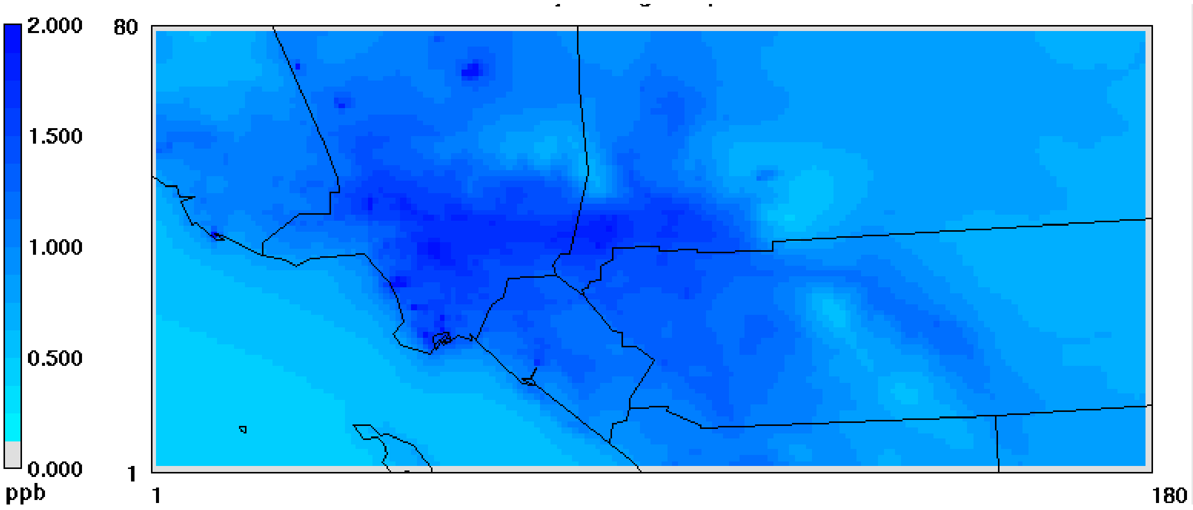


Figure IX-7-2j

CAMx simulated 2018 annual average for total formaldehyde

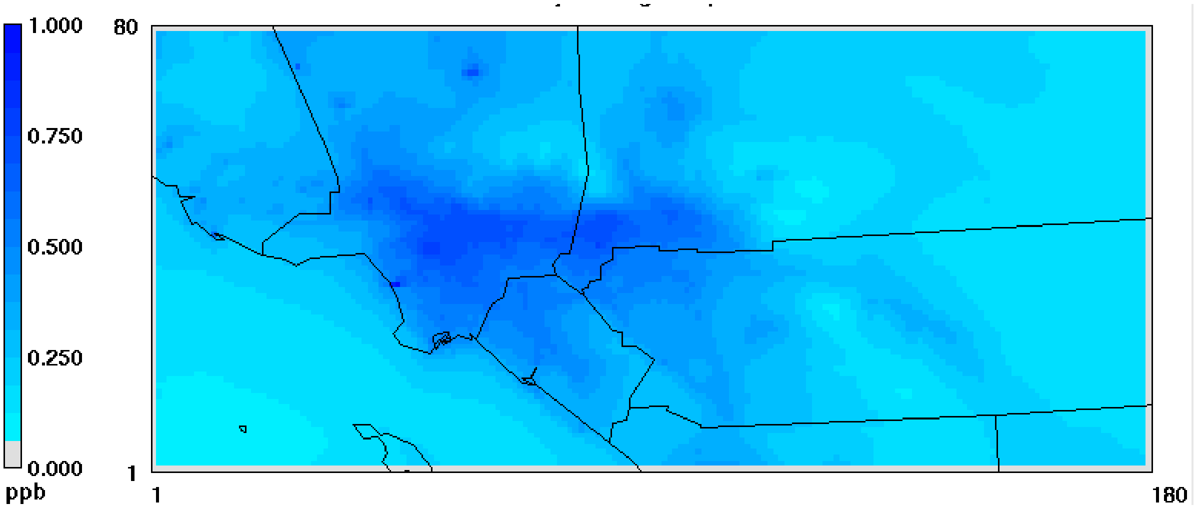


Figure IX-7-2k
CAMx simulated 2018 annual average acetaldehyde

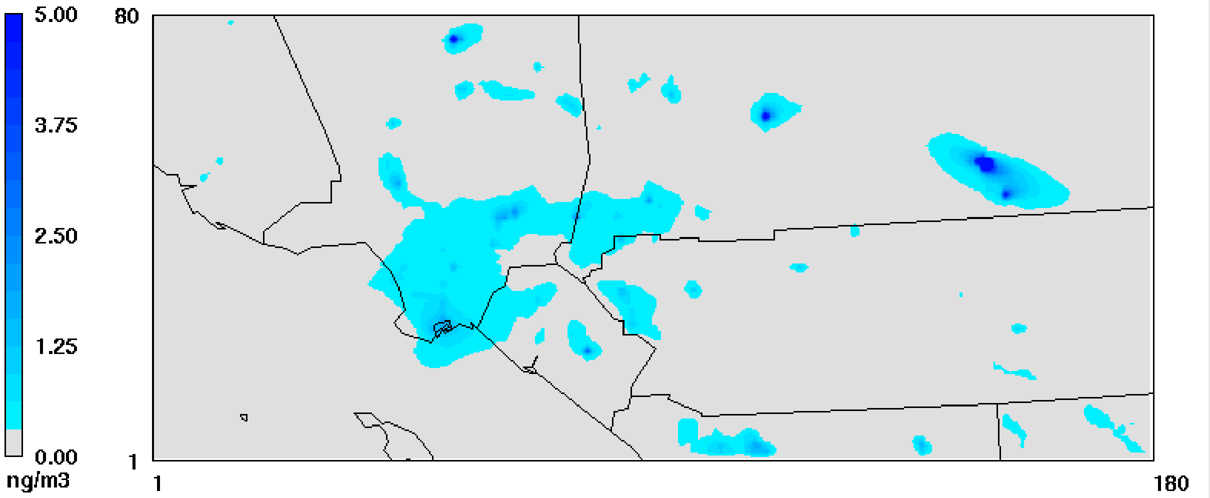


Figure IX-7-2l
CAMx simulated 2018 annual average arsenic TSP

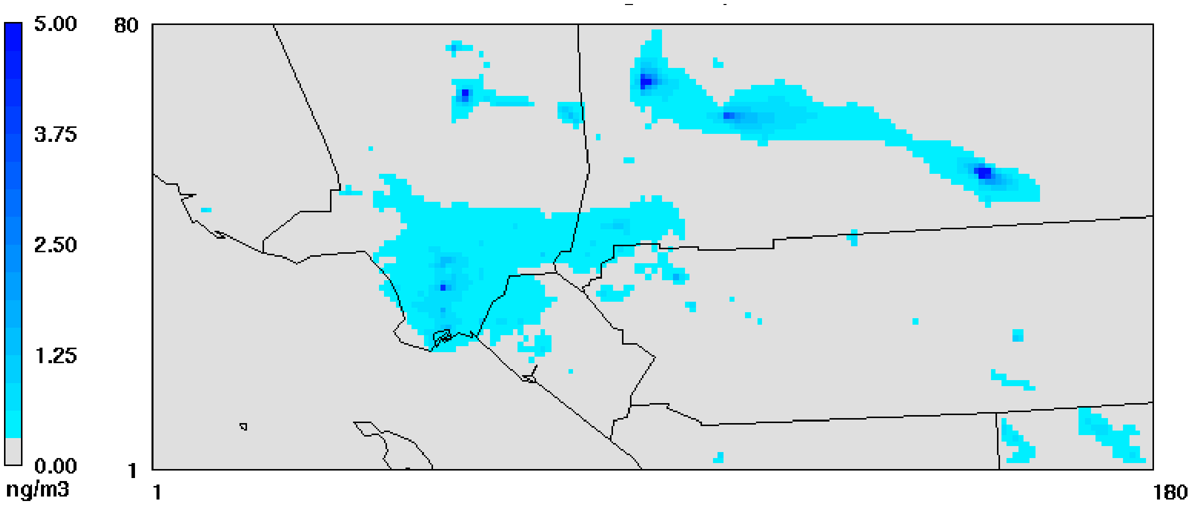


Figure IX-7-2m
CAMx simulated 2018 annual average cadmium TSP

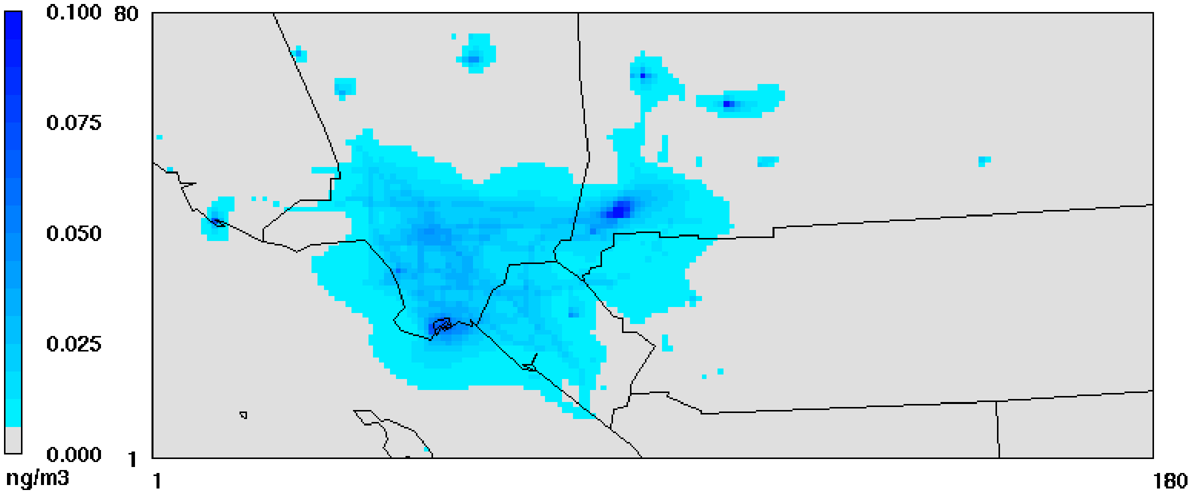


Figure IX-7-2n
CAMx simulated 2018 annual average hexavalent chromium TSP

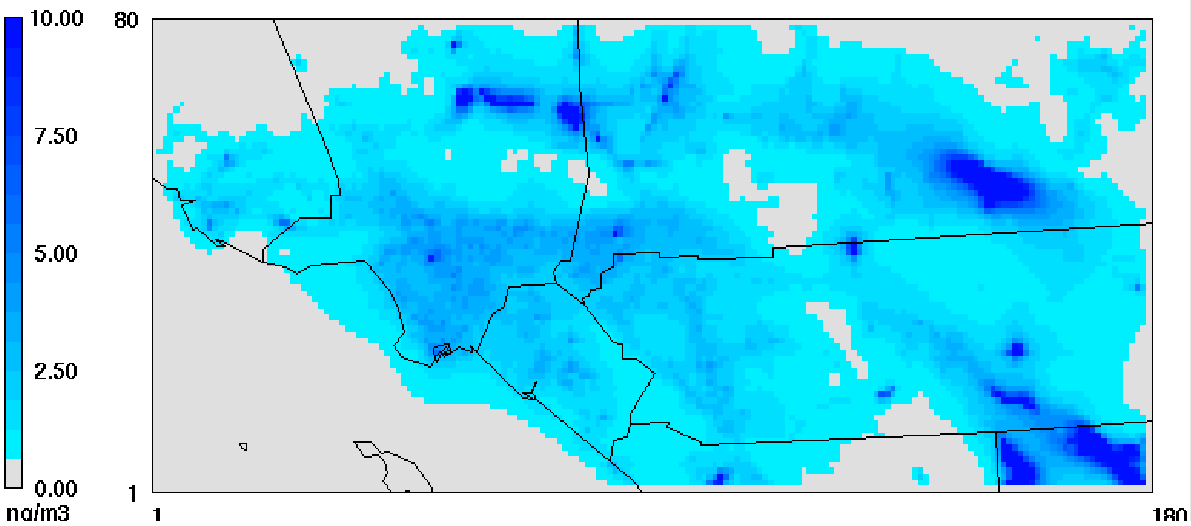


Figure IX-7-2o
CAMx simulated 2018 annual average lead TSP

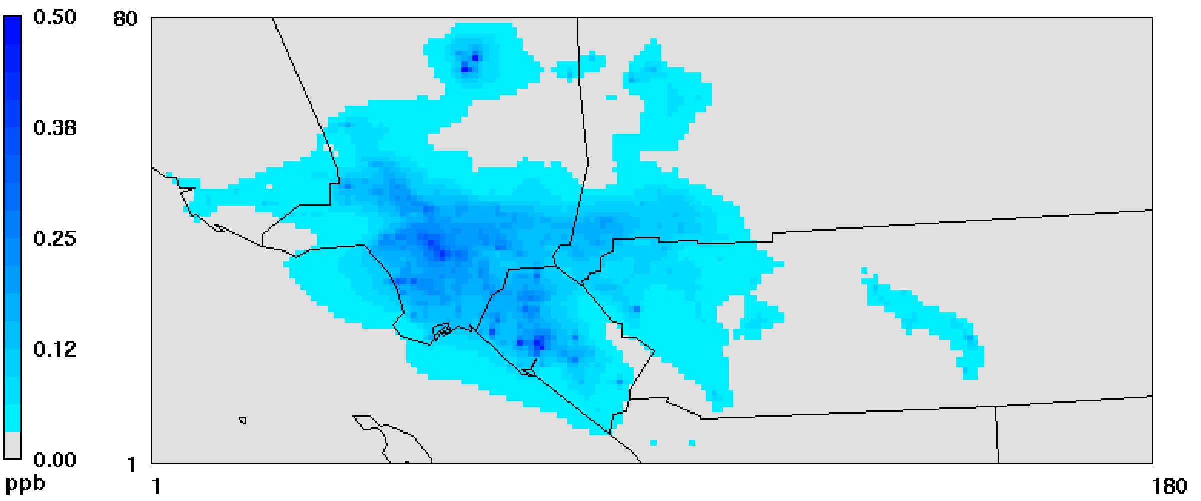


Figure IX-7-2p
CAMx simulated 2018 annual average methylene chloride

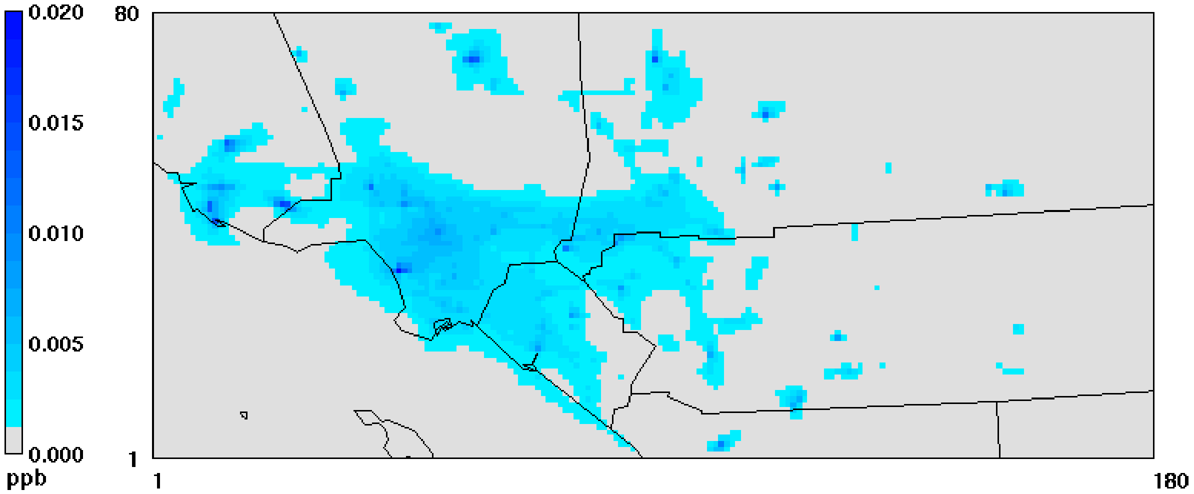


Figure IX-7-2q
CAMx simulated 2018 annual average naphthalene

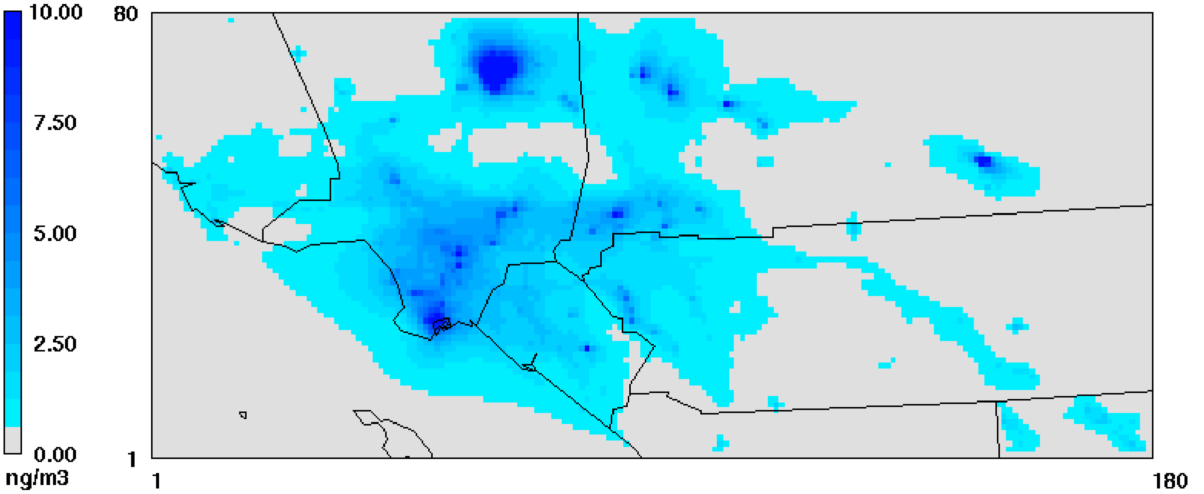


Figure IX-7-2r
CAMx simulated 2018 annual average nickel TSP

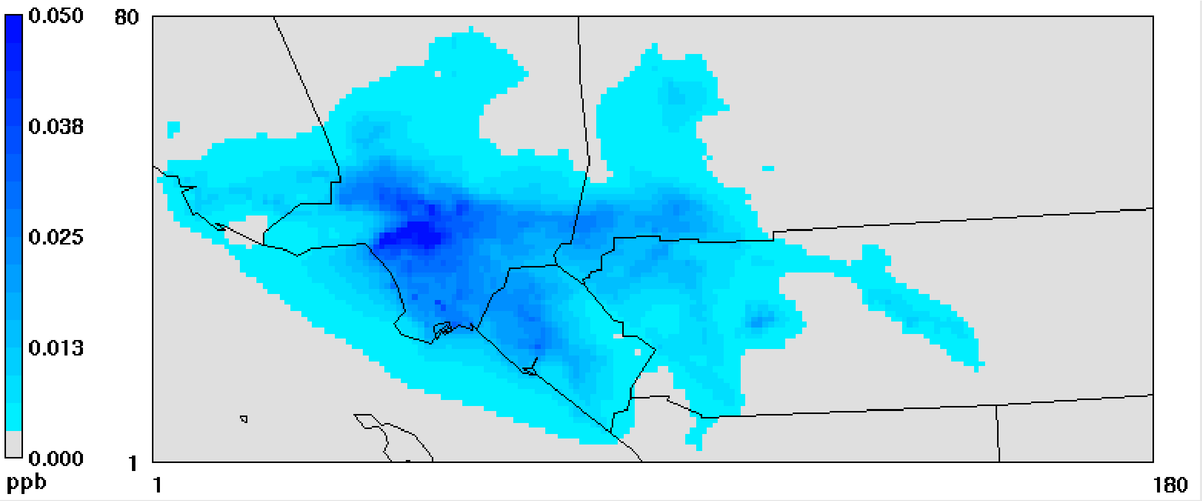


Figure IX-7-2s
CAMx simulated 2018 annual average p-dichlorobenzene

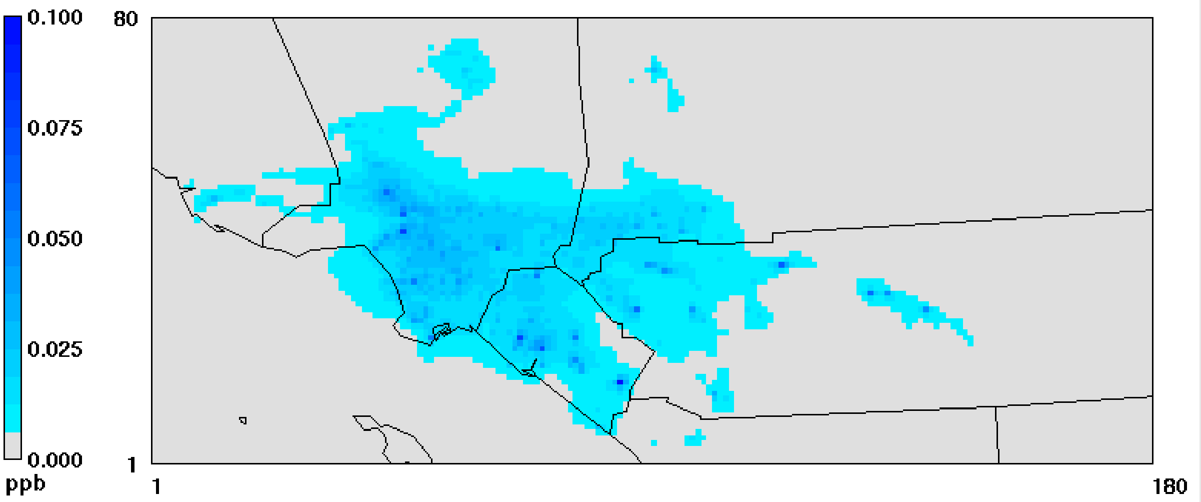


Figure IX-7-2t
CAMx simulated 2018 annual average perchloroethylene

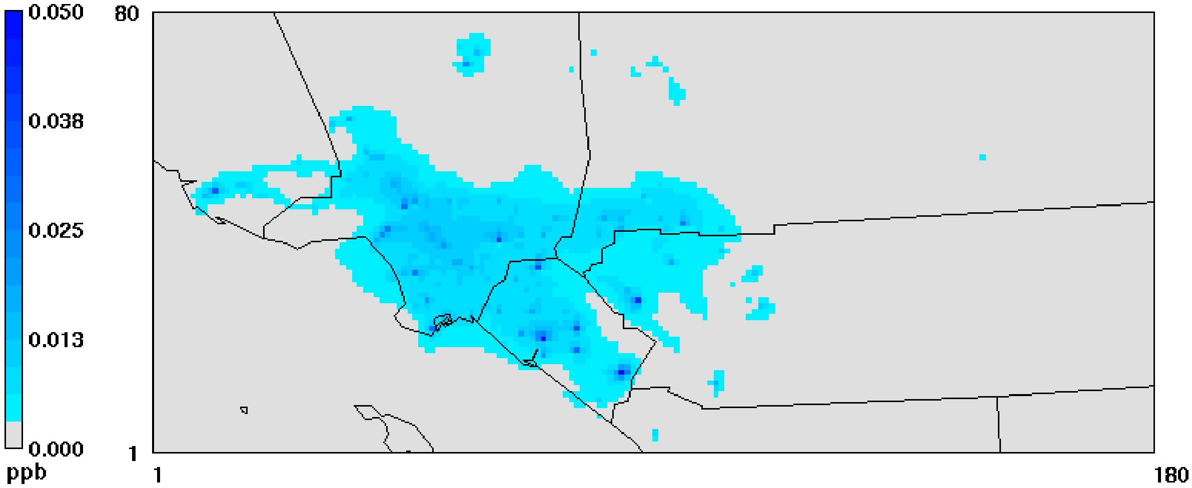


Figure IX-7-2u
CAMx simulated 2018 annual average trichloroethylene

IX.7.5 Estimation of Risk

Figure IX-7-3 depicts the distribution of risk estimated from the predicted annual average concentrations of the key toxic compounds. Risk is calculated for each grid cell as follows:

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

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 the 2015 OEHAA risk assessment guidelines. In addition to the inhalation exposure, which was the method to estimate cancer risk in the previous MATES, a multiple pathway factor was incorporated in the current cancer risk estimation. The multiple pathway factors include additional cancer risk from oral and dermal exposures from toxic metals.

The grid cell having the highest simulated cancer risk of 990-in-a-million was located near the Ports of Los Angeles and Long Beach. Another grid cell with a high risk value (963-in-a-million) was the grid where the Los Angeles International Airport is located. 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 IX-7-4 provides the CAMx RTRAC simulated air toxics risk for the MATES IV period. Figure IX-7-5 depicts the changes in risk from MATES IV (2012-2013) to MATES V (2018-2019) estimated from the CAMx RTRAC simulations. The greatest decrease in risk occurred in the ports area, where the peak risk value changed from 2,607 to 990, reflecting the emission reductions from OGV, CHC and other port operations including cargo handling equipment, port trucks and locomotives. Overall, air toxics risk improved significantly, consistent with air toxic emissions reductions that occurred over the period.

The MATES V period Basin-average population-weighted inhalation-only cancer risk summed for all the toxic components yielded a cancer risk of 424 in a million. The average risk included all populated land cells that reside within the Basin portion of the modeling domain. The MATES IV Basin average inhalation-only risk was 897 per million. Between the MATES IV and MATES V periods, the simulated risk decreased by 53%. The 53% reduction in Basin risk can be attributed to several factors, most notably, changes in diesel emissions between 2012 and 2018. As shown in Chapter 3, the toxic emissions between the two MATES periods decreased by 46%, including the on-road source emissions decreasing by 59% and the off-road source emissions decreasing by 39%. Modeling using the MATES IV emissions with the MATES V meteorology indicates that, under the same meteorological conditions, the risk reduction based on the changes in the emissions between MATES IV and MATES V would have been 49%. Therefore, a small portion of the modeled risk reduction is due to the difference in the meteorological dispersion potential.

Figures IX-7-6a through IX-7-6f depict risk associated with diesel and its specific emissions categories. Figure IX-7-7 provides the risk excluding the contribution of diesel PM. On and off-road diesel impacts are spread throughout the Basin following the transportation corridors and off-road facilities such as the intermodal transfer sites. The shipping impacts are concentrated in the vicinity of the Ports of Los Angeles and Long Beach and the adjacent downwind communities.

Regional risk from non-diesel sources (Figure IX-7-7) is also uniformly distributed throughout the Basin with values typically around 100 -200 in one million, with only a few selected cells showing values exceeding 200 in one million risk.

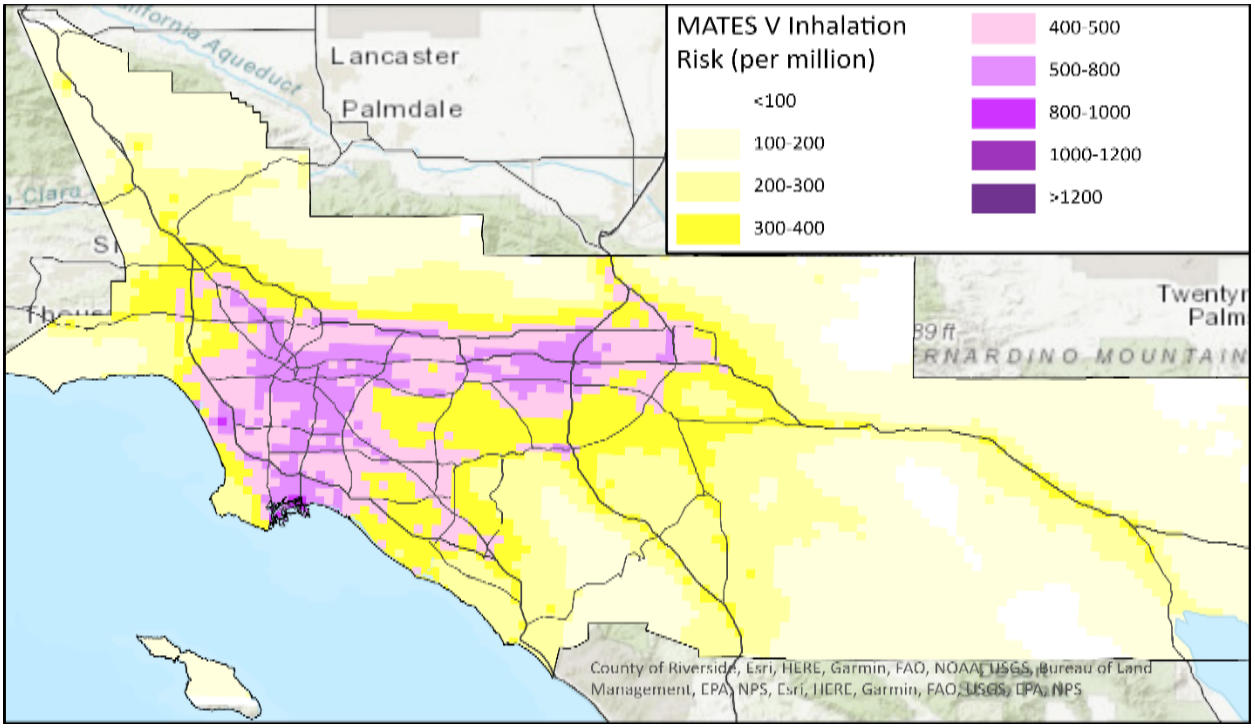


Figure IX-7-3
2018 MATES V CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk

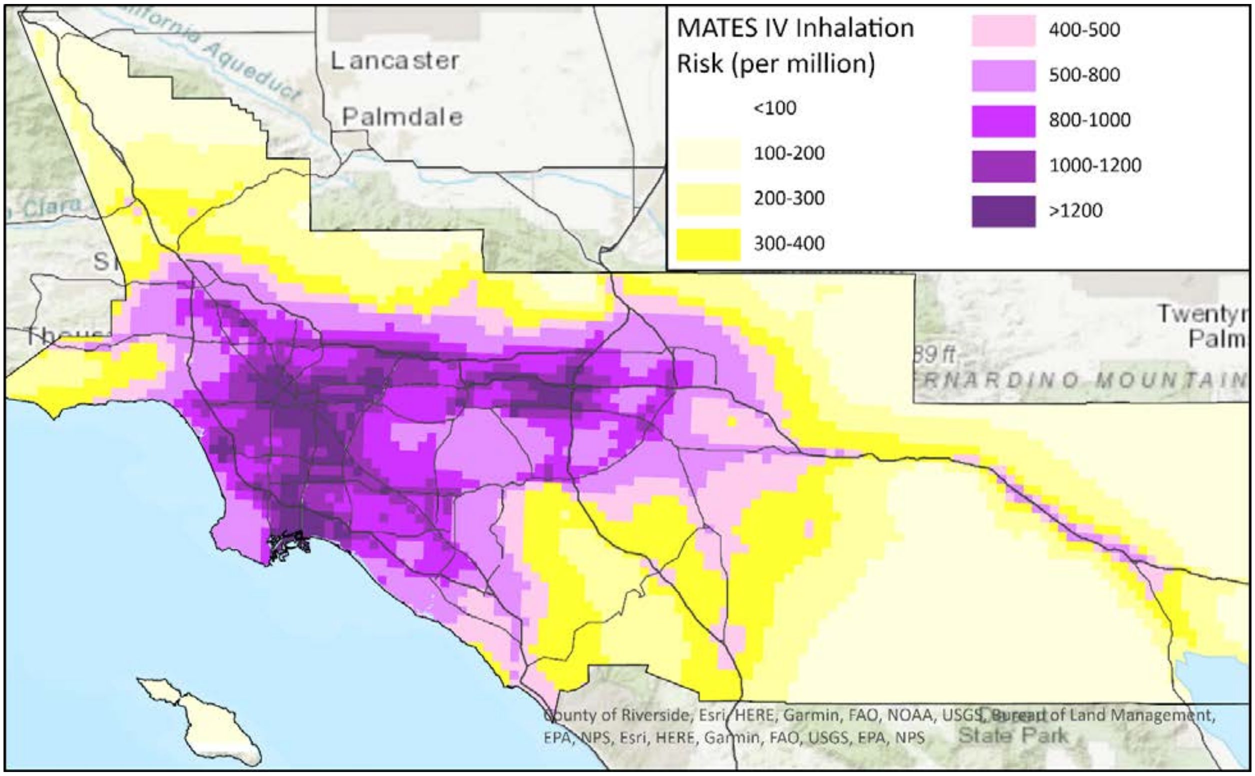


Figure IX-7-4
2012 MATES IV CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk.

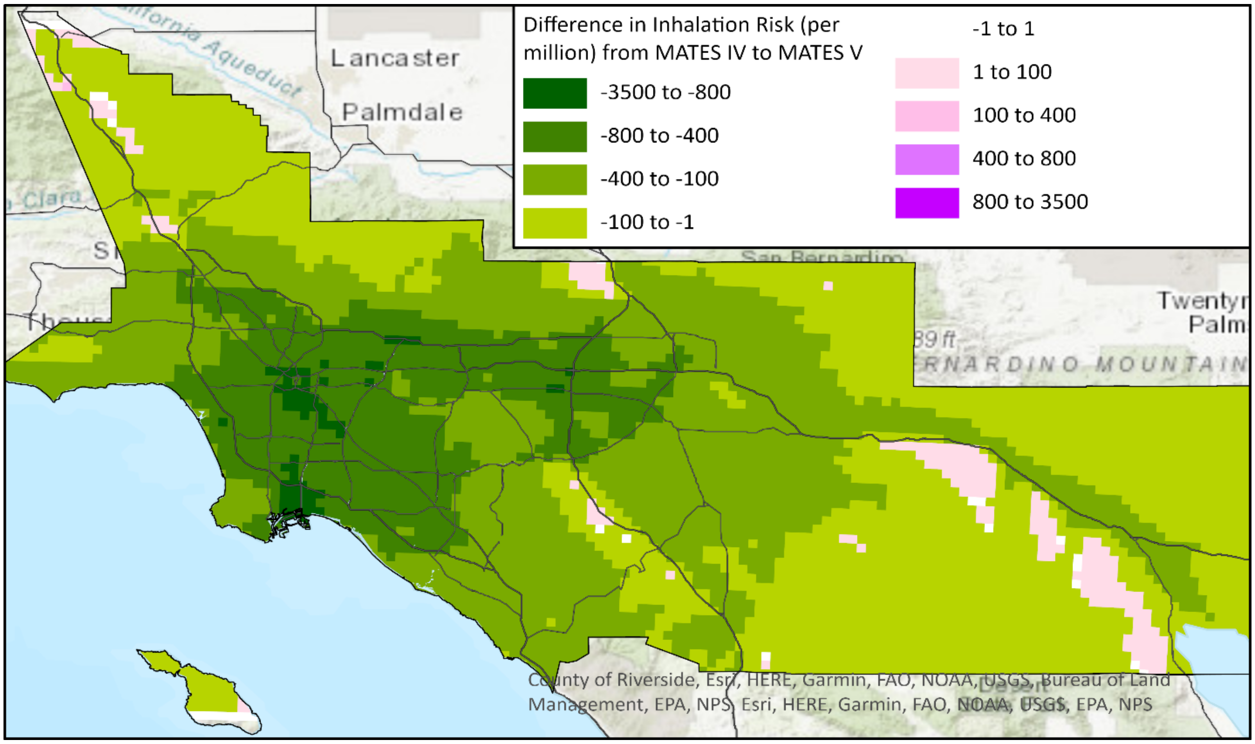


Figure IX-7-5

Change in CAMx RTRAC simulated Inhalation Air Toxics Cancer Risk from 2012 to 2018

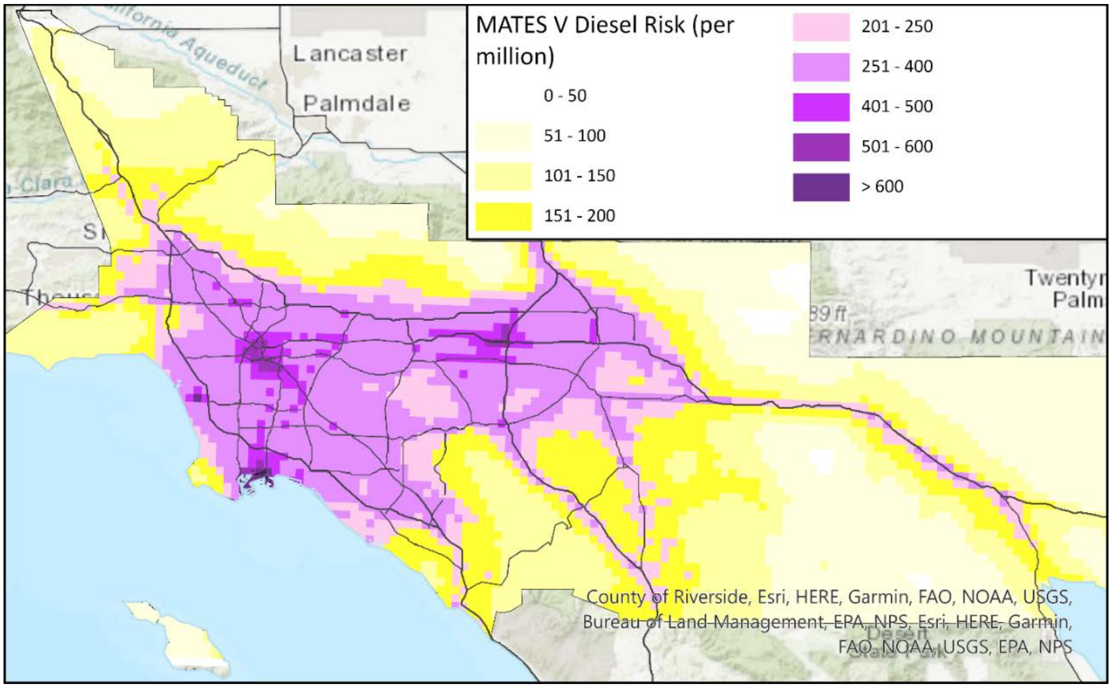


Figure IX-7-6a

MATES V Inhalation Cancer Risk from Diesel PM from All Categories

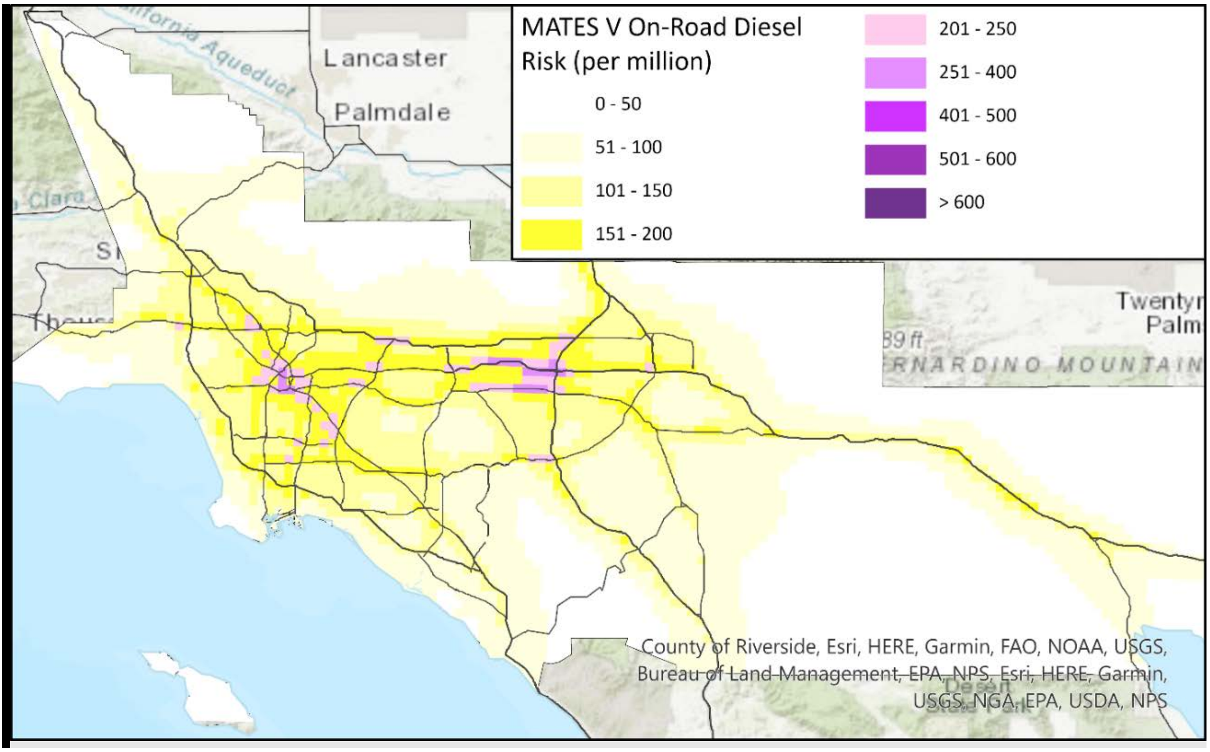


Figure IX-7-6b

MATES V Simulated Inhalation Cancer Risk from On-Road Diesel PM.

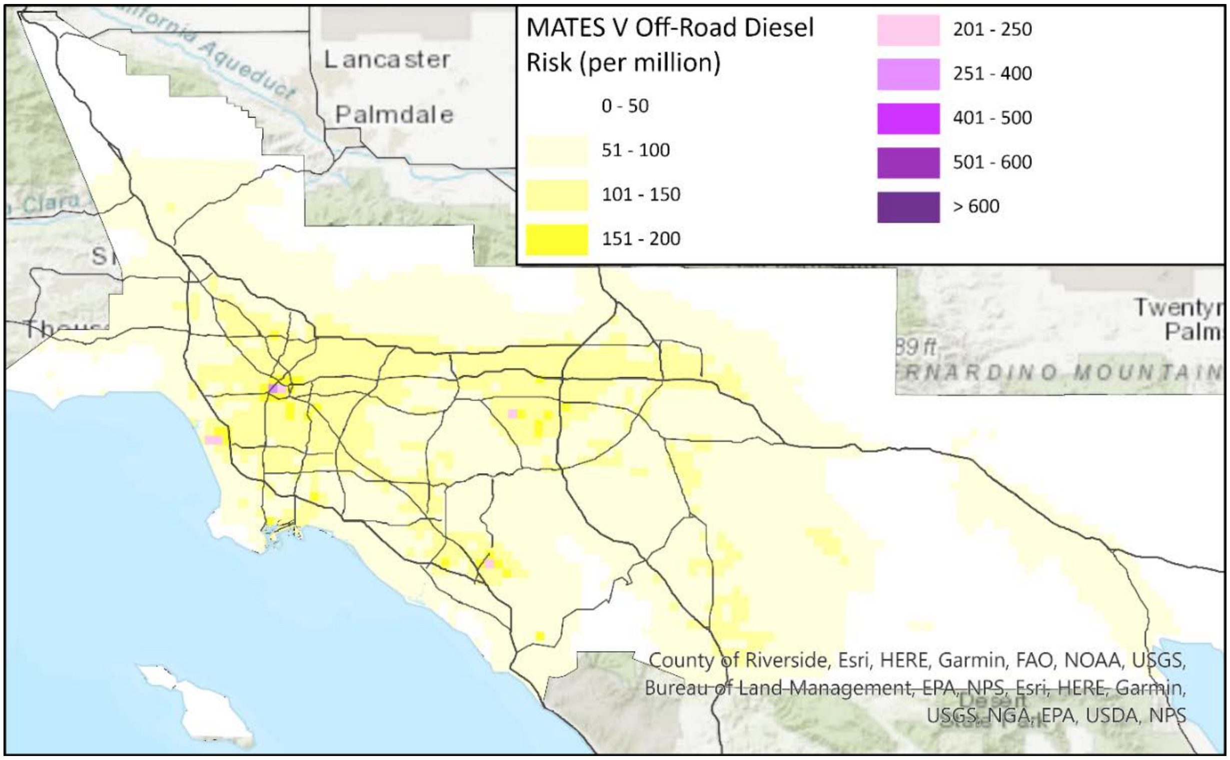


Figure IX-7-6c

MATES V Simulated Inhalation Risk from Off-road Diesel (including railyards but excluding trains and ships).

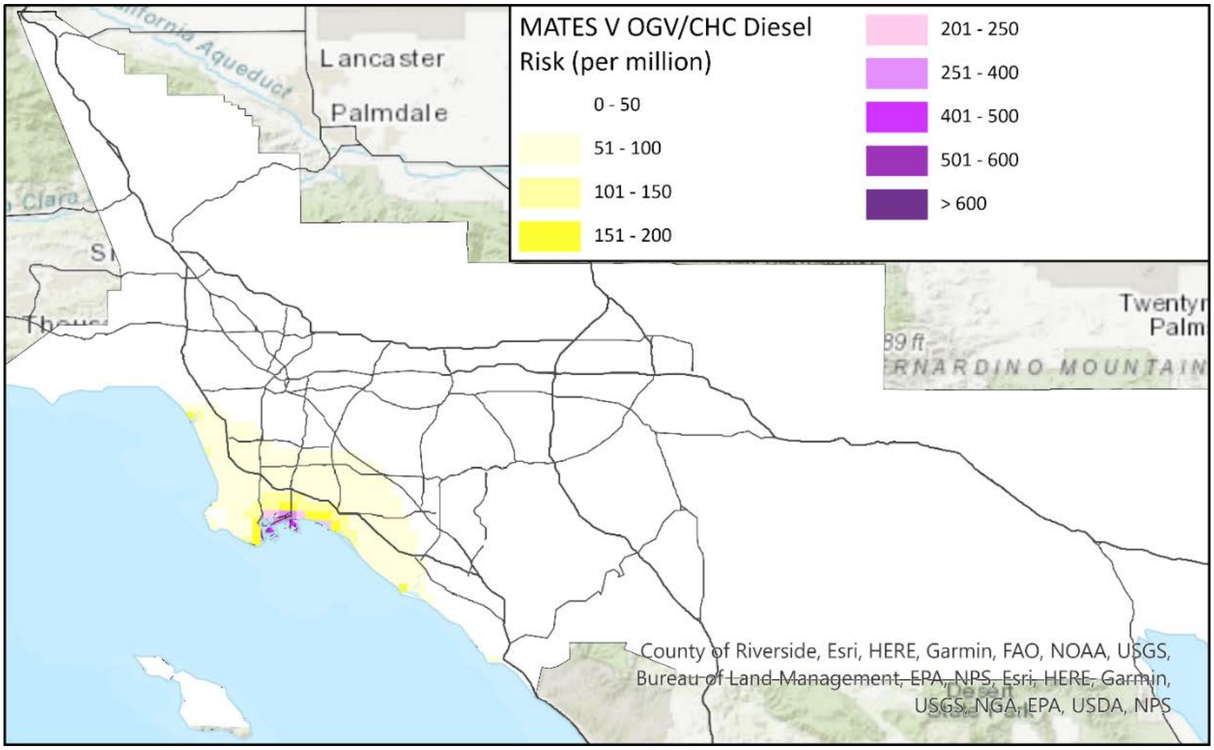


Figure IX-7-6d

MATES V Simulated Inhalation Cancer Risk from Ship Diesel PM.

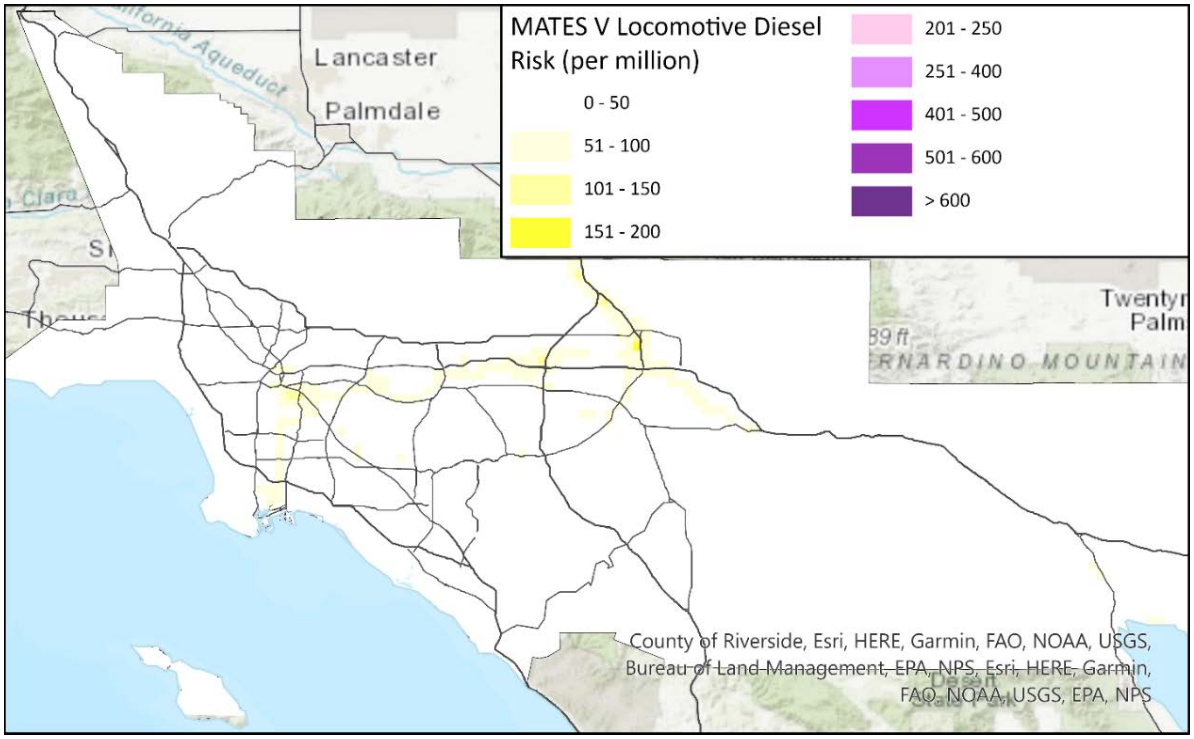
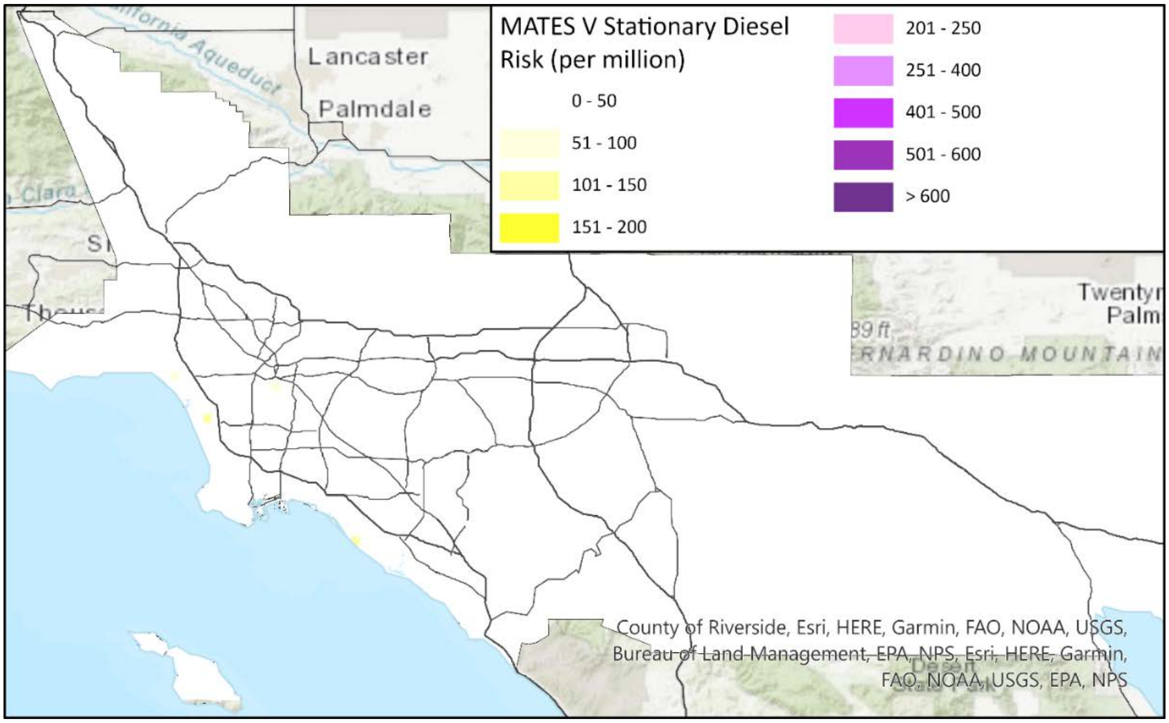


Figure IX-7-6e

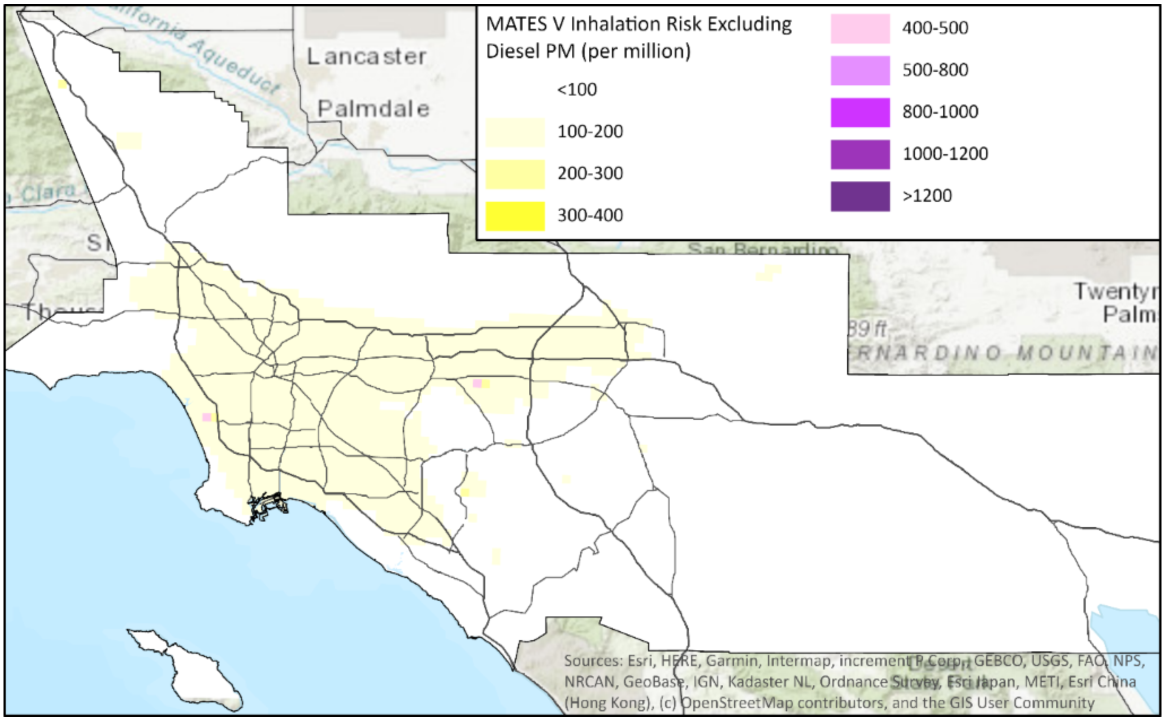
MATES V Simulated Inhalation Cancer Risk from Locomotive Diesel PM (Excluding Railyard Equipment).



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

Figure IX-7-6f

MATES V Simulated Inhalation Cancer Risk from Stationary Diesel PM.

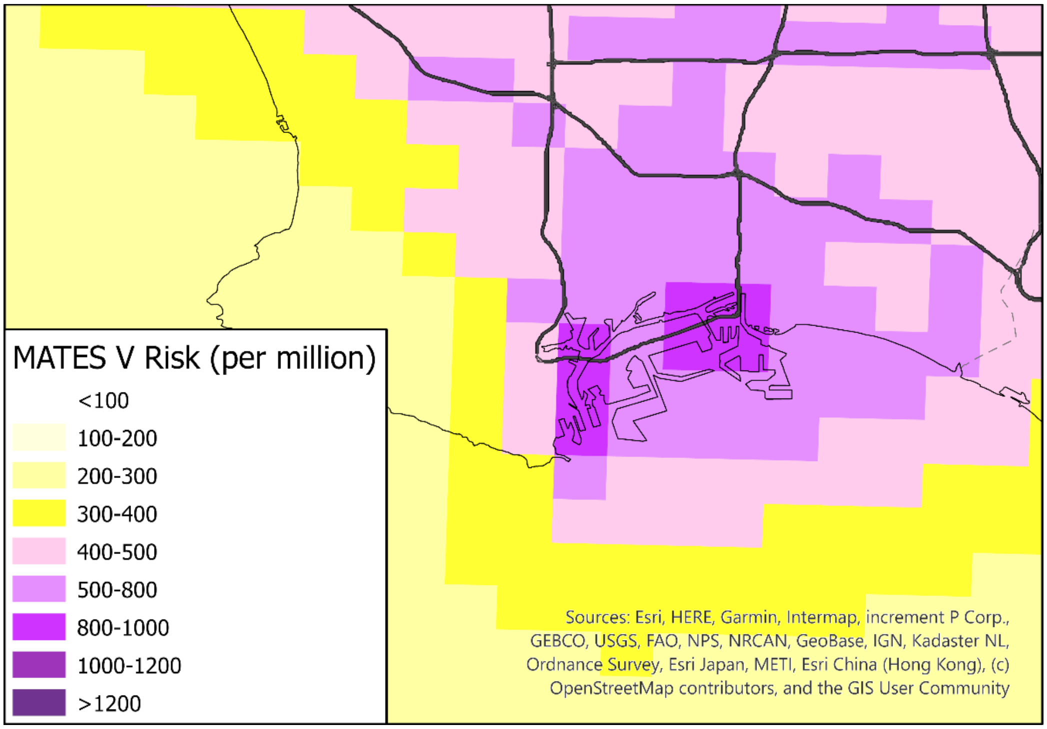


Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure IX-7-7

MATES V Simulated Inhalation Cancer Risk from all air toxics excluding diesel emissions

Figure IX-7-8 provides a close-up plot of the air toxics cancer risk in the Ports area. Table IX-7-7 provides a summary of the air toxics cancer risk estimated for the Basin, for the Ports area, and for the Basin excluding the Ports area. For this assessment, the Ports area includes 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. The MATES V average population-weighted air toxics risk in the Ports area (as defined above) was 504 in one million. The Basin average population-weighted air toxics risk, excluding the grid cells in the Ports area, was 418 in one 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 one million; and the Basin minus the Ports area was 879 in one million. Overall, 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%.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure IX-7-8

2018 Ports area MATES V Simulated Inhalation Air Toxics Cancer Risk

Table IX-7-7

Basin and Port Area Population Weighted Inhalation Air Toxics Cancer Risk

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

IX.7.6 County Risk Assessment

Table IX-7-8 provides the county-by-county air toxics risk to the affected population. As presented in the spatial distribution, the Basin portion of Los Angeles County bears the greatest average cancer risk at 470 per one million. The Basin portion of San Bernardino County has the second highest projected risk at 449 per one million. The estimated risk for Orange County is 379 per million, and the Basin portion of Riverside County was estimated to have the lowest population-weighted risk at 321 per million. As expected, the Coachella Valley portion of Riverside County, which is outside of the Basin, has the lowest toxic risk at 241 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.

Comparison of the county-wide population-weighted risk shows that the greatest reduction occurred in Los Angeles County, with the amount of risk reduction per county being similar. Reductions in emissions from mobile sources including benzene, 1,3-butadiene, and diesel particulate are the primary contributors to the improved county-wide risk.

Table IX-7-8

County-Wide Population-Weighted Air Toxics 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
Basin	15,991,550	897	16,599,786	424	-53
Coachella Valley	465,064	339	479,055	239	-30

* Including the Basin portion only

IX.7.7 Risk from Key Compounds

Table IX-7-9 provides the Basin average breakdown of risk associated with each of the key compounds simulated in the analysis. Diesel particulate ranked highest (70%) as the toxic compound contributing to the overall inhalation cancer risk to the population. The next three highest contributors included benzene, 1,3-butadiene and formaldehyde. The four top toxic pollutants contribute over 90% toxic risk. Formaldehyde (primary and secondary) and acetaldehyde (primary and secondary) contribute 6% and 1.6%, respectively, while the remaining compounds combined accounted for less than 7% of the total.

Table IX-7-9

MATES V Inhalation Cancer Risk from Simulated Individual Toxic Air Contaminants

Toxic Compound	Risk Factor (µg/m^3)	Max Annual Average Concentration	Population Weighted Annual Average Concentration	Units	Risk (per million)	% Contribution
DPM	7.40E-04	1.13	0.41	µg/m3	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/m3	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/m3	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/m3	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/m3	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/m3	0.08	<0.1

IX.7.8 Network Risk Evaluation

Table IX-7-10 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 directly, 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

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 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.

Table IX-7-10

Modeled Inhalation Cancer Risk at Monitoring Locations and Measured 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

*Including modeled species only, Risk from some measured species, such as carbon tetrachloride, chloroform and PAHs are excluded. Measured $EC_{2.5}$ was converted diesel PM as described in the Chapter 2.

+ Among the 10 monitoring stations, 3 stations, Anaheim, Los Angeles and Rubidoux do not have complete data. Therefore 7-station averages are used.

Based on modeled concentrations, the inhalation-only air toxics cancer risk averaged over the 7 stations is 530-in-a-million, which is approximately 11% lower than the measurement-based risk as shown in Figure IX-7-9a.

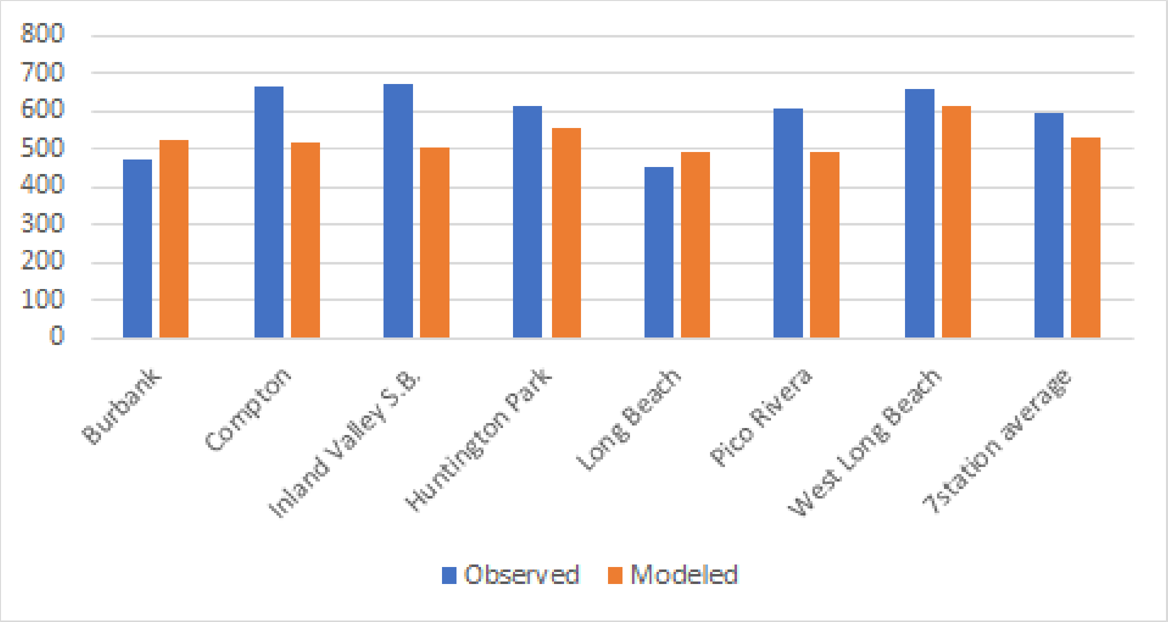


Figure IX-7-9a

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 IX-7-9b 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.

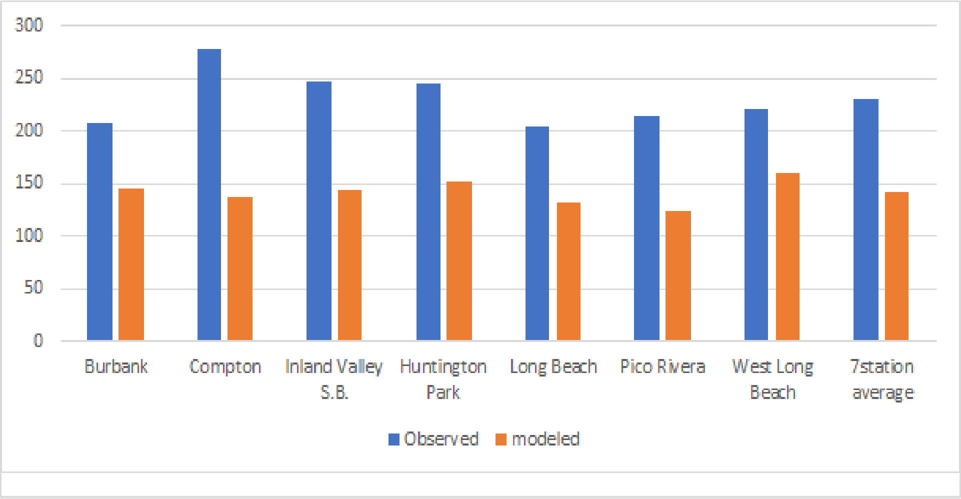


Figure IX-7-9b

MATES V Simulated vs. Measured Non-Diesel Air Toxics Risk (per million)

IX.7.9 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 IX-7-11 lists average risks for individual county and Coachella Valley. Figure IX-7-10 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 IX-7-3, 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 IX-7-12. The reduction in the multiple-pathway risk is similar to the inhalation-only risk trends as shown in Table IX-7-8.

Table IX-7-11
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
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.

*

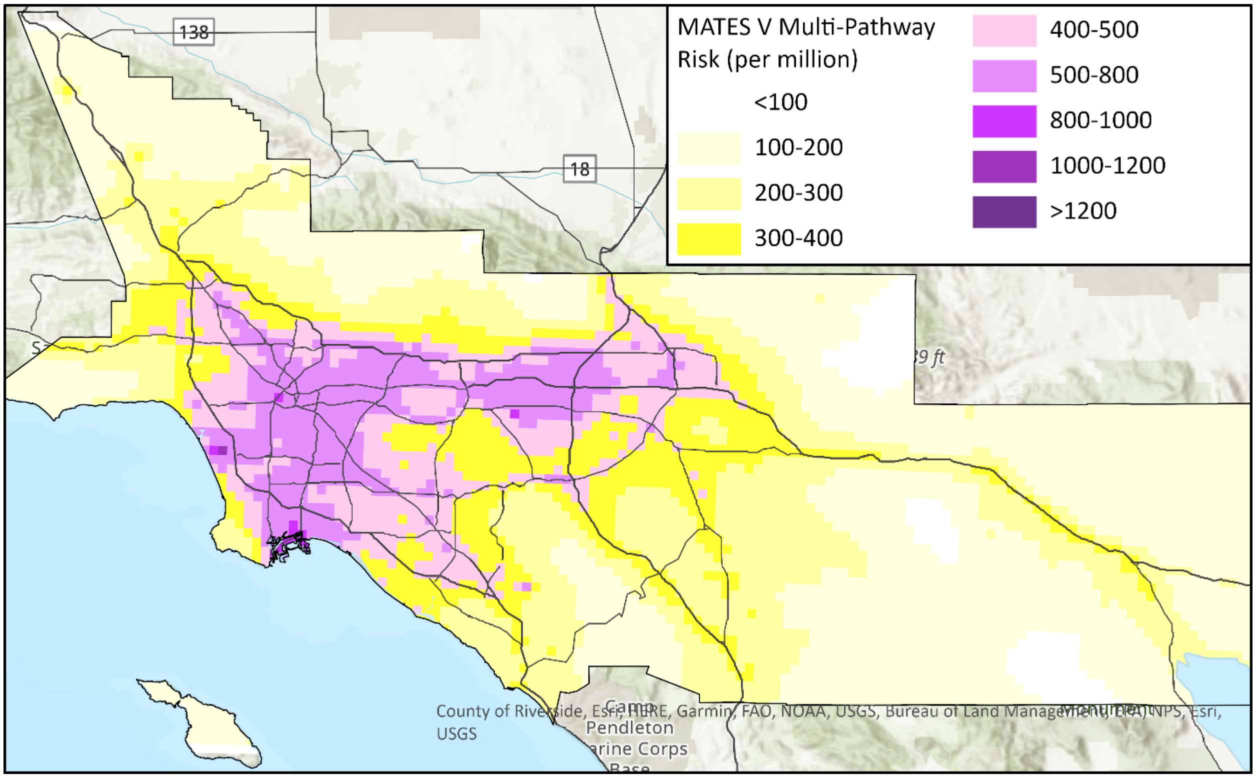


Figure IX-7-10
MATES V CAMx RTRAC Simulated Multiple-Pathway Air Toxic Cancer Risk

Table IX-7-12
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%
Port Area	998,745	1293	1,004,938	559	-57%
Basin Excluding Port Area	14,992,806	978	15,994,848	448	-54%
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.

IX.8 Summary and Conclusions

A regional photochemical modeling system including CAMx with RTRAC algorithm, WRF, MEGAN and mobile source emissions model was employed to simulate air toxics cancer risk for the MATES V study. The population-weighted average Basin air toxics cancer risk is simulated to be 424 per million for inhalation-only risk and 455 per million for multi-pathway risk. The areas of the Basin that are exposed to the higher risk continue to be along the goods movement corridors. The MATES V inhalation-only cancer risk is estimated to be 53% lower than the corresponding risk during the MATES IV period, which was 897 in a million. Much of the risk reduction was due to the reductions of diesel particulate emissions which showed a 51% reduction from 2012 to 2018. 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 46%. The simulated risk showed a greater rate of reduction than the corresponding risk derived from measurements, which showed 31% reduction since MATES IV.

IX.9 References

Byun, D.W., and Ching, J.K.S. (1999). Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling system, U.S. Environmental Protection Agency, EPA/600/R-99/030

California Air Resources Board (CARB) (2017). EMission FACtor (EMFAC) 2017 model and its documentation can be obtained at the following link: http://www.arb.ca.gov/msei/modeling.htm

California Air Resources Board (CARB) (2018). SIP Update can be viewed or downloaded from the following CARB link: https://ww2.arb.ca.gov/resources/documents/2018-updates-california-state-implementation-plan-2018-sip-update

California Air Resources Board (CARB), (2020), Workshop on emissions inventory from small off-road engines (SORE). . https://ww2.arb.ca.gov/sites/default/files/2020-03/SORE2020%20Workshop%20Slides%20March%2025%202020_03302020_ADA_v2.pdf

ENVIRON, Inc.(2005). “METSTAT software for MM5 version 3 (02/11/05),” ENVIRON. Novato, CA 94945, http://www.camx.com/down/support.php

ENVIRON, Inc. (2006). ”KVPATCH software for CAMx,” ENVIRON. Novato, CA 94945, http://www.camx.com/down/support.php

Hong, S.-Y., and H.-L. Pan (1996). Nonlocal boundary layer vertical diffusion in a medium-range forecast model. Mon. Wea. Rev., 124, 2322–2339, doi:10.1175/1520-0493(1996)124,2322

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

Mason, R., Dolwick, P., Carey, P., Kinnee, E., Wilson, M. (2008). Emissions processing and sensitivity air quality modeling of category 3 commercial marine vessel emissions. In: Proceedings from 17th Annual International Emission Inventory Conference, Portland, OR.

O’Brien, J.J. (1970). A note on the vertical structure of the eddy exchange coefficient in the planetary boundary layer. J. Atmos. Sci., 27, 1213-1215

Ranboll Environment and Health. (2018). CAMx User’s Guide Version 6.50. Novato, CA 94998. Available at https://camx-wp.azurewebsites.net/Files/CAMxUsersGuide_v6.50.pdf

Skamarock, W.C., Klemp, J.B., Dudhia, J., Gill, D.O., Barker, D.M., Duda, M.G., Huang, X.-Y., Wang, W., Powers, J.G. (2008). A Description of Advanced Research WRF version 3. NCAR/TN-475+STR, NCAR Technical Note

Southern California Association of Governments (SCAG) (2016). Information on the Southern California Association of Governments 2016 RTP/SCS Available at 2016-2040 RTP/SCS Transportation Conformity Determination - Southern California Association of Governments, https://scag.ca.gov/sites/main/files/file-attachments/f2016rtpscs.pdf?1606005557

South Coast Air Quality Management District (AQMD) (2000). MATES II Documents Available at http://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-ii

South Coast Air Quality Management District (AQMD), (2008). MATES III Documents Available at https://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-iii

South Coast Air Quality Management District (AQMD) (2015). MATES IV Documents Available at https://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-iv

South Coast Air Quality Management District (AQMD) (2016). Air Quality Management Plan. Document available at https://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/final-2016-aqmp

South Coast Air Quality Management District (AQMD) (2020). Draft Final South Coast Air Basin Attainment Plan for 2006 24-Hour PM2.5 Standard. Available at: http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/draft-final-south-coast-air-basin-pm2-5-plan-110320.pdf?sfvrsn=6

U.S. EPA (2006). Guidance on Use of Modeled and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ 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, September, 2006

WRAP (2007). Western Regional Air Partnership, Technical Support System, Emissions Method, Offshore Emissions, http://vista.cira.colostate.edu/

APPENDIX X

MATES V

DRAFT FINAL REPORT

Spatial and Temporal Trends of PM2.5 and TSP Components in the South Coast Air Basin

Appendix X

Spatial and Temporal Trends of PM2.5 and TSP Components in the South Coast Air Basin (An Update from MATES IV)

X.1. Overview

While particulate pollution has decreased significantly over the past decades in the South Coast Air Basin (Basin), exposure to airborne particulate matter and toxic species within particulate matter continues to pose significant health risks for South Coast residents. In order to better understand long-term trends in particulate matter concentration and composition, fine particulate matter ($PM_{2.5}$) and total suspended particulate (TSP) samples were collected and analyzed at ten MATES V sites throughout the Basin as in previous MATES campaigns. This appendix discusses findings from MATES V $PM_{2.5}$ and TSP analysis with particular attention to trends between MATES IV (2012-2013) and MATES V (2018-2019).

$PM_{2.5}$ mass reconstructions at five MATES V sites showed similar patterns to results from MATES IV, with organic matter making up the largest fraction (45-48%) of $PM_{2.5}$ mass, followed by the combined secondary inorganic ion fraction (ammonium sulfate and ammonium nitrate, 37-41%). Seasonal trends in reconstructed $PM_{2.5}$ component concentrations were also largely consistent with those observed in MATES IV, with fall/winter maxima in elemental carbon and ammonium nitrate, summer maxima in ammonium sulfate, and less seasonally distinct or more complex patterns in other components. Elemental carbon levels throughout the Basin dropped substantially between MATES IV and MATES V, with 31-64% reductions at all ten MATES V sites. Ambient toxic metal concentrations measured in TSP samples showed mixed trends by metal and site. Hexavalent chromium and lead concentrations decreased at most sites between MATES IV and MATES V (29 and 21% decreases in basin averages, respectively), while cadmium levels increased at most sites (114% increase in basin average). Trends for other toxic metals, including arsenic, nickel, manganese, antimony, chromium, and cobalt, were more spatially variable with more muted changes in overall basin averages.

X.2. Mass Reconstruction of $PM_{2.5}$

$PM_{2.5}$ consists of a wide range of inorganic and organic species, reflecting diverse sources and complex aerosol chemical processes. $PM_{2.5}$ can be broadly grouped into five major components: elemental carbon (EC), organic matter (OM), secondary inorganic ions (ammonium, nitrate, and sulfate), sea salt, and crustal/soil material. Mass reconstruction of $PM_{2.5}$ from estimated contributions of these components is commonly performed to evaluate consistency between different chemical analyses as well as to assess temporal and spatial variability in $PM_{2.5}$ composition. In the MATES IV study, mass reconstruction calculations showed generally similar $PM_{2.5}$ composition across the Basin, with organic matter and secondary inorganic ions as the dominant fractions (42-46% and 34-38% of average reconstructed mass across all sites, respectively) (South Coast AQMD 2015). To assess changes in $PM_{2.5}$ composition since the MATES IV period (July 2012-June 2013), this exercise was repeated for the five MATES V sites (Anaheim, Central Los Angeles, Inland Valley San Bernardino, Long Beach, and Rubidoux) where the full suite of $PM_{2.5}$ measurements was available.

Mass reconstruction calculations were performed for $PM_{2.5}$ samples collected on a 1-in-6 day schedule from May 2018 through April 2019. Since reconstructed masses were calculated for each MATES V sample (i.e., single observations), concentrations were used as reported without any detection limit censoring. Estimated contributions of each $PM_{2.5}$ component were calculated according to guidance for the EPA Chemical Speciation Network (Air Quality Research Center, University of California, Davis 2019). The only deviation from this guidance was to estimate ammonium sulfate from sulfate ion data measured by ion chromatography (IC) instead of sulfur measured by X-Ray Fluorescence (XRF). Staff made this substitution was due to possible negative bias in XRF data caused by instrumental issues during analysis of MATES V samples.

Two of the components, secondary inorganic ions and sea salt, were calculated with different formulas than those used in MATES IV (see Table 1). The change in the secondary inorganic ions formula resulted in minimal differences in calculated fractions (1-6% difference in site averages). However, the change in sea salt formula did result in significantly lower sea salt fractions (reductions of 0.18-0.55 $\mu g/m^3$, 39-64% in calculated site averages). Calculating sea salt from only chloride ion data may underestimate total sea salt due to chlorine loss from sea salt aerosols during transport (Chow, et al. 2015). However, the alternative formula (sum of sodium and chloride ions) was not used in this study due to uncertainty associated with relatively high sodium concentrations measured on field blank filters. For consistency in comparing MATES IV and MATES V results, MATES IV inorganic ion and sea salt fractions were recalculated with the updated formulas in Table X-1.

Overall, reconstructed and measured filter $PM_{2.5}$ masses for all MATES V samples showed good agreement ($r^2 = 0.84$, $n = 289$). The average ratio of reconstructed mass to measured mass for all samples was 0.99 ± 0.20 (1σ), with the lowest average ratio at Long Beach (0.88 ± 0.21) and highest at Inland Valley San Bernardino (1.09 ± 0.20). As discussed extensively in Chow et al. (2015), the largest sources of uncertainty in the mass reconstruction calculation include sampling artifacts, analytical uncertainty, and scaling factors used to calculate component contributions, particularly the organic matter/organic carbon scaling factor. There is also some uncertainty associated with using concentrations below detection limits in mass reconstruction calculations. In order to assess the size of this effect, potential concentration ranges for each component were calculated by substituting zero and minimum detection limit concentrations for non-detects to calculate lower and upper limits, respectively. These calculations showed that uncertainty in non-detect concentrations had a very minimal effect on average reconstructed mass (less than 2% or 0.15 $\mu g/m^3$). The effect of non-detects was most pronounced for sea salt, where calculated five-site averages for zero-substituted, uncensored, and MDL-substituted data were 0.18, 0.29, and 0.34 $\mu g/m^3$, respectively.

Figure X-1 shows mass balances by site for both MATES IV and MATES V. Site to site comparisons between MATES IV and MATES V are also provided in Table X-2. As in MATES IV, OM was the largest fraction of reconstructed mass at all sites (45-48%), followed by the combined secondary inorganic ion fraction (37-41%). The most notable changes from MATES IV to MATES V were the reductions in ammonium sulfate and EC fractions. Average sulfate concentrations decreased from MATES IV to MATES V at all five sites by 18-23%. Since sulfate aerosols in the Basin are mostly derived from burning of sulfur-containing fuels, including both land-based and ocean-going vessel fuel combustion, the uniform reduction in $PM_{2.5}$ sulfate points to reduced sulfur emissions from these sources. EC concentrations dropped substantially at all five sites (40-49% decrease from MATES IV concentrations), also pointing to reduced emissions from diesel and other fuel combustion. EC trends throughout the Basin are discussed in further detail in Section X.3. Average OM also decreased slightly at all five sites (4-17% decrease from MATES IV concentrations), while ammonium nitrate, crustal material, and sea salt fractions generally remained at similar levels to those calculated in MATES IV.

Seasonal $PM_{2.5}$ concentration and composition patterns are controlled by a combination of meteorological conditions (e.g., temperature, wind direction and speed, solar radiation/actinic flux, atmospheric mixing height) and source changes (e.g., winter wood burning, vegetation growth, wildfires). Figure X-2a shows monthly averages for each $PM_{2.5}$ component, reconstructed mass, and measured mass for the five sites across the MATES V measurement period. Both reconstructed and measured mass showed similar temporal trends, with generally higher values from June to December.

The variable seasonal patterns of calculated $PM_{2.5}$ components were generally consistent with trends observed in MATES IV (Figure X-2b). EC showed clear fall/winter maxima at all sites, likely due to favorable meteorological conditions for particle accumulation, as well as contributions from winter wood burning. OM had a less pronounced seasonal cycle, with inland sites (Inland Valley San Bernardino and Rubidoux) showing summer maxima, OM at Central LA peaking in fall, and Anaheim and Long Beach OM peaking in winter. The variable OM seasonal signals reflect the balance between complex meteorological and source effects at different sites through the year, including increased secondary organic aerosol formation in the summer, cooler temperatures and meteorological conditions favorable for increased particle accumulation in the winter, and seasonal sources of organic matter (e.g., winter wood burning, see Appendix XII). It is important to note that two wildfire events may have had significant effects on OM monthly averages. As evidenced by elevated levoglucosan concentrations and High Resolution Rapid Refresh (HRRR) smoke model forecasts, a smoke plume from wildfires in northern California likely contributed to the highest basin-wide OM concentration of the MATES V period on August 24, 2018, while smoke from the Woolsey/Hill Fires likely contributed to high OM in November 10, 2018 samples.

Ammonium nitrate and ammonium sulfate fractions showed distinct but opposing seasonal signals. The calculated ammonium nitrate fraction peaked in the fall/winter at all five sites (average winter concentrations: 3.03-4.11 $\mu g/m^3$, 1.5-3.2x summer concentrations), while ammonium sulfate peaked in the summer (average summer concentrations: 2.48-2.86 µg/m^3, 3.5-5.8x winter concentrations). These seasonal trends largely reflect meteorological controls on sulfate and nitrate particle chemistry: increased actinic flux during the summer drives photochemical oxidation of sulfur dioxide and sulfate particle formation, while cooler winter temperatures favor nitrate particle formation from gaseous nitric acid (Seinfeld and Pandis 2016).

Both sea salt and crustal material showed generally muted seasonal variability. Seasonal differences in crustal material were more pronounced at inland sites, with summer/fall (June-November) averages (Rubidoux 1.36 µg/m^3, Inland Valley San Bernardino: 1.39 µg/m^3) nearly double the winter/spring (December-May) averages (Rubidoux: 0.76 µg/m^3, Inland Valley San Bernardino: 0.78 µg/m^3). Unlike in MATES IV where calculated sea salt fractions peaked in the summer, sea salt concentrations were slightly lower in the summer compared to the rest of the year. However, this difference was driven by the change in sea salt formula, as recalculated MATES IV data do not show higher summer values. In general, the true sea salt contribution to PM$_{2.5}$ is difficult to estimate due to uncertainty in calculation parameters, as well as the high fraction of chloride results near or below instrument detection limits.

Table X-1. Summary of mass balance reconstruction calculations in MATES IV and MATES V. MATES V formulas are based on current guidance for EPA Chemical Speciation Network (Air Quality Research Center, University of California, Davis 2019). Differences between the studies are highlighted in bold.

Component	MATES IV	MATES V
Elemental carbon	As reported	As reported
Organic matter	1.4 × organic carbon	1.4 × organic carbon
Secondary inorganic ions	**Ammonium + sulfate + nitrate**	**Ammonium nitrate = 1.29 × nitrate** **Ammonium sulfate = 1.375 × sulfate**
Sea salt	**Sodium + chloride**	**1.8 × chloride**
Crustal material	2.2 × aluminum + 2.49 × silicon + 1.63 × calcium + 2.42 × iron + 1.94 × titanium	2.2 × aluminum + 2.49 × silicon + 1.63 × calcium + 2.42 × iron + 1.94 × titanium

Table X-2. Site comparisons of annual average concentrations of calculated $PM_{2.5}$ components, reconstructed mass, and measured mass between MATES IV (July 2012 – June 2013) and MATES V (May 2018 – April 2019). The contribution of each component to overall average reconstructed mass is shown in parentheses. Note that MATES IV ammonium nitrate, ammonium sulfate, and sea salt concentrations were recalculated with updated formulas. All concentrations are in μg/m^3.

Component	Central Los Angeles		Long Beach*		Anaheim		Inland Valley S.B.		Rubidoux	
	IV	V	IV	V	IV	V	IV	V	IV	V
Elemental carbon	1.23 (9%)	0.71 (6%)	0.90 (8%)	0.48 (5%)	0.90 (8%)	0.46 (5%)	1.36 (9%)	0.73 (5%)	1.11 (8%)	0.66 (5%)
Organic matter	6.25 (45%)	5.97 (48%)	5.03 (45%)	4.23 (45%)	5.24 (47%)	4.48 (45%)	6.77 (46%)	6.50 (48%)	6.47 (46%)	5.81 (47%)
Ammonium nitrate	3.27 (23%)	3.00 (24%)	2.13 (19%)	2.12 (22%)	2.11 (19%)	2.44 (25%)	3.23 (22%)	3.37 (25%)	3.58 (25%)	3.18 (26%)
Ammonium sulfate	2.12 (15%)	1.75 (14%)	2.20 (20%)	1.74 (18%)	2.01 (18%)	1.55 (16%)	1.94 (13%)	1.56 (12%)	1.82 (13%)	1.45 (12%)
Sea salt	0.29 (2%)	0.31 (2%)	0.32 (3%)	0.38 (4%)	0.26 (2%)	0.31 (3%)	0.20 (1%)	0.22 (2%)	0.20 (1%)	0.24 (2%)
Crustal material	0.84 (6%)	0.71 (6%)	0.63 (6%)	0.56 (6%)	0.62 (6%)	0.64 (6%)	1.17 (8%)	1.10 (8%)	0.86 (6%)	1.05 (8%)
Reconstructed $PM_{2.5}$ Mass	14.01	12.44	11.20	9.50	11.14	9.88	14.67	13.48	14.05	12.38
Measured $PM_{2.5}$ Mass	14.14	12.43	12.95	10.88	12.37	10.60	14.33	12.55	13.83	12.50

*Station location moved from MATES IV to MATES V.

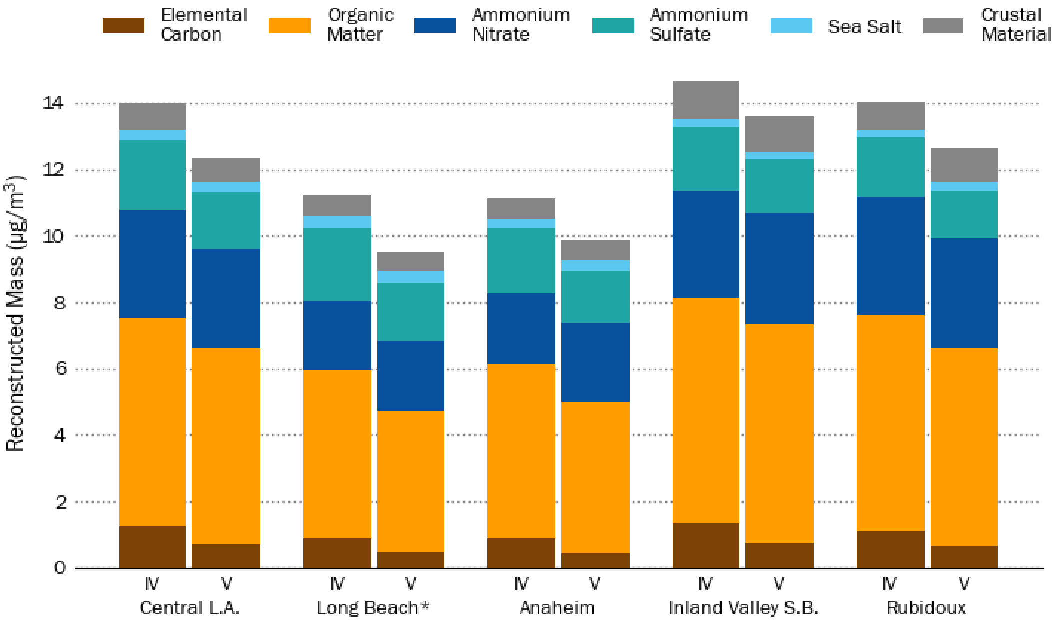


Figure X-1. Average reconstructed $PM_{2.5}$ compositions at five sites in the South Coast Air Basin during MATES IV (July 2012-June 2013) and MATES V (May 2018-April 2019). Asterisk indicates station location moved between MATES IV and V campaigns.

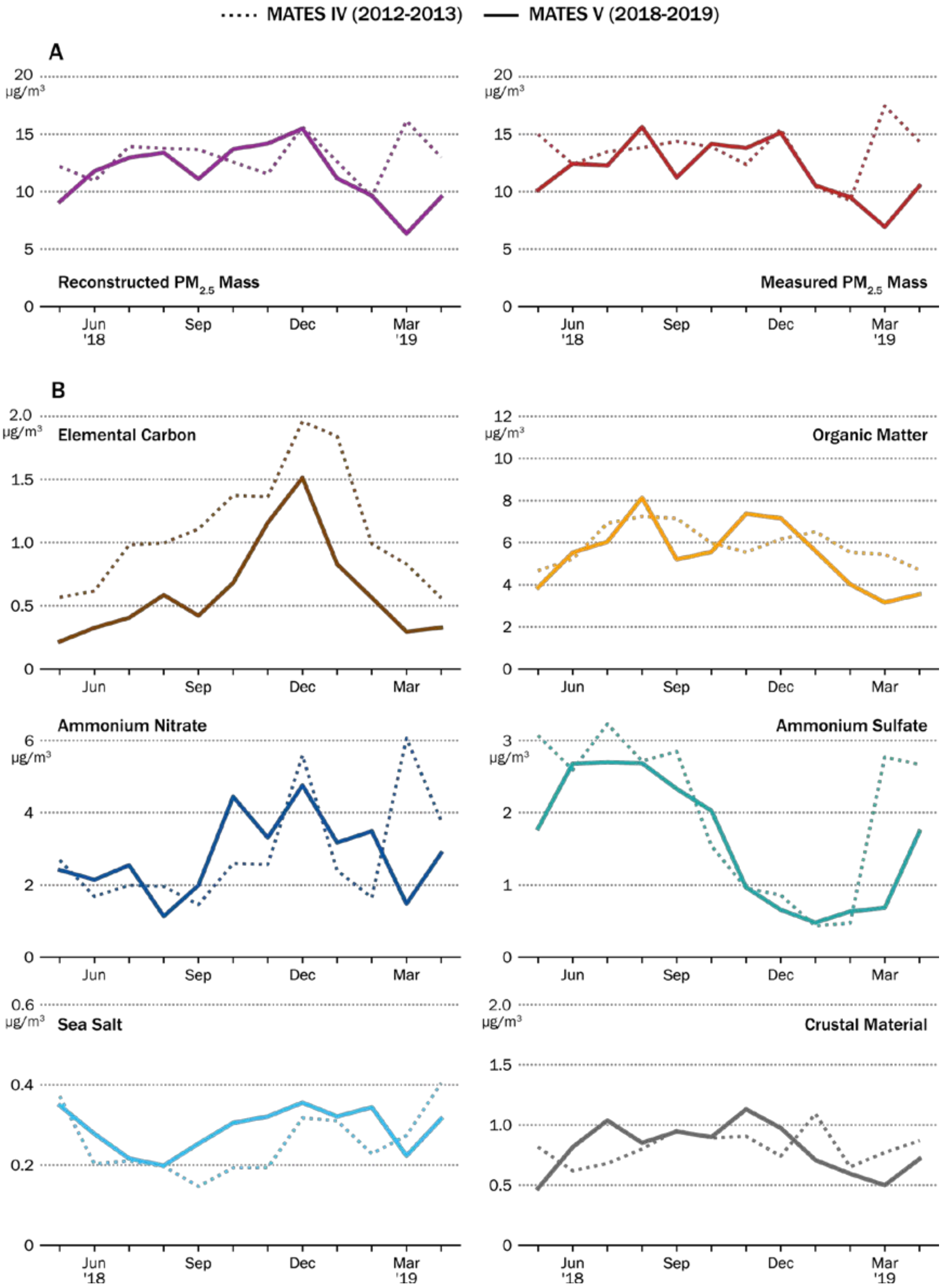


Figure X-2. a. Monthly averages of reconstructed and measured $PM_{2.5}$ mass during MATES V. b. Monthly averages of calculated $PM_{2.5}$ components during MATES V. Bold lines show MATES V five-site (Anaheim, Central L.A., Long Beach, Inland Valley San Bernardino, Rubidoux) averages and dotted lines show MATES IV five-site averages.

X.3. Elemental Carbon in PM2.5

Elemental carbon (EC) is a byproduct of combustion processes, including diesel and gasoline engine combustion, wildfire, and residential wood burning. Critically, $PM_{2.5}$ EC concentrations are currently used to estimate diesel particulate matter, which is the largest contributor to air toxics cancer risk in the Basin (67.3% of total MATES V population-weighted average cancer risk). EC concentrations were measured in $PM_{2.5}$ samples collected on 1-in-6 day schedule at all ten fixed MATES V sites. Black carbon (BC), a closely related but distinct species from EC, was also measured on a continuous basis at all sites and is discussed in more detail in Chapter 5 and Appendix VI.

The average $PM_{2.5}$ EC concentration across all monitoring stations during MATES V was 0.64 ± 0.05 $\mu g/m^3$, which was 45% lower than the MATES IV basin-wide station average. Average EC concentrations at each site ranged from 0.46 $\mu g/m^3$ at Anaheim to 0.75 $\mu g/m^3$ at Inland Valley San Bernardino. Figure X-3 shows EC concentrations decreased at each individual site compared to MATES IV levels, ranging from a 31% drop at Compton to a 64% drop at the Burbank Area station, although the Burbank Area station was relocated between MATES IV and V. Furthermore, basin-wide monthly average concentrations were consistently lower in MATES V (Figure X-4). As observed in MATES IV, EC concentrations at all sites were generally higher in fall/winter compared to spring/summer due to a combination of meteorological conditions and some contribution from residential wood burning. The relative magnitude of the seasonal cycle also remained similar between MATES IV and MATES V, with a ratio of average winter (December-February) basin-wide EC concentration to average summer (June-August) concentration of 2.3 in MATES IV and 2.4 in MATES V.

The uniform spatial and temporal decreases in EC concentrations in the Basin between MATES IV and MATES V point to continued reductions in EC emissions across the basin, which is consistent with a 56% reduction in total $PM_{2.5}$ EC emissions in the MATES V (2018) emissions inventory compared to the MATES IV (2012) inventory (see Appendix VIII). The overall reduction in EC emissions was driven by large reductions across stationary sources (-58%), on-road vehicles (-69%), and other mobile sources (-38%).

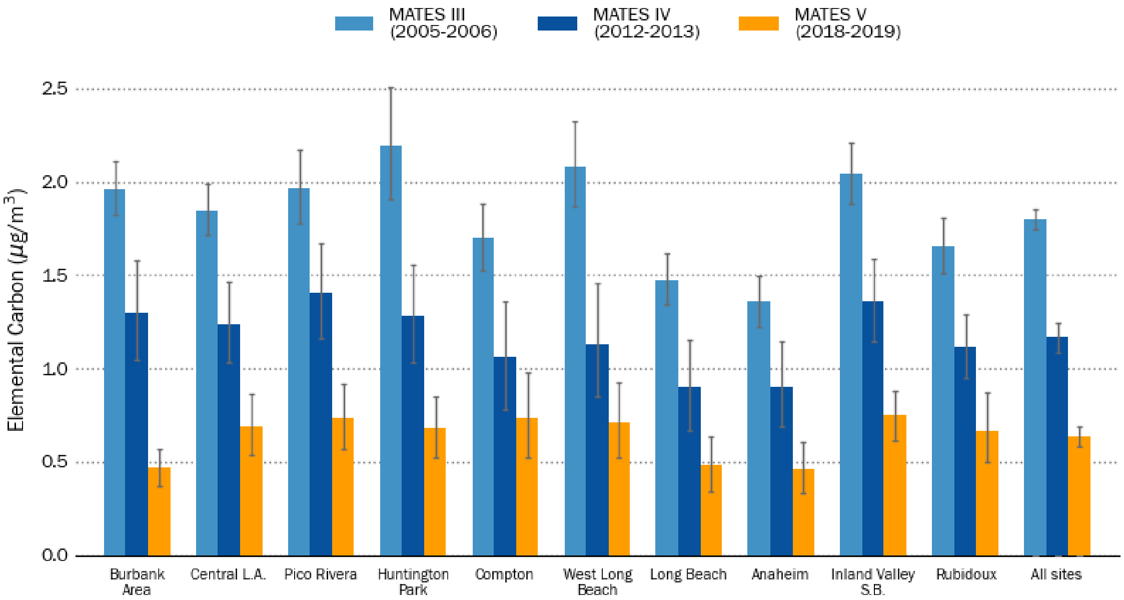


Figure X-3. Kaplan-Meier mean $PM_{2.5}$ elemental carbon concentrations from MATES III to MATES V. Error bars indicate 95% confidence intervals.

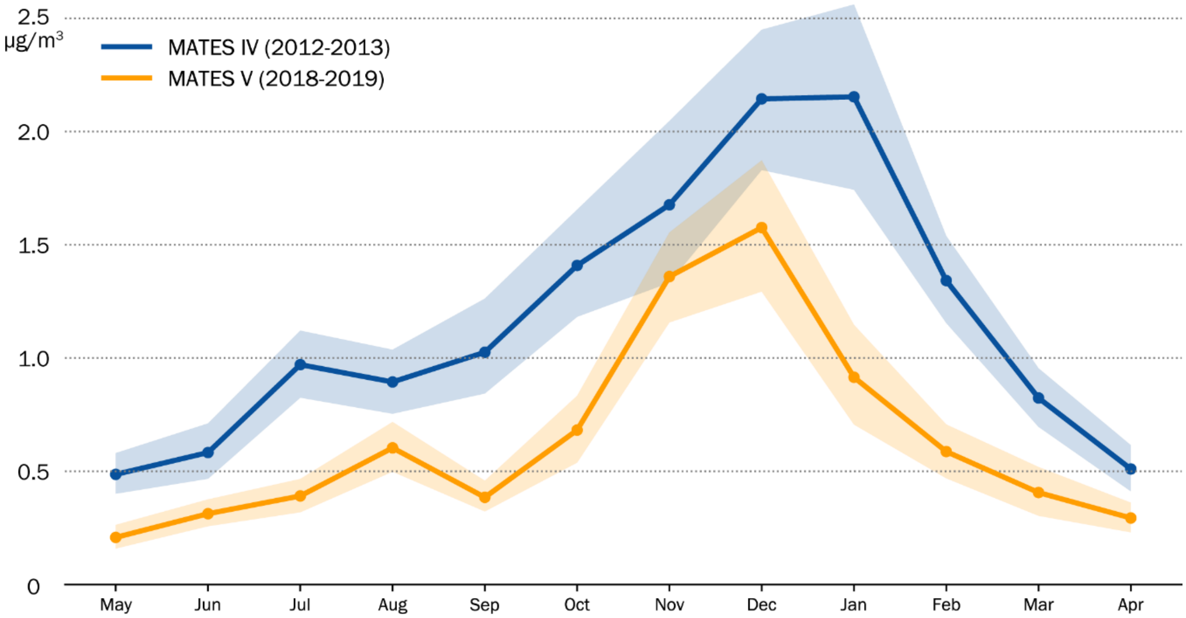


Figure X-4. Comparison of basin-wide station average $PM_{2.5}$ concentrations by month during MATES IV (2012-2013) and MATES V (2018-2019). Shading indicates 95% confidence intervals.

X.4. Metals in TSP

As in previous MATES studies, ambient toxic metal concentrations in the Basin were assessed by analysis of total suspended particulate (TSP) samples, which incorporate both coarse and fine particulate matter fractions. Figures X-5 through X-13 show average MATES V TSP metal concentrations compared to MATES IV levels. Station and basin-wide concentration trends for all metal air toxics from MATES IV to MATES V are also summarized in Figure X-14. Overall, metal air toxics contribute to approximately 10.4% of the MATES V population-weighted average multi-pathway cancer risk in the Basin. The metal species with the largest contributions to total population-weighted MATES V air toxics cancer risk are arsenic (6.4% of total risk) and hexavalent chromium (2.5%). Other metal air toxics that contribute to overall population-weighted cancer risk include cadmium (0.9%), nickel (0.4%), and lead (0.2%). Given the relatively small contribution of each of these metal air toxics to the overall air toxics cancer risk, small changes in the measured levels would not have a large impact on the cancer risk contribution from that pollutant. However, in the exploratory analysis of chronic non-cancer risk based on the measurement data, arsenic was identified as contributing to about half of total risk (Chapter 2). Therefore, changes in arsenic levels may impact the overall chronic non-cancer risk.

The ten-station average arsenic concentration decreased slightly from MATES IV, with increases in average concentration observed at two sites, Anaheim and Pico Rivera, and similar or decreased concentrations at other sites. An analysis of arsenic concentrations from monitoring locations throughout the US showed that the concentrations detected in the MATES V sites were similar to concentrations elsewhere in the US (see Appendix IV, Figure IV-75). Arsenic concentrations were strongly correlated with a number of other metal species at all sites, including manganese (r^2 range of 0.60-0.94, N = 58-61), titanium (r^2 = 0.61-0.92, N = 57-60), vanadium (r^2 = 0.61-0.90, N= 35-45), chromium (r^2 = 0.52-0.86, N = 58-61), and barium (r^2 = 0.54-0.81, N= 51-56).[1] These correlations are consistent with mixed sources of arsenic in the Basin, including crustal material, abrasive vehicle emissions, and industrial emissions, as found in Pakbin et al. (2011). Arsenic, manganese, titanium, and vanadium all showed higher concentrations in the summer/fall at inland sites compared to other sites, which is consistent with increased crustal dust during warmer and drier months.

Hexavalent chromium concentrations decreased at most sites, with a 29% decrease in the basin-wide average from MATES IV to MATES V. The only substantial increase was at Anaheim where average concentrations increased from 0.027 to 0.038 ng/m^3 (+43%) but remained below the MATES V basin-wide average of 0.040 ng/m^3. As observed in MATES IV, average hexavalent chromium concentrations were highest at Compton (0.061 ng/m^3) and Huntington Park (0.057 ng/m^3), although average concentrations decreased substantially compared to MATES IV (-46% at both sites). Compared to other MATES stations, these two stations are located closer to a number of metal-processing facilities that handle hexavalent chromium. South Coast AQMD has conducted special monitoring investigations and enforcement efforts in

---

[1] All $p << 0.001$.

communities where a large number of hexavalent chromium emitting facilities are located and continue to develop and/or amend regulations to control these types of metal emissions. Hexavalent chromium concentrations did not show any strong correlation with other measured TSP metals, which is consistent with distinct or highly variable sources in the Basin.

Average cadmium concentrations increased at most sites, with very large increases at West Long Beach (+ 506%), Rubidoux (+348%), and Burbank Area (+415%). At the Burbank Area station, this increase was largely driven by one extremely high sample (30 ng/m^3) on December 22, 2018, but increases in average concentrations at other sites could not be attributed to any one outlier. Similar to hexavalent chromium, cadmium concentrations did not show strong correlations with any other measured metals across the basin, pointing to distinct or heterogeneous sources.

Basin-wide average concentrations of nickel and lead both declined from MATES IV to MATES V, but trends at individual sites varied. While average nickel concentrations decreased substantially at some sites, the average concentration at Inland Valley San Bernardino rose by 55% compared to MATES IV. Much of the observed increase at Inland Valley San Bernardino was driven by a series of high concentration samples during the summer (June-August). Nickel is also of interest as a tracer of emissions from heavy fuel oil combustion by ocean-going vessels (OGV) (Agrawal, et al. 2009). The usage of heavy fuel oil fuel should have been phased out by OGVs with the low sulfur fuel requirements implemented by the California Air Resources Board[2] and the International Maritime Organization[3] over the past decade. At the two sites near the ports, West Long Beach and Long Beach, nickel concentrations showed virtually no change from levels observed in MATES IV. Nickel concentrations at these sites were only weakly correlated ($r^2 = 0.26$, $p < 0.001$), pointing to the importance of local sources and meteorological patterns. Lead concentrations decreased across the Basin from MATES IV to MATES V by 20-39%, with the exception of Anaheim and Burbank Area stations, where average lead concentrations increased by 28% and 30%, respectively. Average lead concentrations at every site (2.72-7.66 ng/m^3) were well below the National Ambient Air Quality Standard for lead (150 ng/m^3 average over 3 months). Furthermore, every sample measured during MATES V remained below this standard, with the highest individual sample concentration (106.4 ng/m^3) recorded at Huntington Park on April 15, 2019.

Other metals designated as Hazardous Air Pollutants by the EPA and measured as part of MATES V include manganese, antimony, chromium, cobalt, beryllium, and selenium. Temporal trends in these metals, except for beryllium and selenium, are shown in Figures X-10 through X-13 and Figure X-14. Selenium and beryllium concentrations were generally too low to be reliably quantified (77% of MATES V samples were below detection limit for selenium, and 76% were below detection limit for beryllium), so true ambient trends were difficult to discern.

---

[2] For more information, see https://ww2.arb.ca.gov/our-work/programs/ocean-going-vessel-fuel-regulation
[3] For more information, see https://www.imo.org/en/MediaCentre/PressBriefings/Pages/34-IMO-2020-sulphur-limit-.aspx

Basin-wide average concentrations of manganese, antimony, and cobalt increased slightly from MATES IV averages (+3, 4, 13%, respectively), while average chromium concentration declined slightly (-9%). Trends at individual sites varied considerably. While concentrations of these metals uniformly decreased at Central Los Angeles and Huntington Park, concentrations uniformly increased at Anaheim. In general, concentrations of nearly every measured TSP metal increased at Anaheim from MATES IV to MATES V. Since the Anaheim station location and sampling method did not change between the two studies, this trend could be the result of changes in local sources and/or particle transport to this site. Other noteworthy increases include the average cobalt concentration at Long Beach, which doubled between MATES IV (0.37 ng/m^3) to MATES V (0.75 ng/m^3). This increase was primarily driven by high winter concentrations and could reflect closer proximity to a local cobalt source due to the change in the Long Beach station location between MATES IV and MATES V sampling campaigns. Cobalt concentrations at Long Beach were strongly correlated with nickel ($r^2 = 0.93$) and chromium ($r^2 = 0.79$), suggesting a possible common source of these metals at this site.

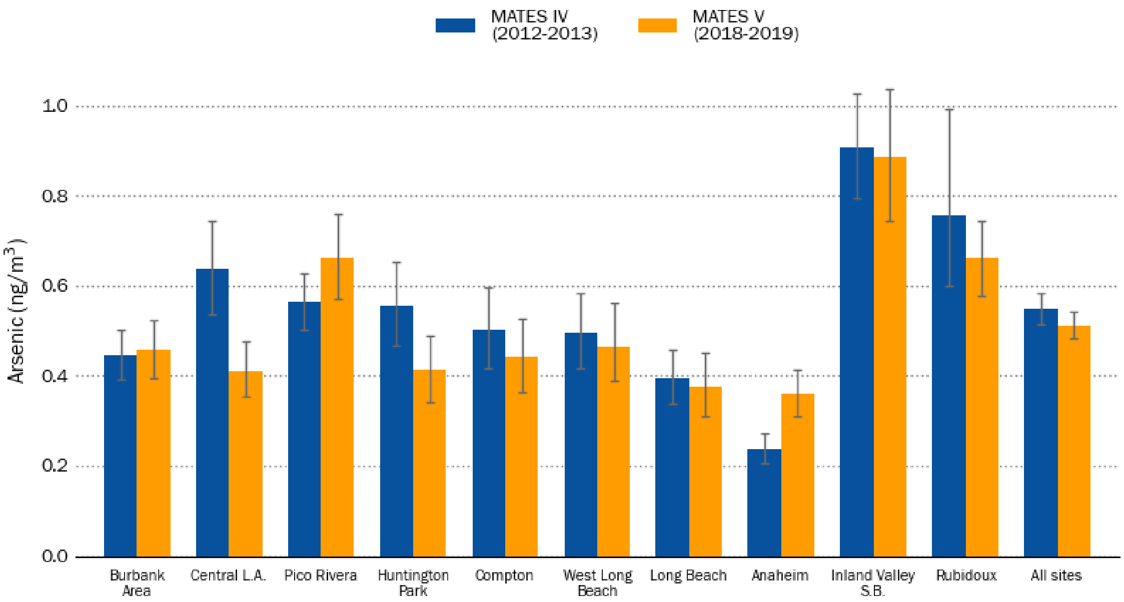


Figure X-5. Kaplan-Meier mean TSP arsenic concentrations by site during MATES IV (2012-2013) and MATES V (2018-2019). Error bars indicate 95% confidence intervals.

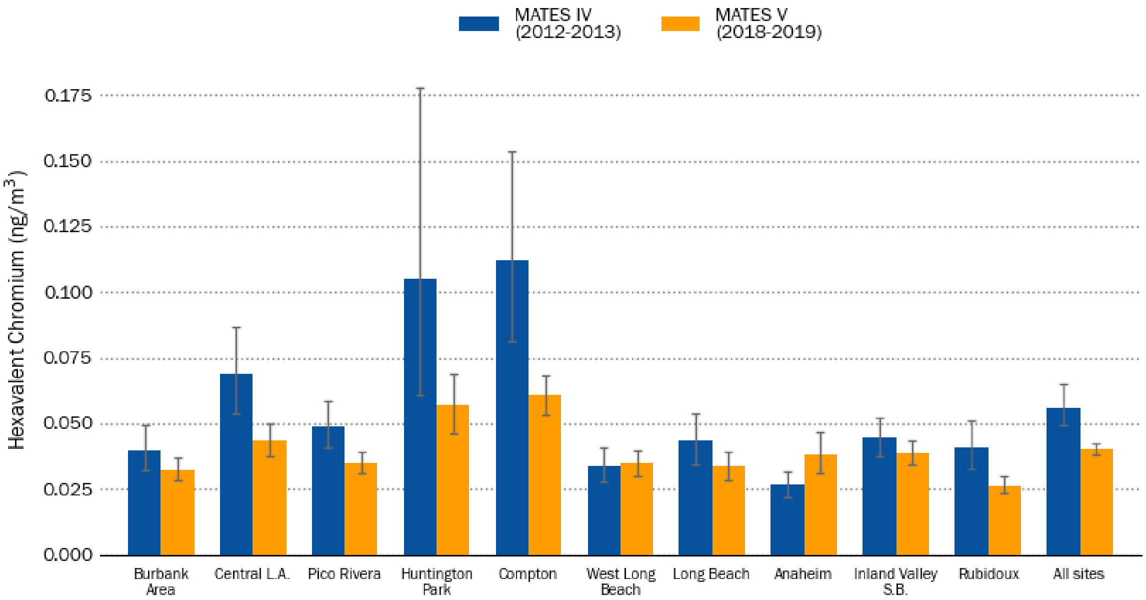


Figure X-6. Kaplan-Meier mean TSP hexavalent chromium concentrations by site during MATES IV (2012-2013) and MATES V (2018-2019). Error bars indicate 95% confidence intervals.

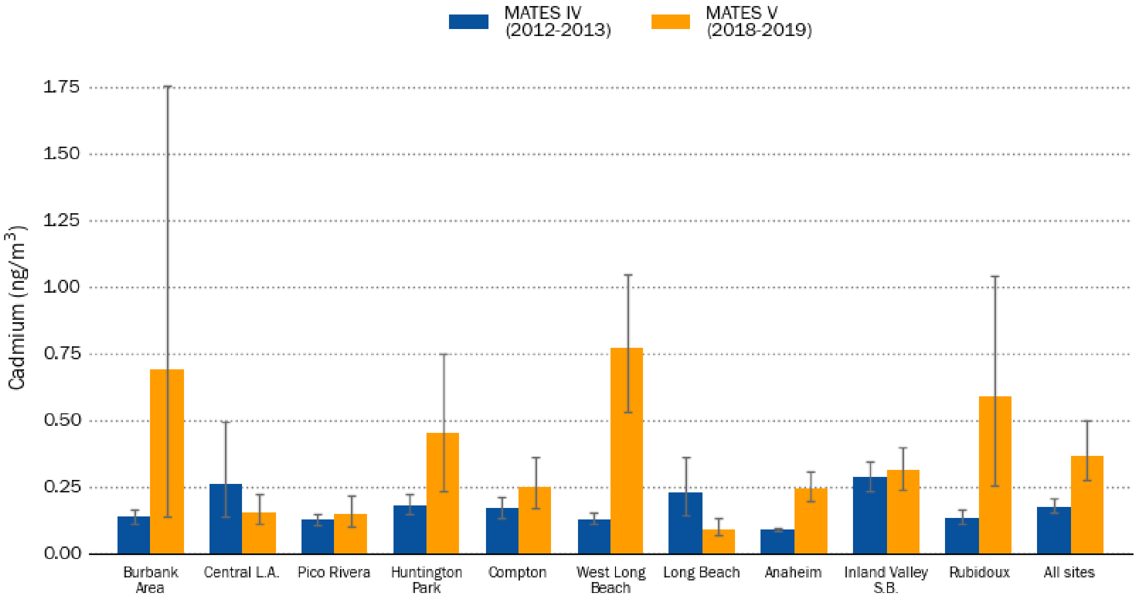


Figure X-7. Kaplan-Meier mean TSP cadmium concentrations by site during MATES IV (2012-2013) and MATES V (2018-2019). Error bars indicate 95% confidence intervals.

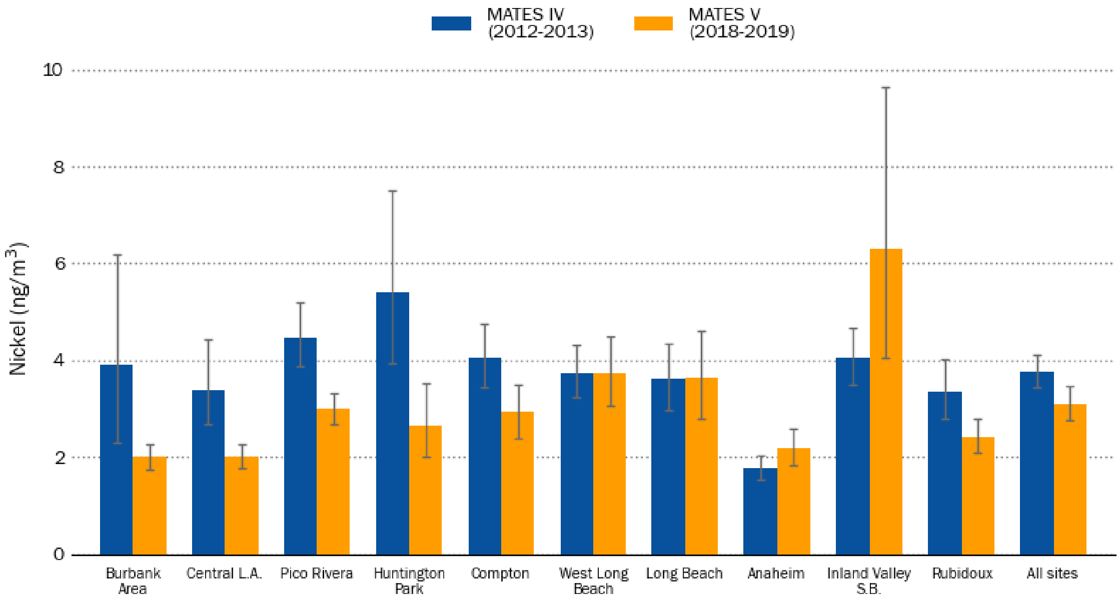


Figure X-8. Kaplan-Meier mean TSP nickel concentrations by site during MATES IV (2012-2013) and MATES V (2018-2019). Error bars indicate 95% confidence intervals.

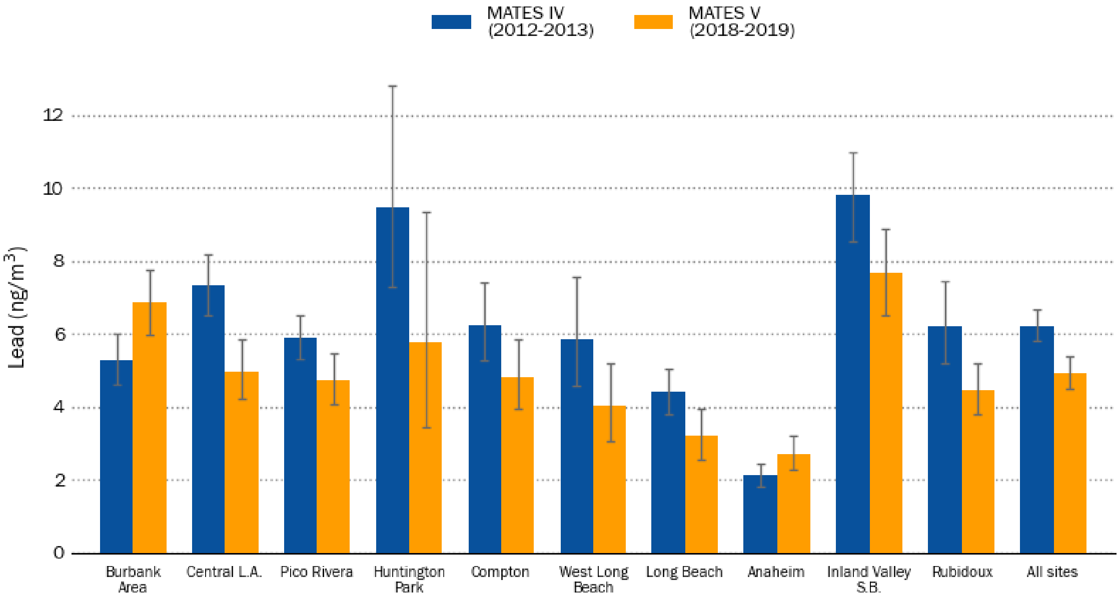


Figure X-9. Kaplan-Meier mean TSP lead concentrations by site during MATES IV (2012-2013) and MATES V (2018-2019). Error bars indicate 95% confidence intervals.

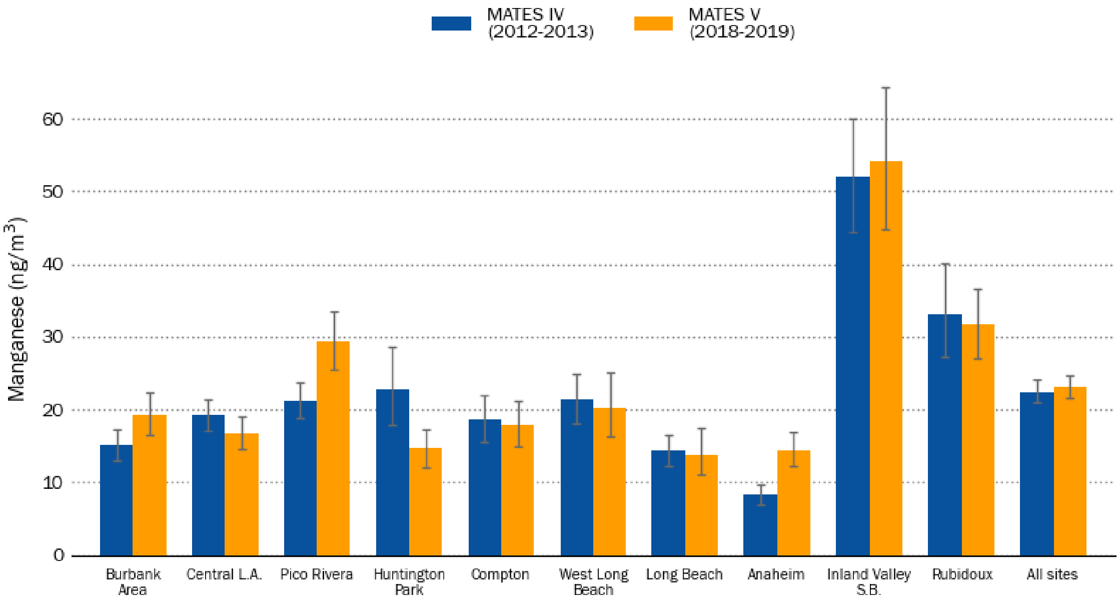


Figure X-10. Kaplan-Meier mean TSP manganese concentrations by site during MATES IV (2012-2013) and MATES V (2018-2019). Error bars indicate 95% confidence intervals.

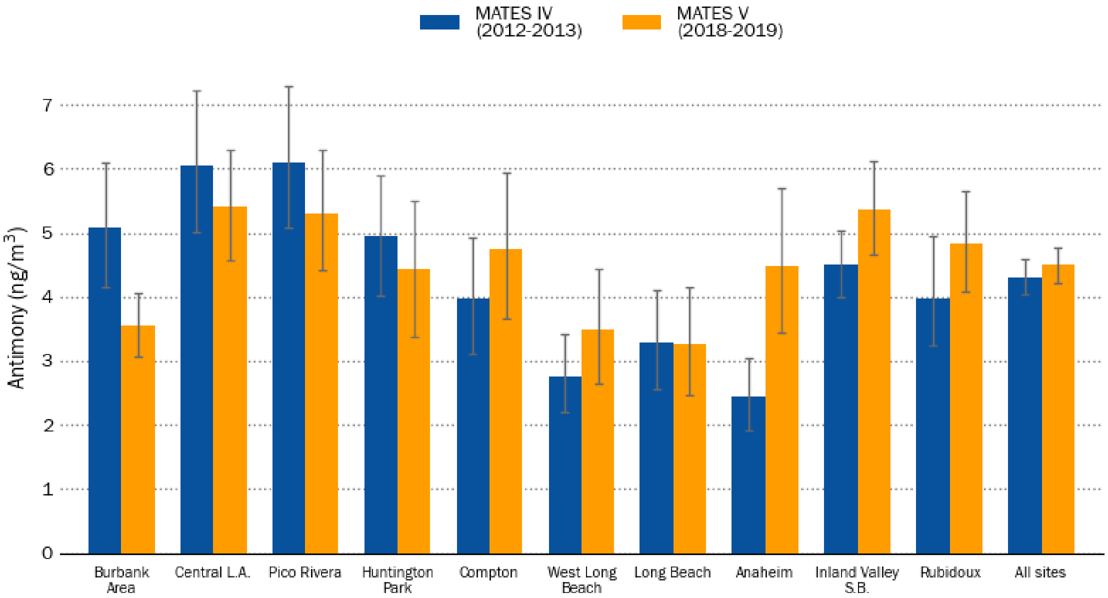


Figure X-11. Kaplan-Meier mean TSP antimony concentrations by site during MATES IV (2012-2013) and MATES V (2018-2019). Error bars indicate 95% confidence intervals.

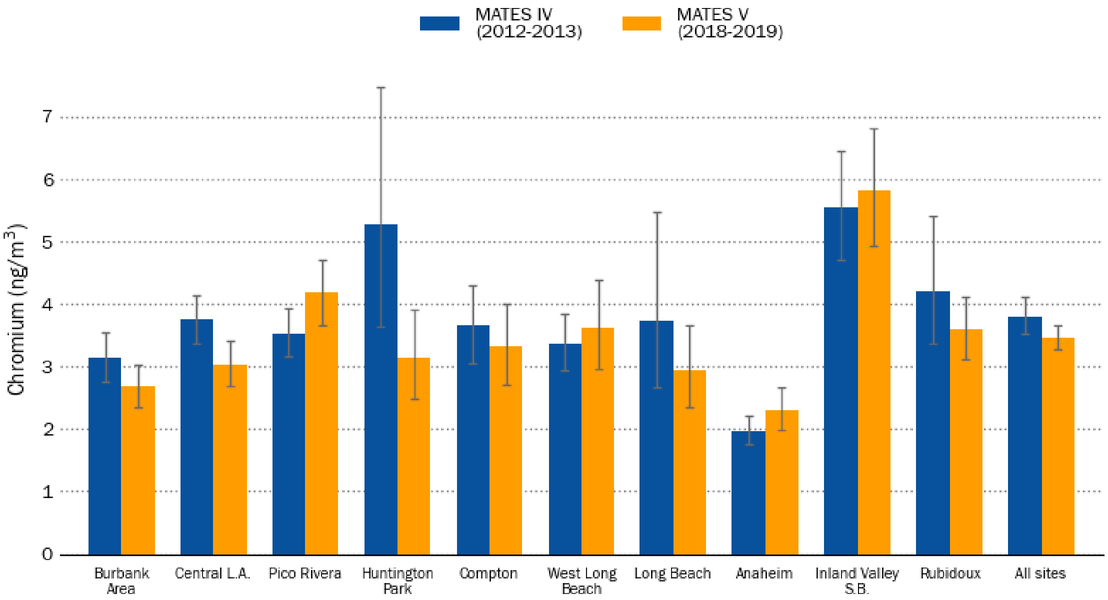


Figure X-12. Kaplan-Meier mean TSP total chromium concentrations by site during MATES IV (2012-2013) and MATES V (2018-2019). Error bars indicate 95% confidence intervals.

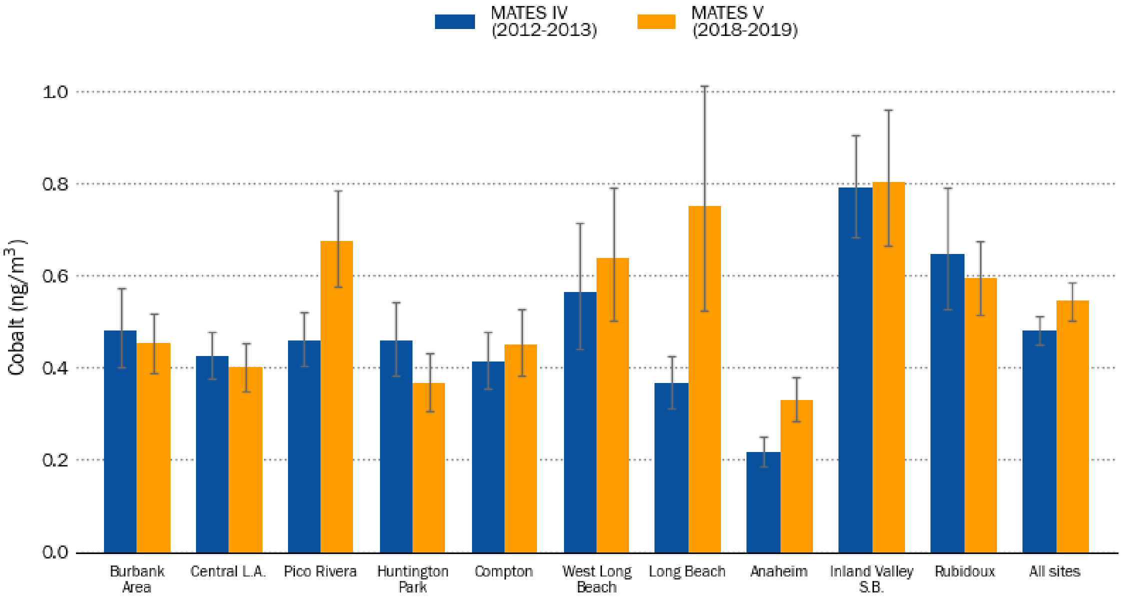
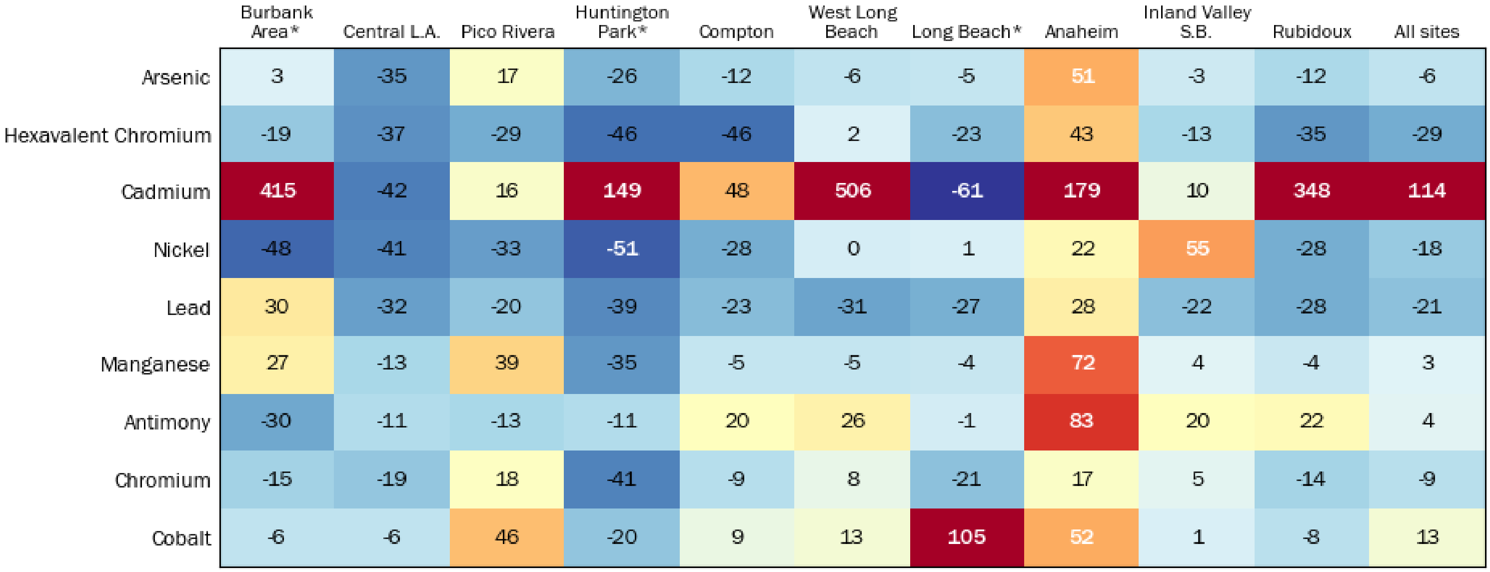


Figure X-13. Kaplan-Meier mean TSP cobalt concentrations by site during MATES IV (2012-2013) and MATES V (2018-2019). Error bars indicate 95% confidence intervals.



	Burbank Area*	Central L.A.	Pico Rivera	Huntington Park*	Compton	West Long Beach	Long Beach*	Anaheim	Inland Valley S.B.	Rubidoux	All sites
Arsenic	3	-35	17	-26	-12	-6	-5	51	-3	-12	-6
Hexavalent Chromium	-19	-37	-29	-46	-46	2	-23	43	-13	-35	-29
Cadmium	415	-42	16	149	48	506	-61	179	10	348	114
Nickel	-48	-41	-33	-51	-28	0	1	22	55	-28	-18
Lead	30	-32	-20	-39	-23	-31	-27	28	-22	-28	-21
Manganese	27	-13	39	-35	-5	-5	-4	72	4	-4	3
Antimony	-30	-11	-13	-11	20	26	-1	83	20	22	4
Chromium	-15	-19	18	-41	-9	8	-21	17	5	-14	-9
Cobalt	-6	-6	46	-20	9	13	105	52	1	-8	13

Figure X-14. Percent change in Kaplan-Meier mean TSP metal concentrations at each station from MATES IV to MATES V. Asterisks indicate station locations that moved between MATES IV and MATES V.

V. Conclusion

The wide range of particulate measurements at fixed sites during MATES V allowed for the evaluation of changes in patterns of particulate pollution in the six years since MATES IV. In general, spatial and seasonal trends in $PM_{2.5}$ composition in the South Coast Air Basin remained similar to those observed in MATES IV. One key change in $PM_{2.5}$ composition was the substantial reduction in average elemental carbon concentrations throughout the basin. On a basin scale, toxic metal concentrations generally decreased or remained at similar levels to those measured in MATES IV, with the exception of a significant increase in average cadmium concentration. However, the overall contribution of cadmium to average population-weighted air toxics cancer risk is less than 1%, and contributions from cadmium to chronic non-cancer risk calculated at each monitoring station are also minimal (basin-wide average of 0.6%). Targeted control measures of both local and regional sources of particulate matter will lead to continued improvement in air quality and reduced health risks in the South Coast Air Basin.

VI. References

Agrawal, Harshit, Rudy Eden, Xinqiu Zhang, Philip M. Fine, Aaron Katzenstein, J. Wayne Miller, Jean Ospital, Solomon Teffera, and David R. Cocker III. "Primary Particulate Matter from Ocean-Going Engines in the Southern California Air Basin." *Environmental Science & Technology* 43 (2009): 5398-5402.

Air Quality Research Center, University of California, Davis. "Data Validation for the Chemical Speciation Network: A Guide for State, Local, and Tribal Agency Validators." 2019.

Chow, Judith C., Douglas H. Lowenthal, L.-W. Antony Chen, Xiaoliang Wang, and John G. Watson. "Mass reconstruction methods for PM2.5: a review." *Air Quality, Atmosphere & Health* 8 (2015): 243-263.

Pakbin, Payam, Zhi Ning, Martin M. Shafer, James. J. Schauer, and Constantinos Sioutas. "Seasonal and Spatial Coarse Particle Elemental Concentrations in the Los Angeles Area." *Aerosol Science and Technology* 45 (2011): 949-963.

Seinfeld, John H., and Spyros N. Pandis. *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change.* Third Edition. Hoboken, NJ: John Wiley & Sons, Inc., 2016.

South Coast AQMD. "Multiple Air Toxics Exposure Study in the South Coast Air Basin: MATES IV." 2015.

APPENDIX XI

MATES V

DRAFT FINAL REPORT

Monitoring Data Treatment Methodologies

Appendix XI

Monitoring Data Treatment Methodologies

Measuring pollutants at low concentrations is more difficult than measuring pollutants at higher concentrations. Occasionally, the concentrations are so low that they are below the method detection limit (MDL). When this happens, we are only confident that the concentration could be as low as zero or as high as the MDL and is probably somewhere in between those two values. However, we cannot give a specific estimate of the concentration with any confidence when it is below the MDL. Every observation has a corresponding MDL. Laboratory technologies typically improve over time, and more recent observations tend to have lower MDLs than older observations. For example, the MDLs in the MATES V data are generally much lower than the MDLs in the MATES II data, see Appendix IV. Data with observations below the MDL are common in environmental data [1] and occur throughout the MATES data. Data below the detection limit are referred to as “nondetects” while data at or above the MDL are referred to as “detects”. Statistical methods are available to perform calculations on data that include nondetects, in order to draw appropriate conclusions regarding spatial or temporal trends.

As laboratory technologies have improved over time, the statistical methods for handling data with nondetects have also improved and the improved methods are becoming more widely used in the environmental sciences. The MATES V analyses follow the guidance provided in Singh et al. (2006) [2] and Helsel (2012) [1]. Singh et al., 2006 [2] is an in-depth U.S. EPA-commissioned report on the topic of handling environmental data below detection limits, the authors of which consulted Dennis Helsel, the author of multiple textbooks describing methods to handle environmental data with nondetects, including Helsel (2012) [1]. General guidance from Helsel (2012) for handling data with nondetects recommends not deleting or ignoring the data below the detection limit and avoiding substitution[1] (e.g., 0.5*MDL) [1]. The analysis methods combine information about the proportions of nondetects with the numerical values of the data at or above the detection limit(s) [1].

The analyses for MATES II, conducted in 2000, used 0.5*MDL substitution to handle nondetects [3, pp. ES-7]. This approach was quite common and was endorsed by the U.S. EPA at the time [4]. Consistent with another EPA report [5], the analyses for MATES III (2008) and MATES IV (2015) reported specific values for data between the MDL and the Limit of Detection (LoD) and reported data below the LoD as zero [6, pp. Appendix VI-1, 7, pp. Appendix IV-1]. We updated our statistical methods for the MATES V measurement data analysis to make use of advancements in the science that are becoming more widely used for handling environmental data with nondetects. To be able to make direct comparisons of pollutant concentrations over time, MATES II through IV data are being re-analyzed alongside the MATES V data using these improved statistical methods.

---

[1] Substitution is only recommended for averaging points in cases where all data points have the same MDL [1, p. xix].

Helsel (2012) outlines three broad approaches to handling data with nondetects: 1) Maximum Likelihood Estimation (MLE), 2) nonparametric methods with a single MDL (applying the highest MDL to all observations if there are multiple MDLs), or 3) nonparametric survival analysis methods [1]. The MLE methods require that the data fit an assumed distribution and either have a small percent of the data be nondetects or have outside knowledge with which to determine the distribution [1]. MLE methods have been shown to perform poorly for skewed data with sample sizes smaller than 70 [1, p. 65]. The MATES data does not consistently meet the requirements of the MLE methods, so the two nonparametric approaches, 2 and 3, are used in analyzing the MATES data.

Summary statistics were generally calculated using the Kaplan-Meier method with Efron's bias correction (from nonparametric survival analysis methods) since it is the most generally applicable of the methods presented in Helsel (2012) [1, p. 85] (See Figure 1). A minimum sample size (number of detects plus the number of nondetects) of 10 is required, otherwise no statistics are calculated [2, p. 91]. Mean concentrations were, in most cases, calculated using the Kaplan-Meier Mean (KM mean) equations in Section 3.11 of Singh et al. (2006) [2] with Efron's bias correction [1, pp. 74-75, 8, pp. 100, 118]. The first exception was when more than 80% of observations were nondetects. In this case, a single estimate of the mean cannot be made for risk calculations, and therefore, we report the percent of data above the maximum MDL instead of calculating an estimate of the mean [1, p. 93]. For the purposes of giving upper and lower bound estimates for the risk calculations, zero substitution and MDL substitutions were used to calculate classical means of concentrations for use in the risk calculations, analogous to the method mentioned in Helsel (2012) [1, p. 94]. The classical mean is used in the rare occurrence when all concentrations were identical because the algorithm in Section 3.11 of Singh et al. (2006) [2] breaks down if there is no variation in the data. This can occur when all concentrations are above the MDL and have the same value or when less than 80% of the data are nondetects and all detects have values equal to the MDL, both of which are rare occurrences. When all data are above their respective MDLs, the KM mean yields the same numerical value as the classical mean.

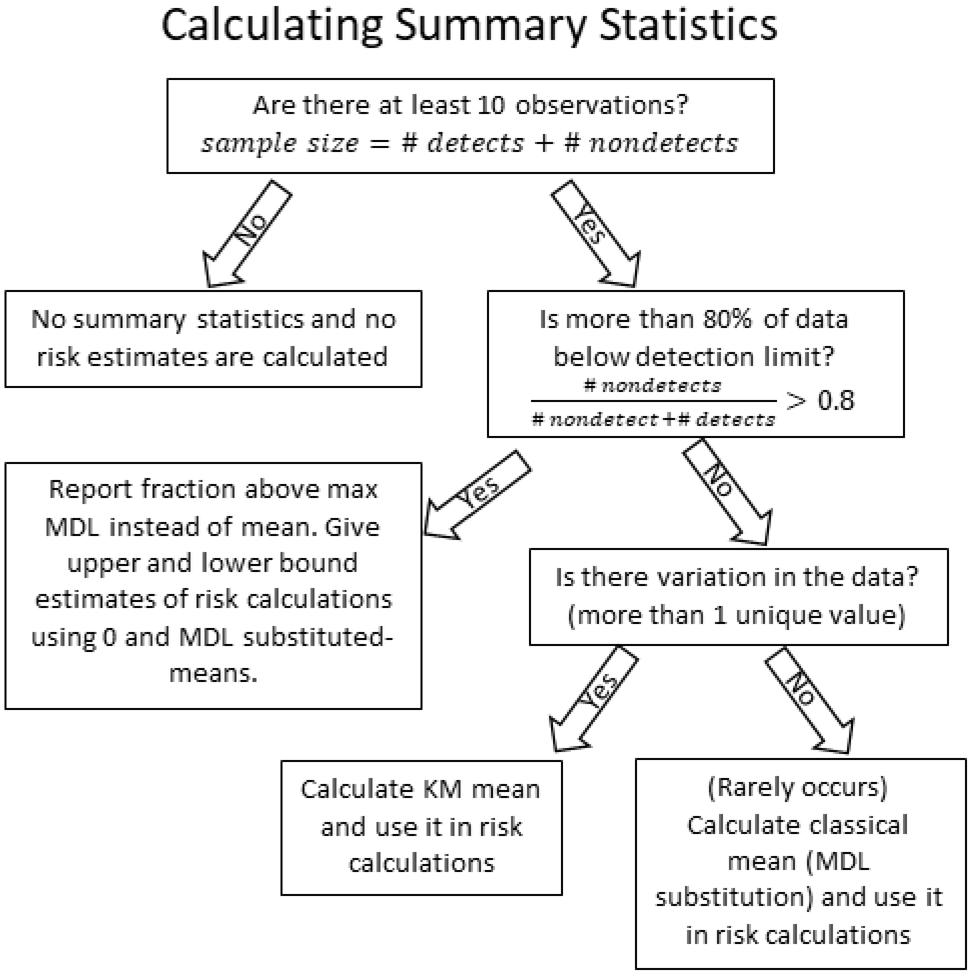


Figure XIV-1: Flow chart for determining how to calculate summary statistics and risk calculations for MATES data.

Calculations of confidence intervals follow guidance from Helsel (2012) [1] and Singh et al. (2006) [2]. Standard deviations and standard errors were calculated according to the equations in Singh et al. (2006) [2, pp. 31, 47]. The 95% confidence intervals were calculated using bootstrapping [1, pp. 103, 136-140]. Briefly, the KM mean is computed from a random sample of the data that is the same size as the data set. The random sampling is taken with replacement from the measurements, so that some measurements may be sampled multiple times while others may not have been sampled. This procedure is repeated 1000 times to give a distribution of KM mean estimates from 1000 random samples of the data. The 2.5th and 97.5th percentiles of the distribution of 1000 KM mean estimates provides the 95% confidence interval [1, pp. 103, 136-140]. The bootstrap 95% confidence intervals are only calculated if the data sample met the requirements to allow a KM mean to be calculated (See Figure 1). If a random sample had more than 80% of the data below the detection limit, then the KM mean cannot be calculated for that iteration and the classical mean using MDL substitution is used for that iteration instead of the KM mean. If none of the random samples used MDL substitution and the average of all of the KM mean estimates did not match the original non-boot-strapped KM mean within three significant digits, then the bootstrap algorithm was run again with progressively larger number of random samples (up to a maximum of 50,000) until convergence was achieved, if possible. In the situation where the original data set had more than 80% below the detection limit and MDL and zero substitution were used to give upper and lower estimates as described in the paragraph above, bootstrapping was performed on the classical means for each the MDL and zero-substituted data sets to get the 95% confidence intervals for each.

For some MATES iterations (i.e., MATES II, III, IV, or V), some or all stations operated for more than a year. To calculate annual mean concentrations, the analysis was limited to data within the time periods shown in Table 1. MATES III was initially intended to collect observations during April 2004 through March 2005 and was extended for a second year due to heavy rainfall and concerns that the measurements would not represent typical meteorology. The MATES III final report presented annual averages for eight of the sites over the two-year monitoring period. Because the Huntington Park and Pico Rivera sites did not have a full second year of data, only data from the first year of measurements at these sites were used to calculate annual statistics [9, pp. ES-2, 10, pp. 1-1]. The current analysis uses the same averaging periods for each of the MATES III sites. In cases when there were multiple observations at a given station on a given day, the observations were merged by taking the (classical) mean of the replicate measurements prior to analyzing the data.

Table XIV-1: Date ranges for data included in this analysis.

MATES Iteration	Start of data used	End of data used
MATES II [11, pp. 1-2]	April 1998	March 1999
MATES III [9, pp. ES-2]	April 2004	March 2006
MATES IV [12, pp. Appendix X-1]	July 2012	June 2013
MATES V	May 2018	April 2019

References

[1] D. Helsel, Statistics for Censored Environmental Data Using Minitab and R, 2nd ed., Hoboken, New Jersey: John Wiley & Sons, Inc., 2012.

[2] 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.

[3] South Coast Air Quality Management District, "Mulitple Air Toxics Exposure Study (MATES-II) Executive Summary," Diamond Bar, 2000.

[4] United States Environmental Protection Agency, "Data Quality Assessment: Statistical Methods for Practitioners EAP QA/G-9S," Washington, DC, 2006.

[5] EPA454/R-01-003, "Pilot City Air Toxics Measurements Summary," 2001.

[6] South Coast Air Quality Management District, "Appendix VI MATES III Final Report Summaries for the MATES III Fixed Monitoring Sites," Diamond Bar, 2008.

[7] South Coast Air Quality Management District, "Appendix IV MATES IV Final Report Summaries for the MATES IV Fixed Monitoring Sites," Diamond Bar, 2015.

[8] J. P. Klein and M. L. Moeschberger, Survival Analysis Techniques for Censored and Truncated Data, 2nd ed., New York: Springer, 2003.

[9] South Coast Air Quality Management District, "MATES III Executive Summary," Diamond Bar, 2008.

[10] South Coast Air Quality Management District, "MATES III Final Report Chapter 1 Introduction," Diamond Bar, 2008.

[11] South Coast Air Quality Management District, "Multiple Air Toxics Exposure Study (MATES-II) Final Report Chapter 1 Introduction," Diamond Bar, 2000.

[12] South Coast Air Quality Management District, "MATES IV Final Report Appendix X The Spatial and Temporal Trends of PM2.5, PM10, and TSP Components in the South Coast Air Basin," Diamond Bar, 2015.

APPENDIX XII

MATES V

DRAFT FINAL REPORT

Biomass Burning Contribution to PM2.5 (Levoglucosan Data Analysis)

Appendix XII

Biomass Burning Contribution to PM2.5 (Levoglucosan Data Analysis)

XII.1. Introduction

MATES is a study that focuses on the measurement and modeling of ambient air toxics for the primary purpose of evaluating health risks due to air pollution. As part of MATES V, levoglucosan, a key tracer of wood smoke, was measured alongside other particulate species at all ten fixed monitoring sites. The addition of levoglucosan measurements provided insight into pollution sources that influence both basin-wide and localized health risks and also allowed for improvement to pollution forecast models to help residents minimize their exposures to air pollution.

Wood smoke from residential wood burning is an important source of wintertime fine particulate matter (PM2.5) in the South Coast Air Basin (South Coast Air Quality Management District, 2008) and concentrations are influenced by both meteorology and human behavior. Levoglucosan is a component of PM2.5 produced during wood burning (Fine, et al., 2001) and was measured in the months leading up to and throughout the MATES V campaign from January 2018 to April 2019. The acquisition of levoglucosan data provided staff with the opportunity to create a forecasting tool specifically tailored to residential wood burning patterns in the Basin. Machine learning techniques were used to create a forecasting model for residential wood smoke based on levoglucosan observations during the MATES V period. The levoglucosan observations are referred to as the ‘training data’ for the model. The influence of meteorology on wood smoke concentrations is represented in the model by meteorological forecast data from the North American Mesoscale (NAM) model (National Centers for Environmental Information, 2020). The influence of human behavior on wood smoke concentrations is represented in the model by calendar-based patterns such as day of week and holidays. Levoglucosan concentrations are modeled with these predictor variables and then conversion factors are used to estimate the PM2.5 concentrations due to wood smoke.

This forecast tool can be used to both estimate wood smoke concentrations on days without MATES V measurements and to predict concentrations on any day with NAM meteorological forecast data—up to three days into the future. South Coast AQMD staff issue a daily air quality forecast for the entirety of Los Angeles, Orange, San Bernardino, and Riverside counties, which takes into account forecasted concentrations of ozone, PM2.5, PM10, carbon monoxide, and nitrogen dioxide. Air quality forecasting models used by South Coast AQMD staff to issue the daily forecast do not completely account for the strong dependence of wood smoke PM2.5 on calendar and meteorological parameters. However, the levoglucosan model can be used to improve PM2.5 predictions during the winter months in the Basin as part of the daily air quality forecast.

XII.2. Background

Levoglucosan (1,6-anhydro-β-D-glucopyranose), a thermal degradation product of cellulose and hemicellulose, is a widely used tracer of biomass burning contributions to atmospheric particulate loading (Simoneit, 2002). Levoglucosan has been shown to be present at very high concentrations in fine particulate (PM2.5) emissions from both residential wood combustion (Schauer, et al., 2001; Fine, et al., 2002) and wildland biomass combustion (Sullivan, et al., 2008; Hosseini, et al., 2013), making it a robust indicator for key biomass burning processes in the Basin. Although particulate levoglucosan concentrations may be reduced by photochemical oxidation (Hennigan, et al., 2010; Hennigan, et al., 2011; Hoffmann, et al., 2010), this effect is mitigated by the dominance of local pollution sources and relatively short distances between monitors within the Basin (South Coast Air Quality Management District, 2016). Additionally, levoglucosan is more stable at cooler temperatures observed in winter (Pratap, et al., 2019) when residential wood burning is most common (South Coast Air Quality Management District, 2008). To date, several studies have incorporated levoglucosan into receptor modeling studies to better characterize the contribution of biomass burning/wood smoke to total PM2.5 mass or PM2.5 organic carbon in the Basin (South Coast Air Quality Management District, 2008; Heo, et al., 2013; Shirmohammadi, et al., 2016).

In addition to levoglucosan, other minor monosaccharide anhydrides produced during hemicellulose pyrolysis can provide further insight into the predominant biomass fuel type. The relative yields of levoglucosan and its isomers mannosan (1,6-anhydro-β-D-mannopyranose) and galactosan (1,6-anhydro-β-D-galactopyranose) have been shown to be characteristic of burns of different vegetation types (e.g., hardwood, softwood, grass, etc.) (Sullivan, et al., 2008; Fine, et al., 2004). Metrics such as the levoglucsoan/mannosan ratio in particulates can thus be used to distinguish different biomass burning sources provided sources are derived from sufficiently distinct vegetation types.

XII.3. Levoglucosan Measurement Methods

Levoglucosan and other monosaccharide anhydrides were analyzed using a method adapted from procedures described in (California Air Resources Board, 2015; Cordell, et al., 2014; Schauer & Sioutas, 2012). Fine particulate matter (PM2.5) for levoglucosan analysis was collected by ambient air filtration onto quartz fiber filters on a dedicated channel of a speciated air sampling system (SASS) PM2.5 sampler at each site. Samples were collected on a 1-in-6 day schedule at all ten fixed MATES V sites except for Central L.A. and Rubidoux, where sampling frequency was increased to a 1-in-3 day schedule to better characterize temporal variability. Prior to analysis, filters were spiked with an internal standard ($^{13}C_6$-levoglucosan) and extracted by ultrasonication in acetonitrile. Extracts were then derivatized with a silanizing reagent to convert monosaccharide anhydrides to trimethylsilyl (TMS) derivatives suitable for gas chromatography-mass spectrometry (GC-MS) analysis. Samples were analyzed by GC-MS using a simultaneous selective ion monitoring (SIM)/full scan method and quantified by comparison to authenticated standards for each compound of interest. Further sampling and analytical details can be found in Appendix III.

XII.4. Levoglucosan Observations

Average levoglucosan concentrations measured at each station over the MATES V analysis period (May 2018-April 2019) are shown in Figure XII-1. With the exception of Compton, average MATES V levoglucosan concentrations at all sites were generally comparable to site averages of 45-60 ng/m^3 measured during the second year of MATES III from May 2005 – April 2006 (South Coast Air Quality Management District, 2008).[1] As expected, levoglucosan concentrations at all sites were much higher during late fall/winter due to increased residential wood burning during cooler months (Figure XII-2). Late fall/winter levoglucosan concentrations at Compton were generally higher than concentrations measured at other sites, which could reflect increased wood burning in this area or closer proximity to a local biomass burning source. Average winter (December-February) mannosan/levoglucosan ratios ranged from 5.5 to 6.3 across the basin, which is consistent with softwood-dominated or mixed hardwood/softwood burning based on reported ranges in the literature ((Fabbri, et al., 2009) and references therein).

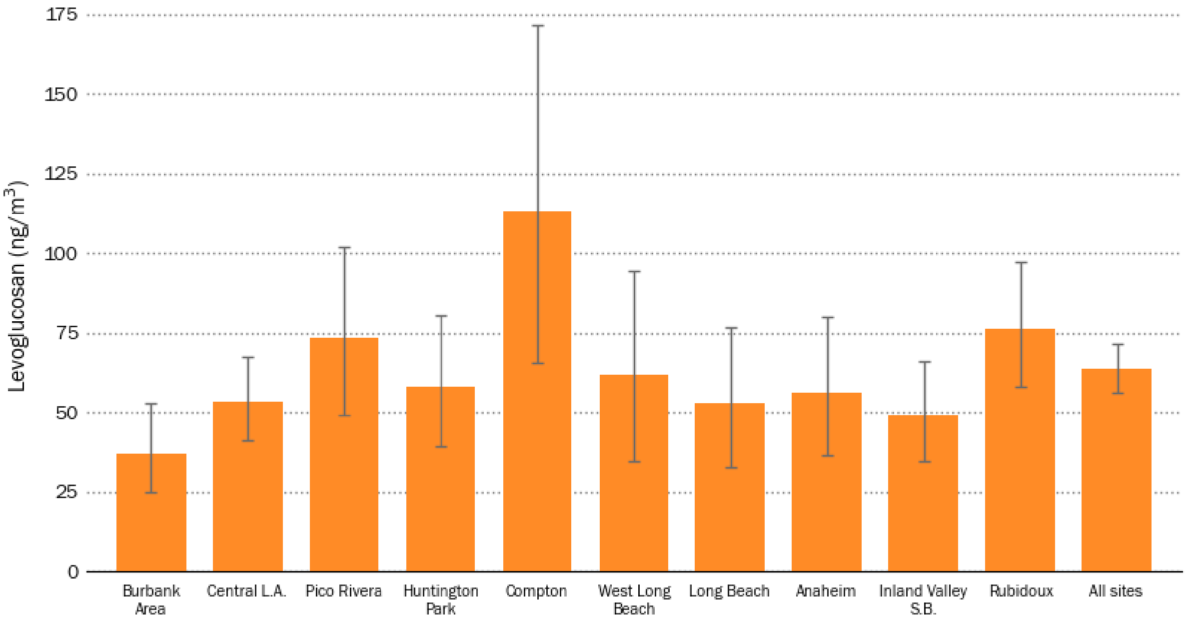


Figure XII-1. Kaplan-Meier mean levoglucosan concentrations measured at MATES V sites from May 2018 to April 2019. Error bars represent 95% confidence intervals of averages. The station name Inland Valley San Bernardino is abbreviated as Inland Valley S.B.

---

[1] Results from three sites (Huntington Park, Long Beach, and Pico Rivera) with incomplete levoglucosan MATES III Year 2 datasets are not included in this range.

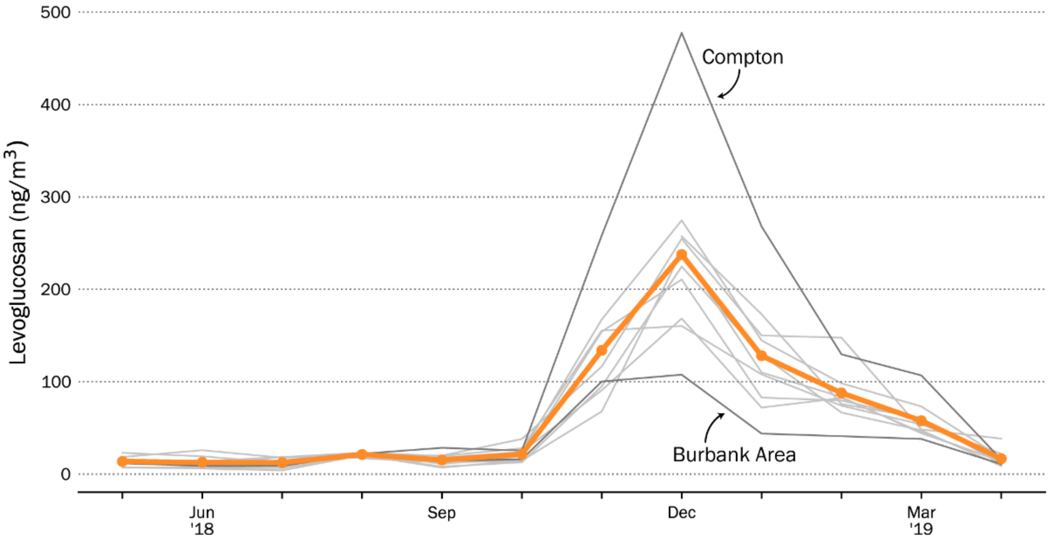


Figure XII-2. Monthly average levoglucosan concentrations during MATES V monitoring period. Gray lines show monthly averages at individual sites, and bold orange line shows Basin (ten site) average.

Outside of the winter wood burning season, several peaks in levoglucosan concentrations coincided with local wildfires or smoke plumes from wildfires outside the Basin, although the magnitude of these peaks was variable. These events included transport of smoke into the basin from northern California wildfires on August 24, 2018 and from the Woolsey/Hill Fires in Ventura County and western Los Angeles County on November 10, 2018. Both events were marked by higher levoglucosan concentrations at sites in the western and coastal portions of the Basin, consistent with westerly transport of smoke into the SCAB. The Euclid Fire south of Chino also may have contributed to an elevated levoglucosan concentration of 108 ng/m^3 at Rubidoux on June 13, 2018 compared to a summer station average of 21 ng/m^3.

XII.5. Conversion Factors

Observed and model forecasted levoglucosan concentrations at each station were scaled by a conversion factor, defined as the ratio of wood smoke PM2.5 to levoglucosan, to estimate total PM2.5 mass due to wood smoke. This conversion factor is a major source of uncertainty for wood smoke PM2.5 estimates since it depends on the fuel burned, the characteristics of the burn (e.g., combustion temperature, combustion efficiency), the age of the smoke, ambient temperature, and actinic flux (Fine, et al., 2001; Fine, et al., 2002; Fine, et al., 2004; Schauer, et al., 2001; Sullivan, et al., 2008; Kuo, et al., 2011; Hennigan, et al., 2011; Hoffmann, et al., 2010; Sang, et al., 2016; Pratap, et al., 2019). This uncertainty is represented in the variety of conversion factors ranging from 8.33 to 41.7 that were either reported in studies or calculated from several studies, see Table XII-1. To empirically constrain the wide range of conversion factors found in the literature, levoglucosan observations with co-located speciated PM2.5 data were analyzed. Several conversion factors reported in the literature produced calculated wood smoke PM2.5 concentrations that were larger than the measured total PM2.5. A maximum empirical conversion factor could be determined by assuming that all of the PM2.5 mass with the exception of soil, ammonium nitrate, and ammonium sulfate was wood smoke PM2.5. The smallest of these empirical conversion factors was used as the new upper-bound estimate of the conversion factors. The lowest conversion factor from the literature (Table XII-1) was used as a lower-bound estimate of the PM2.5 due to wood smoke. The levoglucosan forecast model outputs a lower-bound estimate of the PM2.5 due to wood smoke using the smallest conversion factor from the literature (8.33, see Table XII-1) and an upper-bound estimate of PM2.5 due to wood smoke using the smallest empirical conversion factor (16.39).

Applying this conversion factor range to measured winter levoglucosan concentrations illustrates the potential significance of wood smoke contributions to total PM2.5 mass in the SCAB. From December 2018-February 2019, the period during MATES V when residential wood burning would be expected to reach peak levels, levoglucosan alone constituted an average of 0.8-1.9% of total PM2.5 mass measured at each site (Table XII-1). Winter levoglucosan/PM2.5 mass ratios did not show any clear spatial trend, with average levoglucosan concentrations remaining relatively close to 1% of total mass at most sites. The only exception was at Compton, where levoglucosan represented a larger fraction of average winter PM2.5 mass (1.9%). After applying the range of conversion factors determined above, observed levoglucosan concentrations would translate to wood burning contributions ranging from 7-32% (0.5-4.8 $\mu g/m^3$) of total winter PM2.5 mass at individual sites, with a basin average of 11-21% (1.3-2.5 $\mu g/m^3$). These levoglucosan-based estimates are somewhat higher than estimated winter biomass burning contributions at Central L.A. and Rubidoux from 2002-2007 determined using a Positive Factorization Matrix (PMF) receptor model (Central L.A.: 1.7 $\mu g/m^3$/8.3% PM2.5 mass, Rubidoux: 1.0 $\mu g/m^3$/5.0% PM2.5 mass (Hasheminassab, et al., 2014)). However, this finding is consistent with a decrease in emissions from non-wood smoke PM2.5 sources relative to wood smoke PM2.5 sources.

Table XII-1: Conversion factors derived from literature for use in wood smoke model.

Conversion Factor	Citation	Notes
8.3333	(Fine, et al., 2001)	Calculated from numbers in the paper: "The results in Table 3 also indicate that almost all of the emitted fine particulate mass consists of organic compounds. Organic carbon contributes over 80% of the fine particle mass in the emissions from every wood species studied." "Between 3% and 12% of the fine particulate organic compound emissions are accounted for by levoglucosan"
9.01	(Busby, et al., 2016)	"We used a combination of the experimental and published values for L_A, L_B and L_S to establish a low and a high estimate of the conversion factor. Using only the most relevant published results (Fine et al., 2004a) gives a [conversion factor] = 9.01, which is used here as a lower limit" "L_A, L_B, and L_S are the levoglucosan mass fractions for aspen, birch, and spruce woodsmoke respectively."
10.4	(Busby, et al., 2016) (citations therein)	"Piazzalunga et al. (2011) generated conversion factors of 10.4 using literature values and 16.9 using [positive matrix factorization] in Italy."
10.4167	(Fine, et al., 2001)	Calculated from numbers in the paper: "The results in Table 3 also indicate that almost all of the emitted fine particulate mass consists of organic compounds. Organic carbon contributes over 80% of the fine particle mass in the emissions from every wood species studied." "Between 3% and 12% of the fine particle organic compound emissions are accounted for by levoglucosan"
10.7	(Busby, et al., 2016) (citations therein)	"Schmidl et al. (2008) and Caseiro et al. (2009) measured, reported and used a conversion factor of 10.7 to calculate wood smoke particulate from levoglucosan."
10.7	(Busby, et al., 2016) (citations therein)	"Herich et al. (2014) compared results for multiple studies in alpine regions of Europe and found that wood smoke PM to levoglucosan ratios varied from 10.7 to 25.2."
10.72	(Busby, et al., 2016)	"Using all data and the minimum and maximum wood smoke PM2.5 estimates from the [carbon-14 analysis methods] data yielded [conversion factor] = 10.72 ± 0.61 and 12.91 ± 0.74, respectively."
11.31	(Busby, et al., 2016)	slope of [carbon-14 analysis methods] vs levoglucosan, removing the highest point
11.45	(Busby, et al., 2016)	"Another approach is to calculate and average the ratios of wood smoke PM2.5 to levoglucosan for each sample. Using minimum and maximum estimates for wood smoke PM2.5 from the

		[carbon-14 analysis methods] data yielded mean [conversion factor] values of 11.45 ± 0.89 and 13.8 ± 1.1, respectively."
11.46	(Busby, et al., 2016)	slope of [carbon-14 analysis methods] vs levoglucosan, removing the 4 highest points
11.82	(Busby, et al., 2016)	"analyses. Fig. 2(b) demonstrates a high correlation between the levoglucosan and [carbon-14 analysis methods] measures with a slope ([conversion factor]) of 11.82 ± 0.67 (r2 = 0.97, F = 1257, n = 40)."
12.2	(Busby, et al., 2016)	"device type data by zip code was utilized together with wood species survey data to generate site-specific [conversion factor] values weighted for both wood species and device type. These conversion factors, calculated using LB and LS from Table 3 and the published value for LA, ranged from 12.2–12.4. There was significant concern about these site-specific results because of the combined uncertainties in L values, wood species usage, and stove type usage. Because of this, and because they are bracketed by [lower and upper bound conversion factors], they were not used for additional calculations."
12.4	(Busby, et al., 2016)	"device type data by zip code was utilized together with wood species survey data to generate site-specific [conversion factor] values weighted for both wood species and device type. These conversion factors, calculated using LB and LS from Table 3 and the published value for LA, ranged from 12.2–12.4. There was significant concern about these site-specific results because of the combined uncertainties in L values, wood species usage, and stove type usage. Because of this, and because they are bracketed by [lower and upper bound conversion factors], they were not used for additional calculations."
12.91	(Busby, et al., 2016)	"Using all data and the minimum and maximum wood smoke PM2.5 estimates from the [carbon-14 analysis methods] data yielded [conversion factor] = 10.72 ± 0.61 and 12.91 ± 0.74, respectively."
13.3	(Busby, et al., 2016)	"An upper limit [conversion factor] was calculated using the average experimental values for LB and LS from Table 3 over all burn conditions and the published value of LA. The resulting [conversion factor] = 13.3 is strongly influenced (43%) by the published value for aspen."
13.8	(Busby, et al., 2016)	"Another approach is to calculate and average the ratios of wood smoke PM2.5 to levoglucosan for each sample. Using minimum and maximum estimates for wood smoke PM2.5 from the [carbon-14 analysis methods] data yielded mean [conversion factor] values of 11.45 ± 0.89 and 13.8 ± 1.1, respectively."
15.12	(Busby, et al., 2016)	"wood smoke PM2.5 concentration estimated from [chemical mass balance] is plotted vs the measured levoglucosan levels …"

		"Separate regression of the results at the three sites yields slopes of 15.12 ± 0.39 (r2 = 0.96, F = 1470, n = 57), 23.3 ± 2.2 (r2 = 0.89, F = 464, n = 58) and 19.8 ± 2.5 (r2 = 0.84, F = 245, n = 46) at the North Pole, Peger Rd., and State Building sites, respectively. The slopes are estimates of the [conversion factor] values assuming that [chemical mass balance] modeling provides an accurate estimate of wood smoke PM2.5."
16.9	(Busby, et al., 2016) (citations therein)	"Piazzalunga et al. (2011) generated conversion factors of 10.4 using literature values and 16.9 using [positive matrix factorization] in Italy."
18.3	(Busby, et al., 2016) (citations therein)	"Zhang et al. (2010a) used [positive matrix factorization] to obtain a conversion factor of 18.3 for the southeastern US"
19.8	(Busby, et al., 2016)	"wood smoke PM2.5 concentration estimated from [chemical mass balance] is plotted vs the measured levoglucosan levels … "Separate regression of the results at the three sites yields slopes of 15.12 ± 0.39 (r2 = 0.96, F = 1470, n = 57), 23.3 ± 2.2 (r2 = 0.89, F = 464, n = 58) and 19.8 ± 2.5 (r2 = 0.84, F = 245, n = 46) at the North Pole, Peger Rd., and State Building sites, respectively. The slopes are estimates of the [conversion factor] values assuming that [chemical mass balance] modeling provides an accurate estimate of wood smoke PM2.5."
23.3	(Busby, et al., 2016)	"wood smoke PM2.5 concentration estimated from [chemical mass balance] is plotted vs the measured levoglucosan levels … "Separate regression of the results at the three sites yields slopes of 15.12 ± 0.39 (r2 = 0.96, F = 1470, n = 57), 23.3 ± 2.2 (r2 = 0.89, F = 464, n = 58) and 19.8 ± 2.5 (r2 = 0.84, F = 245, n = 46) at the North Pole, Peger Rd., and State Building sites, respectively. The slopes are estimates of the [conversion factor] values assuming that [chemical mass balance] modeling provides an accurate estimate of wood smoke PM2.5."
25.2	(Busby, et al., 2016) (citations therein)	"Herich et al. (2014) compared results for multiple studies in alpine regions of Europe and found that wood smoke PM to levoglucosan ratios varied from 10.7 to 25.2."
33.3333	(Fine, et al., 2001)	Calculated from numbers in the paper: "The results in Table 3 also indicate that almost all of the emitted fine particulate mass consists of organic compounds. Organic carbon contributes over 80% of the fine particle mass in the emissions from every wood species studied." "Between 3% and 12% of the fine particulate organic compound emissions are accounted for by levoglucosan"

35.25	(Villalobos, et al., 2017)	Calculated from numbers in the paper: "wood burning is responsible for 84.6%", "The mean levoglucosan/PM2.5 ratio (0.021) is similar to the ratio found in Santiago (0.024)". Lev/PM2.5_tot = 0.024, PM2.5_wood/PM2.5_tot = 0.846, solve for PM2.5_wood, which gives a conversion factor of 0.846/0.024 = 35.25
40.29	(Villalobos, et al., 2017)	Calculated from numbers in the paper: "wood burning is responsible for 84.6%", "The mean levoglucosan/PM2.5 ratio (0.021) is similar to the ratio found in Santiago (0.024)". Lev/PM2.5_tot = 0.021, PM2.5_wood/PM2.5_tot = 0.846, solve for PM2.5_wood, which gives a conversion factor of 0.846/0.021 = 40.29
41.6667	(Fine, et al., 2001)	Calculated from numbers in the paper: "The results in Table 3 also indicate that almost all of the emitted fine particulate mass consists of organic compounds. Organic carbon contributes over 80% of the fine particle mass in the emissions from every wood species studied." "Between 3% and 12% of the fine particulate organic compound emissions are accounted for by levoglucosan"

Table XII-2. Average winter (December 2018-February 2019) PM2.5 and levoglucosan concentrations and estimated biomass burning contributions to total PM2.5 at MATES V sites. Low and high estimates were calculated with levoglucosan-PM2.5 conversion factors of 8.33 and 16.4, respectively.

Station	$PM_{2.5}$ mass (µg/m^3)	Levoglucosan (ng/m^3)	Levoglucosan/$PM_{2.5}$ (%)	Estimated biomass burning $PM_{2.5}$ (µg/m^3)		Estimated biomass burning contribution to total $PM_{2.5}$ (%)	
				Low	High	Low	High
Burbank Area	7.76	64	0.83	0.53	1.1	6.9	14
Central L.A.	10.71	127	1.18	1.1	2.1	9.8	19
Pico Rivera	13.53	178	1.31	1.5	2.9	11	22
Huntington Park	12.55	124	0.99	1.0	2.0	8.3	16
Compton	15.10	292	1.93	2.4	4.8	16	32
West Long Beach	13.82	168	1.22	1.4	2.8	10	20
Long Beach	11.94	140	1.17	1.2	2.3	9.8	19
Anaheim	12.48	145	1.16	1.2	2.4	9.6	19
Inland Valley S.B.	10.82	108	0.99	0.90	1.8	8.3	16
Rubidoux	12.66	188	1.48	1.6	3.1	12	24
Basin Average	12.14	153	1.26	1.3	2.5	11	21

XII.6. Model Training Data

Levoglucosan observations included the measurements made at 10 stations from May 2018 through April 2019, and additional measurements during the lead-up period to MATES V (January-April 2018). All of these measurements were incorporated into a training set for a new wood smoke forecasting model. Four levoglucosan observations were removed from the training set because they were impacted by smoke according to Hazard Mapping System (HMS) smoke plume data (National Oceanic and Atmospheric Administration Office of Satellite and Product Operations, 2020; NOAA OSEPO, 2020), and thus not representative of residential wood burning. Three additional observations were removed due to missing data from the NAM weather model (National Centers for Environmental Information, 2020). The data for 9% of randomly-selected dates with observations were separated as a held-out data set to be used for model verification. The held-out data set contained 57 observations. The final training data set contained 854 observations. Figure XII-3 shows the time series of levoglucosan measurements by station.

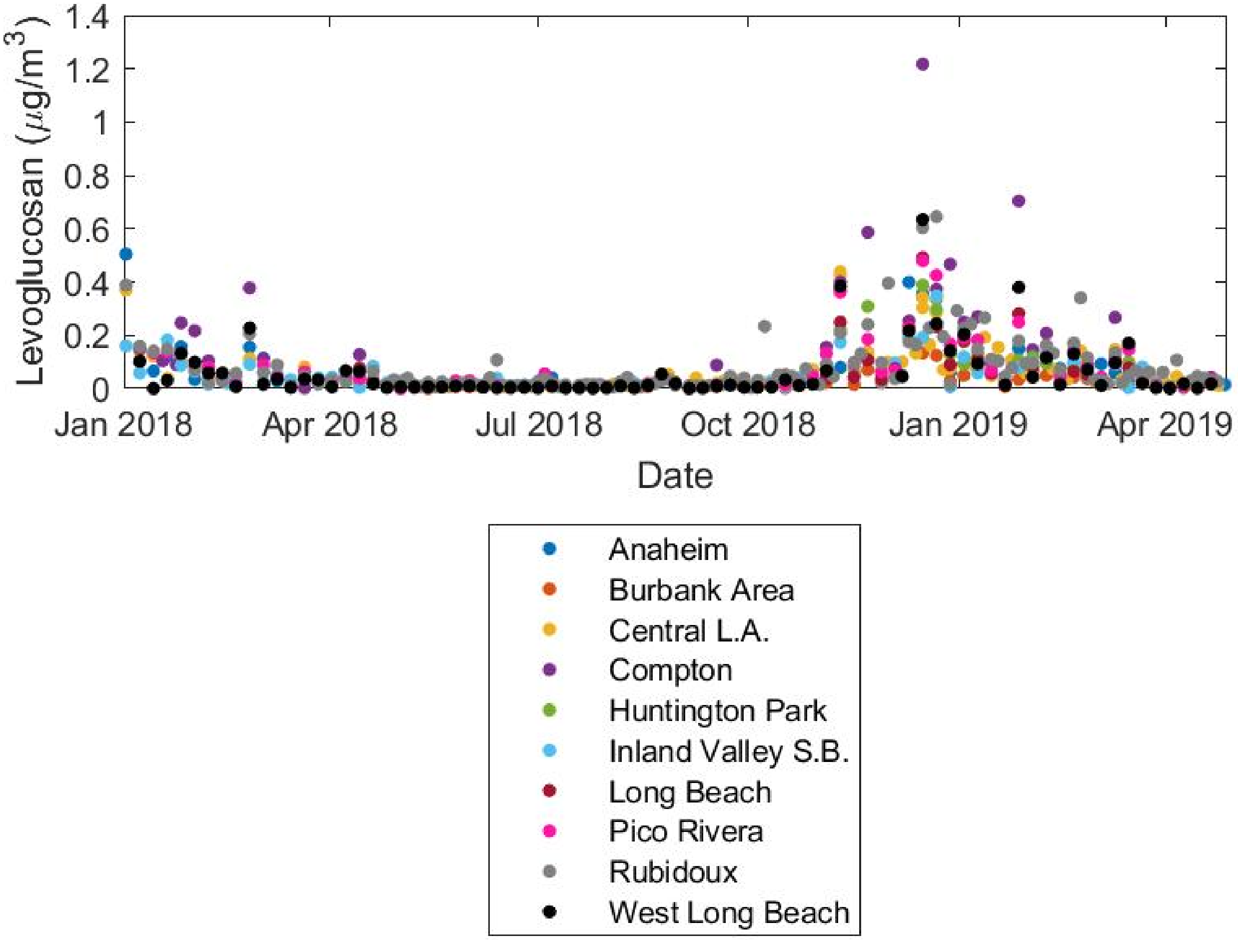


Figure XII-3: Time series of levoglucosan measurements by station.[2] The station name Inland Valley San Bernardino is abbreviated as Inland Valley S.B.

XII.7. Model Configuration

Matlab's Regression Learner® software (MathWorks, 2020) was used to train the model. First, several built-in algorithms were implemented with all predictor variables to help identify the best performing algorithm. The exponential Gaussian Process Regression (Exponential GPR) algorithm had the lowest root mean squared error (RMSE). After determining the best performing algorithm, the number of predictor variables was reduced empirically from an initial list of 33 predictor variables by removing one at a time and re-training the Exponential GPR algorithm. Removing variables can improve model performance due to collinearities among predictor variables or predictor variables not being strongly related to levoglucosan concentrations. If the RMSE improved without a variable, that variable was permanently left out

---

[2] One data point (Rubidoux on 10/8/2018) was invalidated after the model was operational for the 2019-2020 winter season. The invalidation of one data point in the training data is likely to cause only a minor change in the model.

of the training and the next variable was tried. This process led to a final list of 21 predictor variables included in the training (see Table XII-3).

XII.8. Predictor Variables

The model is trained to create forecasts for the 10 stations that were in the training data using 21 predictor variables, see Table XII-3 and Figure XII-4 - Figure XII-5. Station is a categorical variable indicating the name of the monitoring station, and the levoglucosan forecasts are made only at the stations with levoglucosan measurements. This variable serves as a proxy for characteristics and emission patterns of the area around each monitor. The remaining predictor variables are either calendar-based (determined by day of week, proximity to holiday, etc.) or meteorologically-driven, based on the North American Mesoscale Forecast System at a resolution of 12 km (12 km NAM) (National Centers for Environmental Information, 2020). Since the 12 km NAM model provides a forecast out to 84 hours, the levoglucosan model can be used to create a 3-day forecast.

The meteorological forecast data for the station locations were extracted by using data in the grid cell in which each monitor is located. The naming convention for the meteorological variables is that “TodayEve” variables describe a summary of the weather during 4 PM – 11 PM of the evening before the forecasted date. This is because the weather variables that promote an accumulation of PM2.5 (such as low planetary boundary height and calm winds) the evening before the forecasted date will promote higher PM2.5 concentrations the next day. “Tomorrow” in variable names indicates that the variable is a summary of the forecasted weather for the date of the forecast.

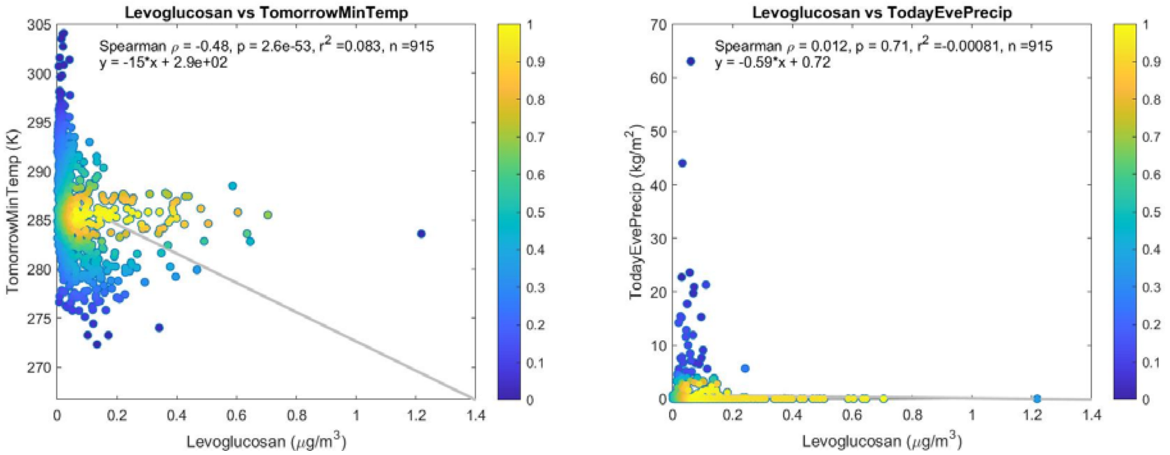
The variables used in the final version of the model and their descriptions are presented in Table XII-3. The following variables were empirically removed as predictor variables for the levoglucosan model: DayOfWeekName, Eve, TodayEveMinTemp, TodayEveMaxTemp, TodayEveRH, TodayEveUwind, TodayEveVent, TomorrowDSWRF, TomorrowMaxTemp, TomorrowPBH, TomorrowPrecip, and CumulativePM25Factors. These variables follow the naming conventions established in Table XII-3. The variable “Eve” is a categorical (binary) variable indicating if the date to be forecasted was December 24 or December 31 (‘Yes’) or any other day (‘No’). “CumulativePM25Factors” is analogous to “CumulativeFactors,” except that it is based on PM2.5 instead of levoglucosan.

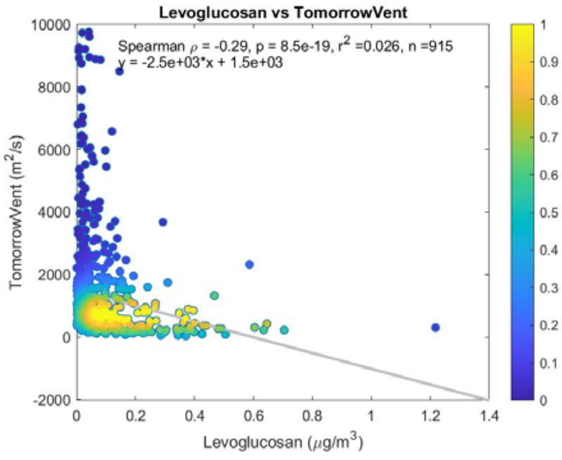
Table XII-3: Predictor Variables for Levoglucosan Forecast Model.

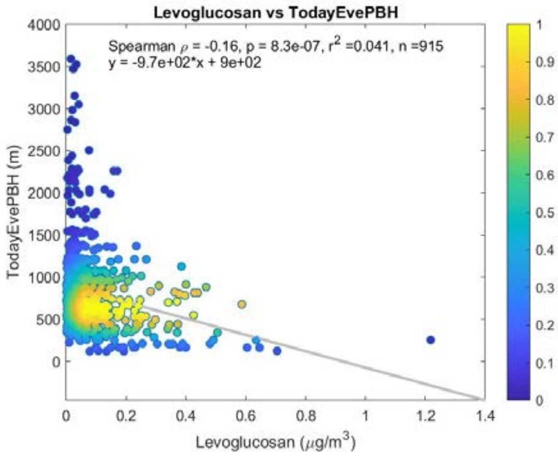
Variable	**Description**
Station	Station is a categorical variable indicating the name of the monitoring station. This variable serves as a proxy for characteristics and emission patterns of the area around each monitor.
TomorrowMinTemp	TomorrowMinTemp indicates the minimum temperature at 2 m above ground forecasted during the day of the forecast in the NAM 12 km model grid cell containing the station.
TodayEvePrecip	TodayEvePrecip is a summation of forecasted precipitation during 4 PM – 11 PM on the day before the forecast.
TomorrowVent	TomorrowVent is the average ventilation rate of the planetary boundary layer for the forecasted date.
TodayEvePBH	TodayEvePBH is the maximum planetary boundary height during 4 PM – 11 PM the day before the forecasted date.
TomorrowUwind	TomorrowUwind is the average of the east/west component of the wind at a height of 10 m above ground level for the forecasted date.
TodayEveVwind	TodayEveVwind is the average of the north/south component of the wind at height of 10 m above ground level during 4 PM – 11 PM the day before the forecasted date.
TomorrowVwind	TomorrowVwind is the average of the north/south component of the wind at a height of 10 m above ground level for the forecasted date.
TomorrowRH	TomorrowRH is the average relative humidity at a height of 2 m above ground level for the forecasted date.
TodayEveDSWRF	TodayEveDSWRF is the average downwelling shortwave radiation flux (i.e., sunlight) during 4 PM – 11 PM the day before the forecasted date.
TodayEveVwind850mb	TodayEveVwind850mb is the average north/south component of the wind at an altitude of 850 mb during 4 PM – 11 PM the day before the forecasted date.
TomorrowVwind850mb	TomorrowVwind850mb is the average north/south component of the wind at an altitude of 850 mb for the forecasted date.
TodayEveUwind850mb	TodayEveUwind850mb is the average east/west component of the wind at an altitude of 850 mb during 4 PM – 11 PM the day before the forecasted date.
TomorrowUwind850mb	TomorrowUwind850mb is the average east/west component of the wind at an altitude of 850 mb for the forecasted date.
TodayEveMinTempCat	TodayEveTempCat is a categorical variable with value ‘cold’ if TodayEveMinTemp is at or below 288 K and warm otherwise.
TomorrowMaxTempCat	TomorrowMaxTempCat is a categorical variable with value ‘cold’ if TomorrowMaxTemp is at or below 297 K and warm otherwise.

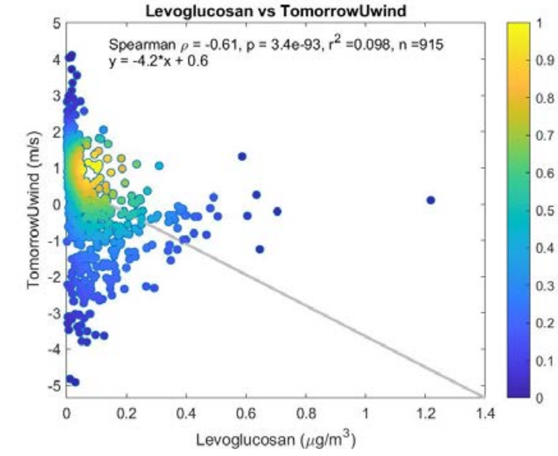
MonthName	MonthName is a categorical variable indicating the month.
Weekend	Weekend is a categorical variable indicating if a day is a weekday or part of the weekend.
HolidayType	HolidayType is a categorical variable indicating if a day was a major holiday, minor holiday, or not a holiday.
ProximityToMajorHoliday	ProximityToMajorHoliday is 0 on major holidays, -1 the day before and after a major holiday, -2 two days before or after a major holiday, or -3 three days before or after a major holiday. All other days are -4 with the assumption that holiday-related activities only influence residential wood burning patterns within three days before or after a holiday.
CumulativeFactors	CumulativeFactors is an integer variable that indicates how closely the meteorological conditions resemble aggregate descriptions of the weather conditions corresponding to the highest 10% levoglucosan concentrations. For example, if TomorrowMinTemp for a date of interest was less than the highest TomorrowMinTemp corresponding to the highest 10% of levglucosan measurements, CumulativeFactors would be increased by 1. CumulativeFactors is increased by 1 if ProximityToMajorHolidays is greater than -4. CumulativeFactors is also increased by 1 for weekends. The maximum value for CumulativeFactors would be 22.

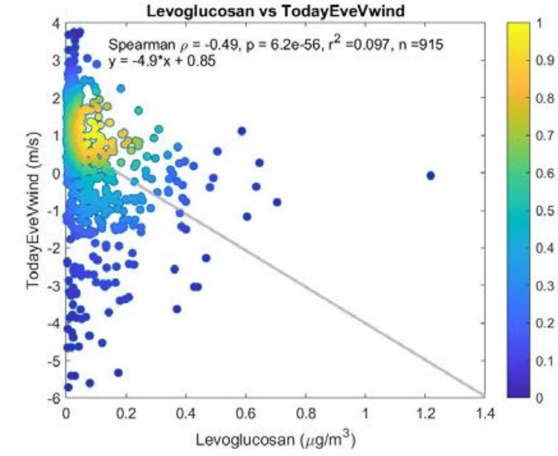
Figure XII-4 illustrates how each of the non-categorical predictors vary with levoglucosan concentration. Figure XII-5 shows the time series of levoglucosan concentration and the ProximityToMajorHoliday variable.

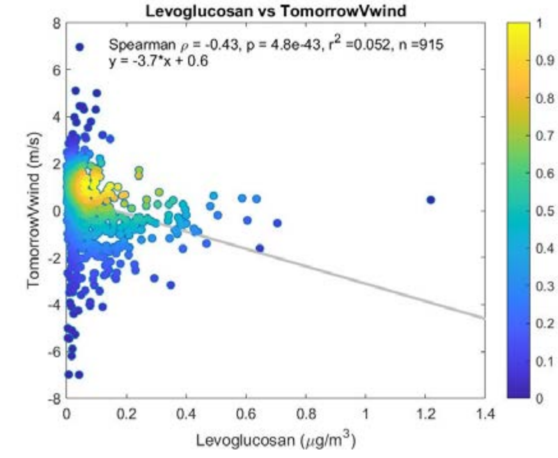


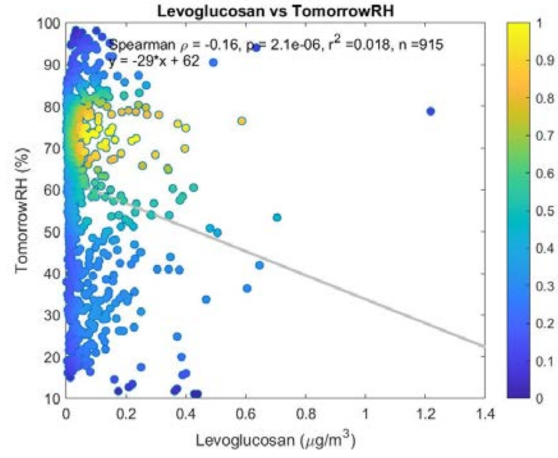

Levoglucosan vs TomorrowVent
Spearman ρ = -0.29, p = 8.5e-19, r^2 =0.026, n =915
y = -2.5e+03*x + 1.5e+03
TomorrowVent (m^2/s)
10000
8000
6000
4000
2000
0
-2000
Levoglucosan (μg/m^3)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


Levoglucosan vs TodayEvePBH
Spearman ρ = -0.16, p = 8.3e-07, r^2 =0.041, n =915
y = -9.7e+02*x + 9e+02
TodayEvePBH (m)
4000
3500
3000
2500
2000
1500
1000
500
0
Levoglucosan (μg/m^3)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


Levoglucosan vs TomorrowUwind
Spearman ρ = -0.61, p = 3.4e-93, r^2 =0.098, n =915
y = -4.2*x + 0.6
TomorrowUwind (m/s)
5
4
3
2
1
0
-1
-2
-3
-4
-5
Levoglucosan (μg/m^3)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


Levoglucosan vs TodayEveVwind
Spearman ρ = -0.49, p = 6.2e-56, r^2 =0.097, n =915
y = -4.9*x + 0.85
TodayEveVwind (m/s)
4
3
2
1
0
-1
-2
-3
-4
-5
-6
Levoglucosan (μg/m^3)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


Levoglucosan vs TomorrowVwind
Spearman ρ = -0.43, p = 4.8e-43, r^2 =0.052, n =915
y = -3.7*x + 0.6
TomorrowVwind (m/s)
8
6
4
2
0
-2
-4
-6
-8
Levoglucosan (μg/m^3)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


Levoglucosan vs TomorrowRH
Spearman ρ = -0.16, p= 2.1e-06, r^2 =0.018, n =915
y = -29*x + 62
TomorrowRH (%)
100
90
80
70
60
50
40
30
20
10
Levoglucosan (μg/m^3)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

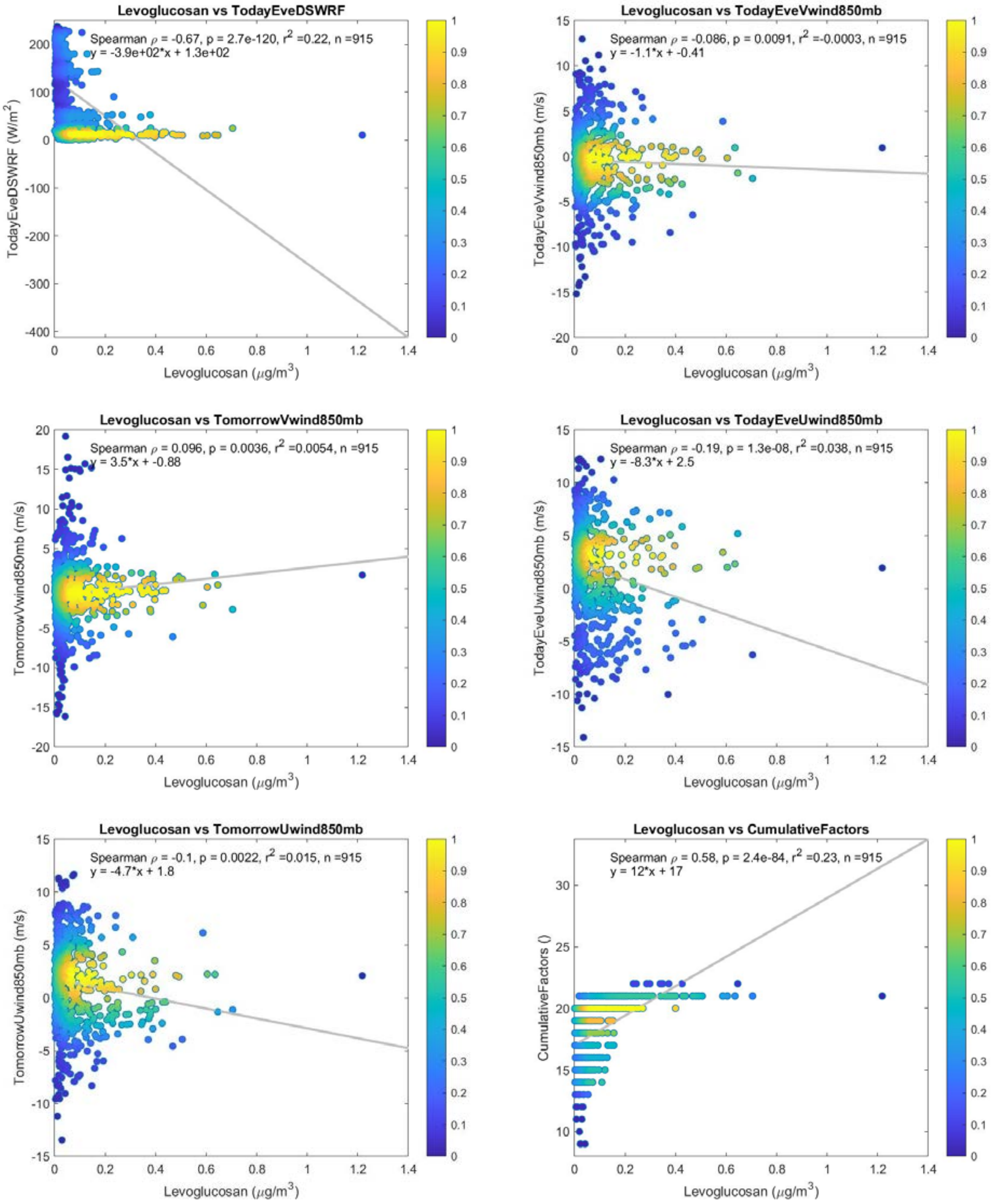


Figure XII-4: Density scatter plots of levoglucosan and the weather variables in Table XII-3. The color bars indicate the relative density of data points next to each other, as data can be plotted on top of each other in scatter plots.

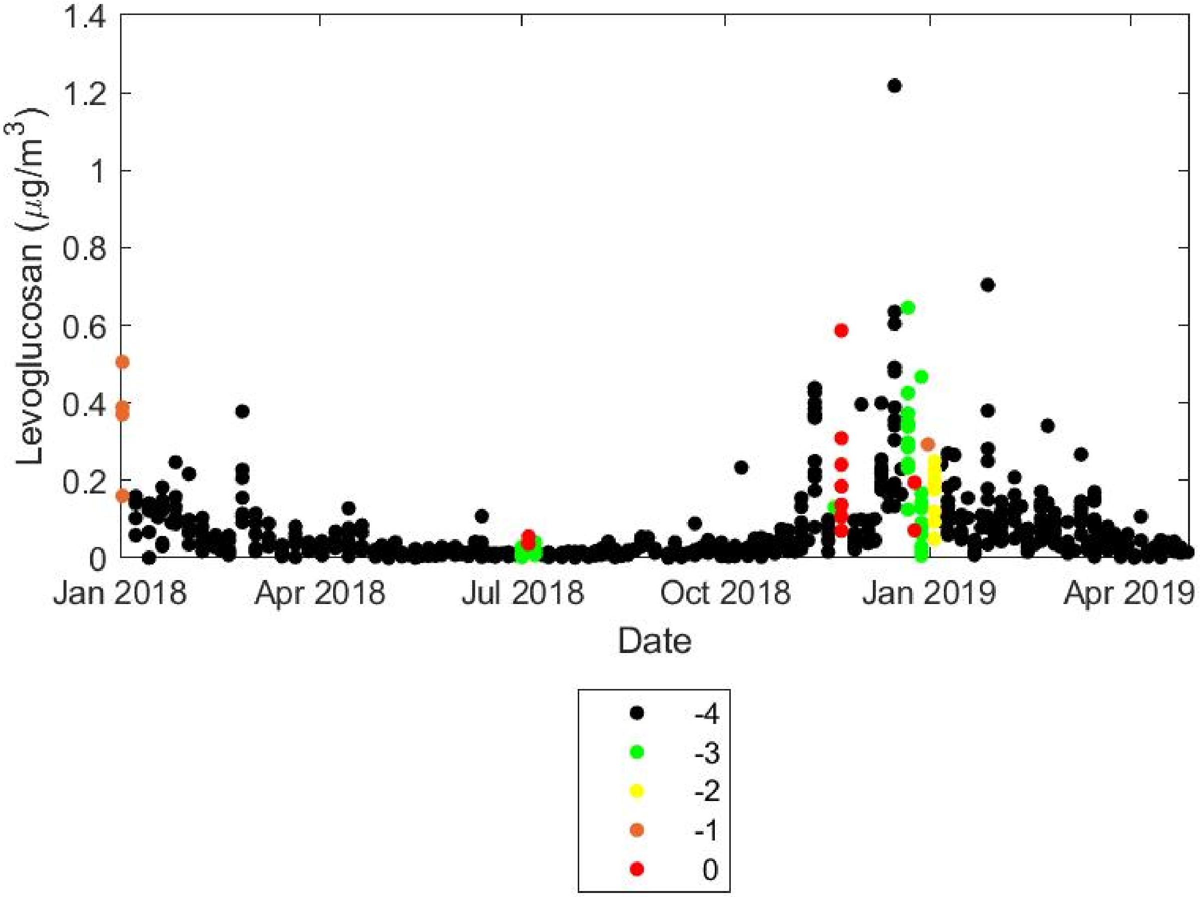


Figure XII-5: Time series of Proximity to Major Holiday variable. The different colored dots represent the number of days before or after a major holiday, with 0 being the holiday date, -1, -2, and -3 being one, two, or three days before or after a major holiday, respectively. All other days are considered "-4", with the assumption that holiday-related activities only influence residential wood burning patterns within three days before or after a holiday.

XII.9. Model Performance

The training used 10-fold cross validation, and the Regression Learner application calculated an RMSE of 0.049 ug/m3 and an R-squared of 0.73. Figure XII-6 shows the scatter plot of the 57 held-out data points and the corresponding prediction from the model (hindcast). The RMSE and R-squared for the held-out data set are 0.0554 and 0.85, respectively.

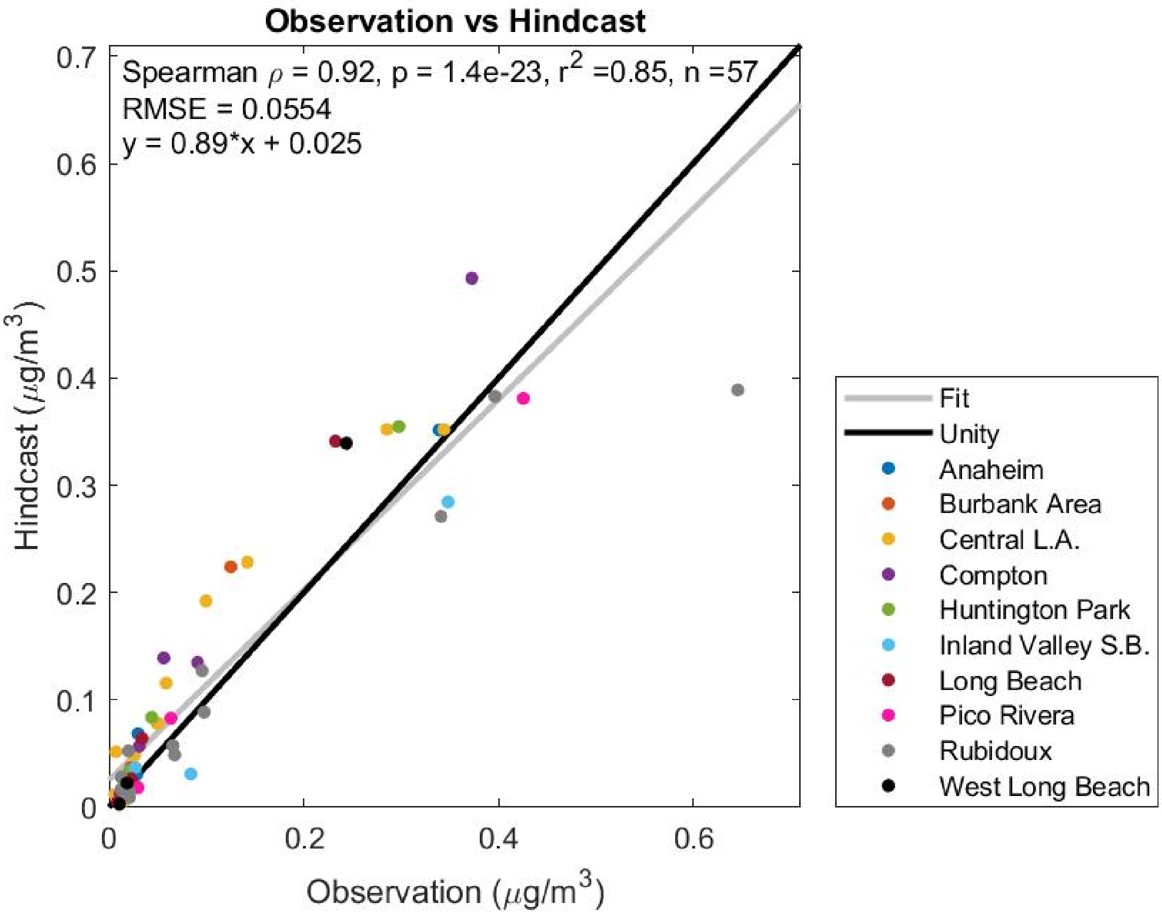


Figure XII-6: Scatter plot of held-out observations and corresponding predictions (hindcast). The station name Inland Valley San Bernardino is abbreviated as Inland Valley S.B.

XII.10. Application to Daily Air Quality Forecasts

While residential wood smoke may contribute significantly to PM2.5 concentrations on certain days in the winter months, emission inventories for PM2.5 chemical transport forecasting models apportion wood smoke based on a static temporal profile that is not dependent on meteorology. Wood smoke PM2.5 predictions from other forecasting models used by South Coast AQMD staff to issue daily forecasts also have high levels of uncertainty because of their inability to capture the human behavioral influence on burning patterns. In order to improve winter-time predictions of total PM2.5, the midpoint of the upper- and lower-bound estimates of wood smoke PM2.5 from the levoglucosan model is used in a weighted ensemble of PM2.5 forecast models to improve predictions of total PM2.5 when widespread residential wood burning occurs.

XII.11. Multi-Year Time Series

The levoglucosan model predictions can be generated for any day for which the predictor variables can be calculated, i.e., any day for which the NAM data is available. Residential wood burning patterns may gradually change over the course of several years, which means that the model will need to be trained with new levoglucosan measurement data. However, residential wood burning patterns are unlikely to change substantially over the course of a few years. As such, staff has run the levoglucosan model backward in time to create retrospective forecasts starting on January 1, 2017 through the start of the on-going operational model runs, resulting in a time series from January 1, 2017 through January 1, 2021.

This multi-year time series of levoglucosan model predictions has been used to help guide outreach efforts for the Check Before You Burn Initiative related to Rule 445 (South Coast Air Quality Management District, 2013; South Coast Air Quality Management District, 2020). To achieve this goal, we used levoglucosan model wood smoke PM2.5 predictions during the 2020-2021 and 2019-2020 Check Before You Burn seasons (November to February) to estimate the impact of wood burning on the annual mean PM2.5 concentration and the 98th percentile of daily PM2.5 concentrations—two important statistics for the PM2.5 federal standards. Outreach was prioritized in communities with higher PM2.5 concentrations along with a larger contribution from residential wood smoke.

XII.12. Conclusion

Analysis of measured levoglucosan concentrations has provided critical insight into the spatial and temporal trends of wood smoke throughout the South Coast Air Basin. Development of a machine learning model with the levoglucosan measurements has improved the accuracy of wintertime forecasts and allowed for prioritization of outreach for the Check Before You Burn program in communities most impacted by residential wood smoke.

XII.13. References

Busby, B. D., Ward, T. J., Turner, J. R. & Palmer, C. P., 2016. Comparison and Evaluation of Methods to Apportion Ambient PM2.5 to Residential Wood Heating in Fairbanks, AK. *Aerosol and Air Quality Research,* Volume 16, pp. 492-503.

California Air Resources Board, 2015. *Standard operating procedure for the analysis of levoglucosan, mannosan, and galactosan in ambient air using gas chromatography/mass spectrometry (SOP MLD073),* Sacramento: s.n.

Cordell, R., White, I. & Monks, P., 2014. Validation of an assay for the determination of levoglucosan and associated monosaccharide anhydrides for the quantification of wood smoke in atmospheric aerosol.. *Analytical and Bioanalytical Chemistry,* Volume 406, pp. 5283-5292.

Fabbri, D. et al., 2009. Levoglucosan and other cellulose and lignin markers in emissions from burning of Miocene lignites. *Atmospheric Environment,* Volume 43, pp. 2286-2295.

Fine, P. M., Cass, G. R. & Simoneit, B. R. T., 2001. Chemical Characterization of Fine Particle Emissions from Fireplace Combustion of Woods Grown in the Northeastern United States. *Environ. Sci. Technol.,* Volume 35, pp. 2665-2675.

Fine, P. M., Cass, G. R. & Simoneit, B. R. T., 2004. Chemical Characterization of Fine Particle Emissions from the Wood Stove Combustion of Prevalent United States Tree Species. *Environ. Eng. Sci.,* Volume 21, pp. 705-721.

Fine, P. M., Cass, G. R., Simoneit & T., B. R., 2002. Organic compounds in biomass smoke from residential wood combustion: Emissions characterization at a continental scale. *J. Geophys. Res.,* 107(D21), p. 8349.

Hasheminassab, S. et al., 2014. Spatial and temporal variability of sources of ambient fine particulate matter (PM2.5) in California. *Atmospheric Chemistry and Physics,* Volume 14, pp. 12085-12097.

Hennigan, C. J. et al., 2011. Chemical and physical transformations of organic aerosol from the photo-oxidation of open biomass burning emissions in an environmental chamber. *Atmos. Chem. Phys.,* Volume 11, pp. 7669-7686.

Hennigan, C. J. et al., 2010. Levoglucosan stability in biomass burning particles exposed to hydroxyl radicals. *Geophys. Res. Lett.,* Volume 37, p. L09806.

Heo, J. et al., 2013. Source apportionments of PM2.5 organic carbon using molecular marker Positive Matrix Factorization and comparison of results from different receptor models. *Atmos. Environ.,* Volume 73, pp. 51-61.

Hoffmann, D., Tilgner, A., Iinuma, Y. & Herrmann, H., 2010. Atmospheric Stability of Levoglucosan: A Detailed Laboratory and Modeling Study.. *Environ. Sci. Technol.,* Volume 44, pp. 694-699.

Hosseini, S. et al., 2013. Laboratory characterization of PM emissions from combustion of wildland biomass fuels. *J. Geophys. Res.,* Volume 118, pp. 9914-9929.

Kuo, L.-J., Louchouarn, P. & Herbert, B. E., 2011. Influence of combustion conditions on yields of solvent-extractable anhydrosugars and lignin phenols in chars: Implications for characterizations of biomass combustion residues. *Chemosphere,* 85(5), pp. 797-805.

MathWorks, 2020. *Regression Learner.* [Online]
Available at: https://www.mathworks.com/help/stats/regressionlearner-app.html
[Accessed 17 June 2020].

National Centers for Environmental Information, 2020. *North American Mesoscale Forecast System (NAM).* https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/north-american-mesoscale-forecast-system-nam: s.n.

National Oceanic and Atmospheric Administration Office of Satellite and Product Operations, 2020. *Hazard Mapping System Fire and Smoke Product.* [Online]
Available at: https://www.ospo.noaa.gov/Products/land/hms.html
[Accessed 23 June 2020].

NOAA OSEPO, 2020. *Index of /pub/FIRE/HMS/GIS.* [Online]
Available at: https://satepsanone.nesdis.noaa.gov/pub/FIRE/HMS/GIS/
[Accessed 23 June 2020].

Pratap, V. et al., 2019. Investigation of levoglucosan decay in wood smoke smog-chamber experiments: The importance of aerosol loading, temperature, and vapor wall losses in interpreting results. *Atmospheric Environment,* Volume 199, pp. 224-232.

Sang, X. F. et al., 2016. Chemical stability of levoglucosan: An isotopic perspective. *Geophysical Research Letters,* Volume 43, pp. 5419-5424.

Schauer, J. J., Kleeman, M. J., Cass, G. R. & Simoneit, B. R. T., 2001. Measurement of Emissions from Air Pollution Sources. 3. C1-C29 Organic Compounds from Fireplace Combustion of Wood. *Environ. Sci. Technol.,* Volume 35, pp. 1716-1728.

Schauer, J. & Sioutas, C., 2012. *Source apportionment of carbonaceous aerosols using integrated multi-variant and source tracer techniques and a unique molecular marker data set,* Sacramento: s.n.

Shirmohammadi, F. et al., 2016. Fine and Ultrafine Particulate Organic Carbon in the Los Angeles Basin: Trends in Sources and Composition. *Sci. Total Environ.,* Volume 541, pp. 1083-1096.

Simoneit, B. T., 2002. Biomass burning – a review of organic tracers for smoke from incomplete combustion. *Applied Geochemistry,* Volume 17, pp. 129-162.

South Coast Air Quality Management District, 2008. *Final Environmental Assessment: Proposed Rule 445 - Wood Burning Devices.* [Online]
Available at: http://www.aqmd.gov/docs/default-source/ceqa/documents/aqmd-projects/2008/final-environmental-assessment-for-proposed-rule-445.pdf
[Accessed 18 June 2020].

South Coast Air Quality Management District, 2008. *MATES III Appendix VII PM2.5 Source Apportionment for the South Coast Air Basin Using Chemical Mass Balance Receptor Model.* [Online]
Available at: http://www.aqmd.gov/docs/default-source/air-quality/air-toxic-studies/mates-iii/mates-iii-final-report-(september-2008)/appendix-vii-pm2-5-source-apportionment-for-the-south-coast-air-basin-using-chemical-mass-balance-receptor-model.pdf?sfvrsn=10
[Accessed 22 September 2020].

South Coast Air Quality Management District, 2008. *Multiple Air Toxics Exposure Study in the South Coast Air Basin: MATES III.* [Online]
Available at: http://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-iii/mates-iii-final-report
[Accessed 24 November 2020].

South Coast Air Quality Management District, 2013. *Rule 445 – Wood Burning Devices.* [Online]
Available at: http://www.aqmd.gov/docs/default-source/rule-book/rule-iv/rule-445.pdf
[Accessed 19 June 2020].

South Coast Air Quality Management District, 2016. *2016 Air Quality Management Plan Appendix II Current Air Quality.* [Online]
Available at: https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/final-2016-aqmp/appendix-ii.pdf?sfvrsn=4
[Accessed 22 September 2020].

South Coast Air Quality Management District, 2020. *Check Before You Burn - Frequently Asked Questions.* [Online]
Available at: https://www.aqmd.gov/home/programs/community/cbyb---faq
[Accessed 19 June 2020].

Sullivan, A. P. et al., 2008. A method for smoke marker measurements and its potential application for determining the contribution of biomass. *J. Geophys. Res.,* Volume 113, p. D22302.

Villalobos, A. M., Barraza, F., Jorquera, H. & Schauer, J. J., 2017. Wood burning pollution in southern Chile: PM2.5 source apportionment using CMB and molecular markers. *Environmental Pollution,* Volume 225, pp. 514-523.

APPENDIX XIII

MATES V

DRAFT FINAL REPORT

Black Carbon and Elemental Carbon Comparison

Appendix XIII

Black Carbon and Elemental Carbon Comparison

XIII.1 Introduction

During MATES V, continuous black carbon (BC) monitors (i.e. AE33 Aethalometers) and 24-hr integrated speciation samplers (i.e. SASS; used to collect the particle samples that were then analyzed for EC and other major components of $PM_{2.5}$) were operated at all sites. Both samplers were operated in air-conditioned trailers through $PM_{2.5}$ inlets, approximately 10 m above the ground level and subsequently, the quartz-fiber filters were analyzed for organic carbon (OC) and elemental carbon (EC). More information about sampling procedures is available in Appendix VI.

BC concentrations are derived through a light absorption process correlated with the deposited soot particles on the filter while EC represents a thermally refractory portion of the carbon measured based on the preferential oxidation. Although EC and BC are operationally defined based on the measurement method used and are not considered measurements of the same species, they are generally highly correlated (Lack et al., 2014). A few studies have directly compared BC and EC measurements and investigated the relationship between them (Cesari et al., 2018; Jeong et al., 2004; Mousavi et al., 2018; Sharma et al., 2004). Such comparisons usually indicate satisfactory correlation coefficients but various degrees of bias (slope). This is probably related to the choice of the coefficients used to convert absorption measurements to BC estimates or to assumptions inherent in the thermal-optical methods used to measure EC and different instruments used in each study. In this appendix, the results from simultaneous EC and BC measurements are compared with each other and their correlation is investigated.

XIII.2 Results

As shown in Figure XIII-1, a comparison between the 24-hr average BC concentrations and the corresponding EC levels for all MATES V sites shows a good correlation ($r^2 = 0.88$). The plot also shows that there is an intercept of 365 nm/m^3 on the fitted line which shows that when the filter-based EC measurements are zero or near zero, aethalometers are measuring higher BC values. This might be due to the fact that Aethalometers are continuous monitors and have higher sensitivity at low concentrations compared to filter-based EC measurements.

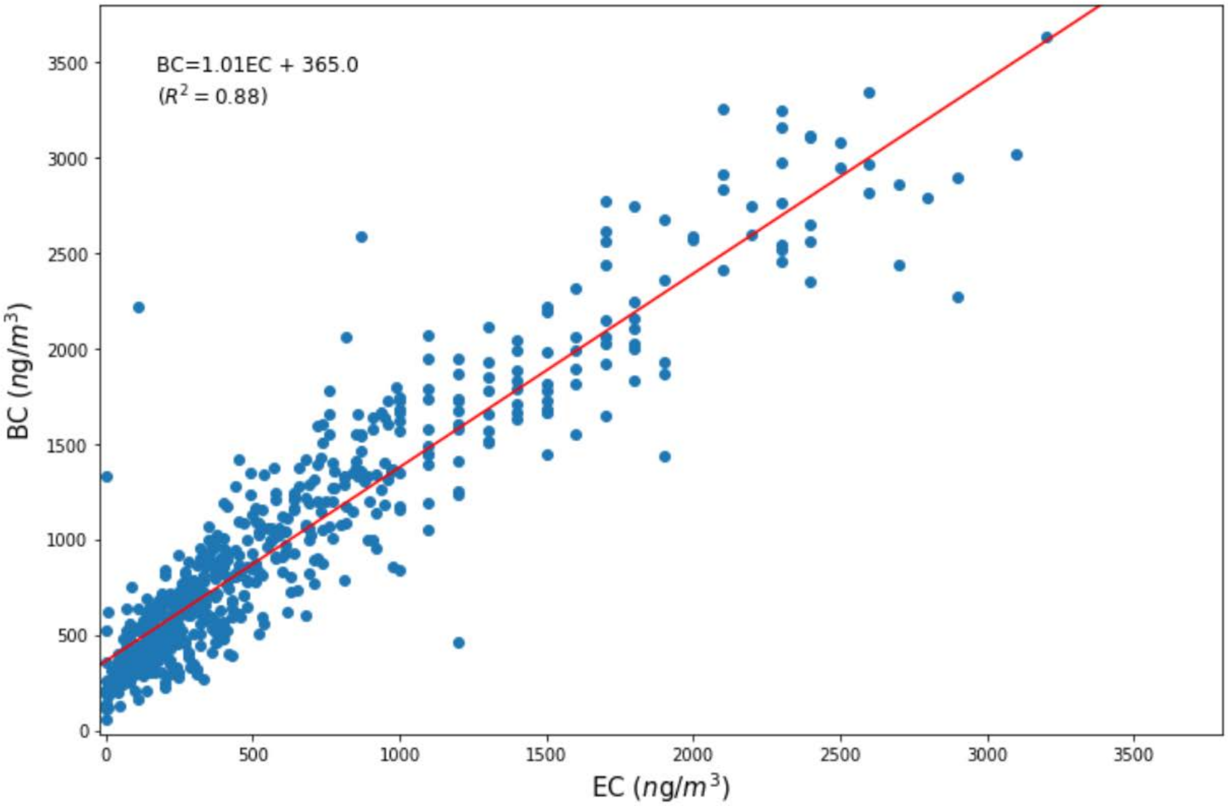


Figure XIII-1. Comparison of daily average BC and EC concentrations, measured at all stations during MATES V

Previous research has indicated that the correlation between EC and BC can be site-specific (Jeong et al., 2004). Figure XIII-2 shows the regression analysis between BC and EC measurements at each site. High correlation coefficients ($0.77 < r^2 < 0.94$) show good agreement between the two measurements at each site. The slope changes from 0.86 to 1.13 while a positive intercept is observed at each site between 231 to 493 ng/m^3. A site-specific correction factor is calculated based on actual measurements to convert the optical BC measurements to thermal-optical EC equivalents. EC is a required PM component in an attainment regional modeling approach in an Air Quality Management Plan/State Implementation Plan. However, EC measurements require a time-consuming and relatively expensive method, whereas BC measurements can be performed relatively cheaply, continuously (i.e. higher time resolution), and with much less required maintenance. Therefore, such conversions are useful information to substitute EC or to use as supporting data to substantiate EC measurements.

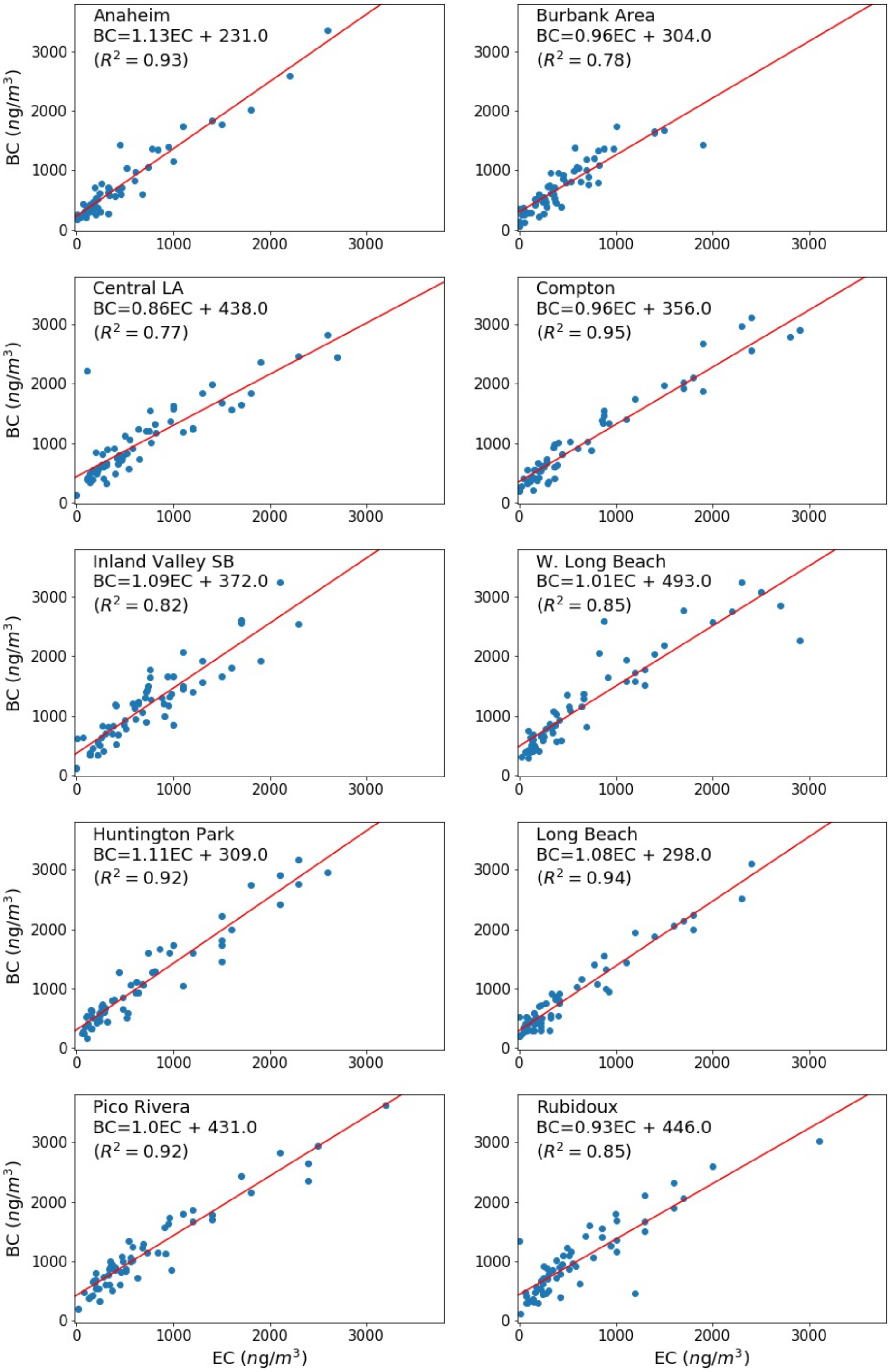


Figure XIII-2. Comparison of daily average BC and EC concentration at each MATES V site

It should be noted that the calculated fitted lines for all stations are close to the overall fitted line shown in figure VI-7 which allows applying a universal correction factor, without causing a significant deviation from unity as is shown in Figure XIII-3.

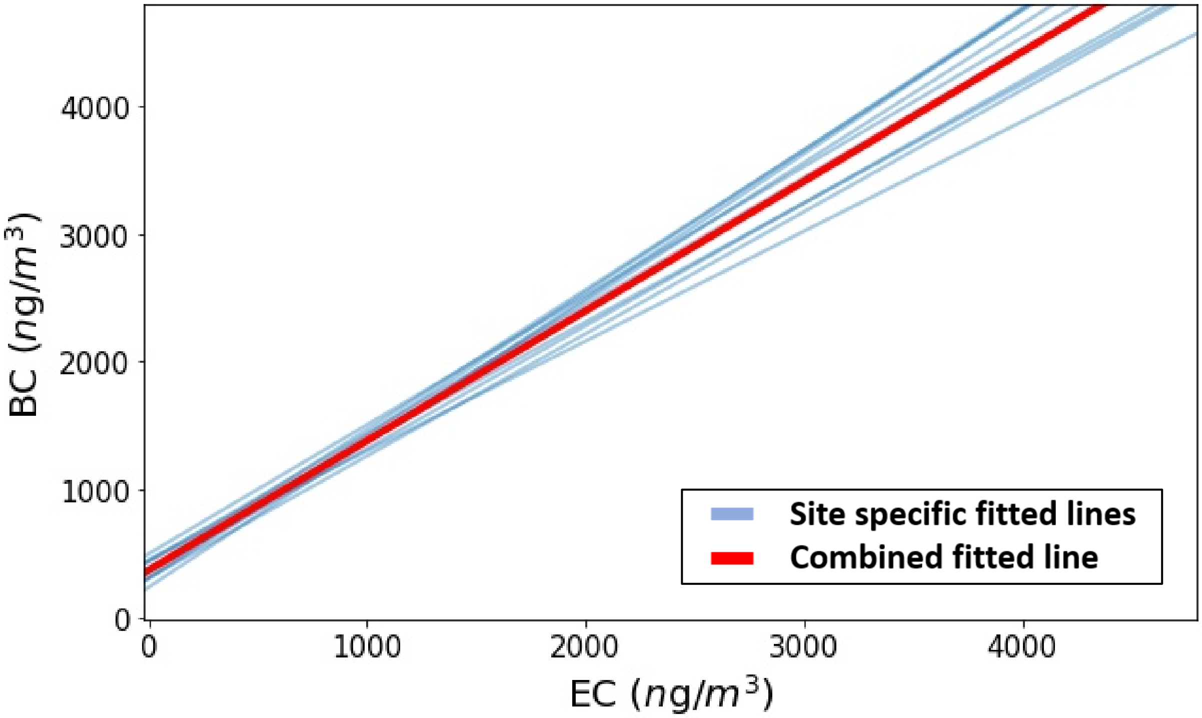


Figure XIII-3. Comparison of fitted lines between site-specific analysis (blue) and all the combined data (red) for MATES V BC and EC data correlations

Generally, particulate BC measured by the Aethalometer is a reliable surrogate for particulate EC measured by subsequent chemical analysis on the filter, especially in cases where the trends and changes of ambient BC concentrations are of interest, or in large air quality monitoring networks. The concurrent measurement of BC and EC with both optical and thermal-optical methods, however, provides additional information for identifying emission sources.

XIII.3 Summary

One of the major areas of interest in air monitoring is to evaluate continuous monitoring technologies in order to reduce the frequency and amount of filter-based technologies that are expensive and time-consuming. Aethalometers offer a tremendous opportunity to move towards more desired continuous, higher time resolution sampling (as short as 1-minute) and supplement or reduce the need for more expensive, time-consuming filter-based sampling. The comparison between filter-based EC and continuous BC concentrations measured by Aethalometer shows good agreement between the two measurements at each site and suggests that continuous BC measurement can be a reliable surrogate for particulate filter-based EC while providing higher temporal resolution and better detection limits at lower concentrations.

XIII.4 References

Cesari, D., Merico, E., Dinoi, A., Marinoni, A., Bonasoni, P., Contini, D., 2018. Seasonal variability of carbonaceous aerosols in an urban background area in Southern Italy. Atmos. Res. 200, 97–108.

Jeong, C.-H., Hopke, P.K., Kim, E., Lee, D.-W., 2004. The comparison between thermal-optical transmittance elemental carbon and Aethalometer black carbon measured at multiple monitoring sites. Atmos. Environ. 38, 5193–5204.

Lack, D.A., Moosmüller, H., McMeeking, G.R., Chakrabarty, R.K., Baumgardner, D., 2014. Characterizing elemental, equivalent black, and refractory black carbon aerosol particles: a review of techniques, their limitations and uncertainties. Anal. Bioanal. Chem. 406, 99–122.

Mousavi, A., Sowlat, M.H., Hasheminassab, S., Polidori, A., Sioutas, C., 2018. Spatio-temporal trends and source apportionment of fossil fuel and biomass burning black carbon (BC) in the Los Angeles Basin. Sci. Total Environ. 640, 1231–1240.

Sharma, S., Lavoué, D., Cachier, H., Barrie, L.A., Gong, S.L., 2004. Long-term trends of the black carbon concentrations in the Canadian Arctic. J. Geophys. Res. Atmos. 109.

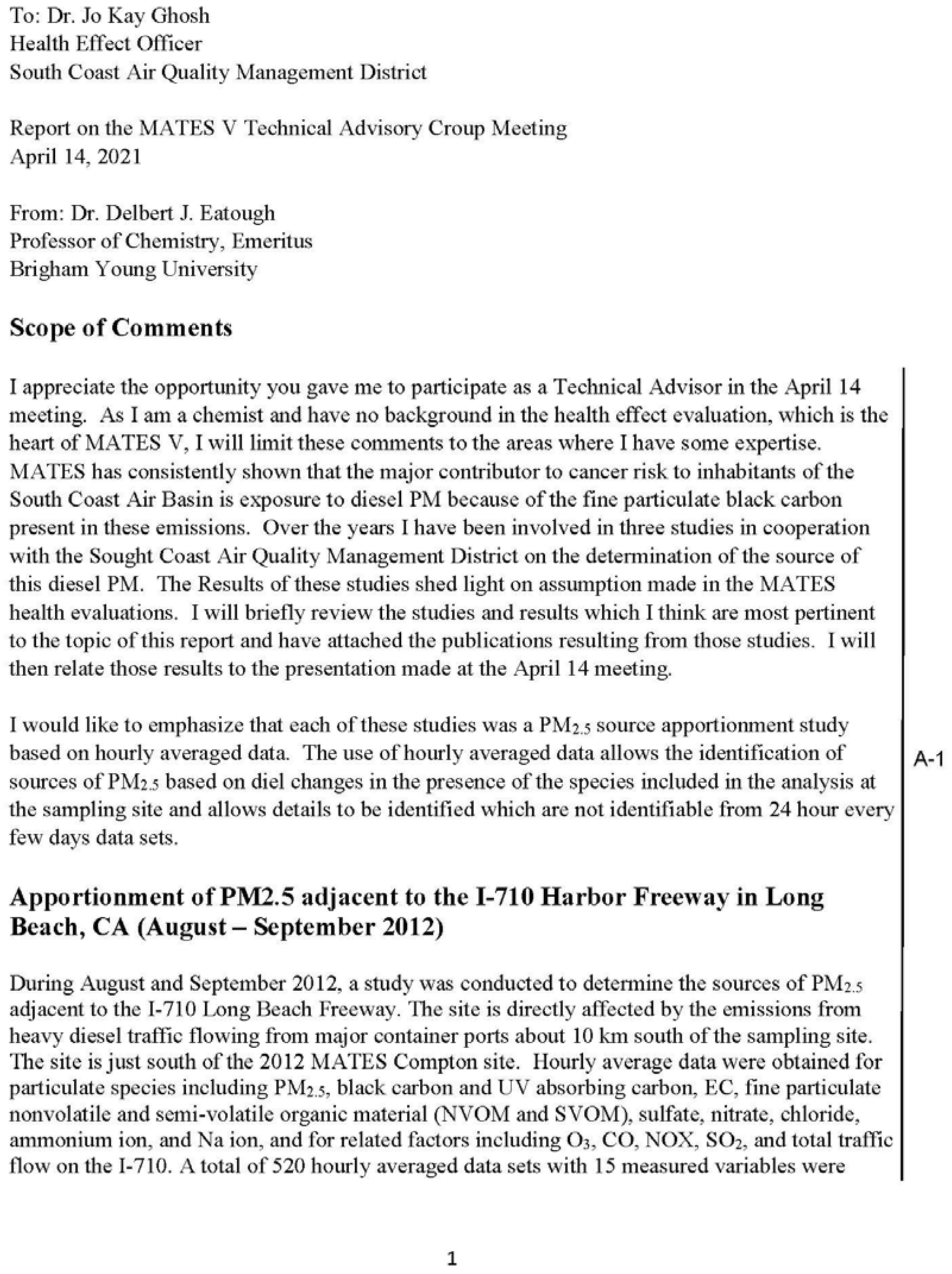
APPENDIX XIV

MATES V

DRAFT FINAL REPORT

Comments Received on MATES V Draft Report

Comment Letter A from Delbert Eatough



To: Dr. Jo Kay Ghosh
Health Effect Officer
South Coast Air Quality Management District

Report on the MATES V Technical Advisory Croup Meeting
April 14, 2021

From: Dr. Delbert J. Eatough
Professor of Chemistry, Emeritus
Brigham Young University

Scope of Comments

I appreciate the opportunity you gave me to participate as a Technical Advisor in the April 14 meeting. As I am a chemist and have no background in the health effect evaluation, which is the heart of MATES V, I will limit these comments to the areas where I have some expertise. MATES has consistently shown that the major contributor to cancer risk to inhabitants of the South Coast Air Basin is exposure to diesel PM because of the fine particulate black carbon present in these emissions. Over the years I have been involved in three studies in cooperation with the Sought Coast Air Quality Management District on the determination of the source of this diesel PM. The Results of these studies shed light on assumption made in the MATES health evaluations. I will briefly review the studies and results which I think are most pertinent to the topic of this report and have attached the publications resulting from those studies. I will then relate those results to the presentation made at the April 14 meeting.

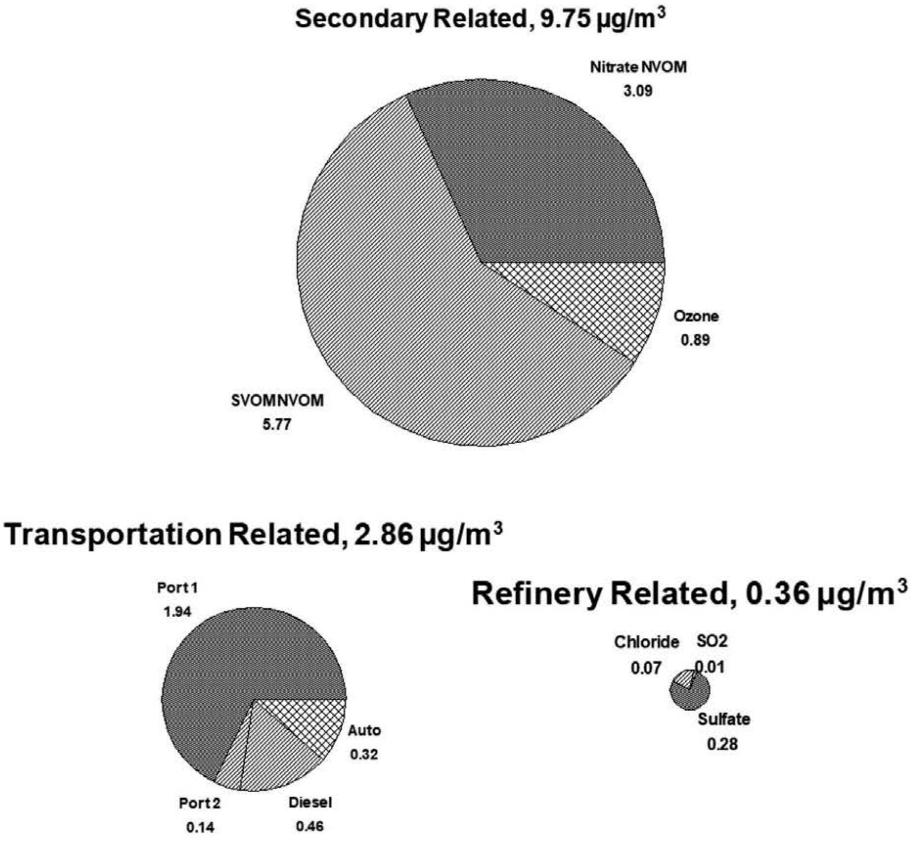
A-1

I would like to emphasize that each of these studies was a $PM_{2.5}$ source apportionment study based on hourly averaged data. The use of hourly averaged data allows the identification of sources of $PM_{2.5}$ based on diel changes in the presence of the species included in the analysis at the sampling site and allows details to be identified which are not identifiable from 24 hour every few days data sets.

Apportionment of PM2.5 adjacent to the I-710 Harbor Freeway in Long Beach, CA (August – September 2012)

During August and September 2012, a study was conducted to determine the sources of $PM_{2.5}$ adjacent to the I-710 Long Beach Freeway. The site is directly affected by the emissions from heavy diesel traffic flowing from major container ports about 10 km south of the sampling site. The site is just south of the 2012 MATES Compton site. Hourly average data were obtained for particulate species including $PM_{2.5}$, black carbon and UV absorbing carbon, EC, fine particulate nonvolatile and semi-volatile organic material (NVOM and SVOM), sulfate, nitrate, chloride, ammonium ion, and Na ion, and for related factors including O_3, CO, NOX, SO_2, and total traffic flow on the I-710. A total of 520 hourly averaged data sets with 15 measured variables were analyzed by EPA-PMF v5.0. The key features of the results are shown in the following Figure from the publication.

Pie charts of the contribution of the three factors contributing to secondary related factors, the four factors contributing to transportation-related factors and the three factors contributing to the refinery-related factors to total PM$_{2.5}$. The area of each graph and pie section are related to the contribution of each to total PM$_{2.5}$.



A-1 cont.

As indicated in the above figure, Secondary Related PM$_{2.5}$ was responsible for 75% of the PM$_{2.5}$ and 3% was from Refinery Related emissions. The later came from upsets at a nearby refinery. The remainder, 22%, was from traffic related emissions.

The major objective of the study was to determine the impact of traffic from the ports at the monitoring site. Factors related to both diesel traffic originating from the ports and diesel traffic from non-port origins were identified. The diesel traffic originating from the ports was responsible for 9% of the total traffic and 95% of the BC measured at the sampling site. The non-port diesel traffic was responsible for 15% of the total traffic and 5% of the BC. While the Port 1 diesel traffic coming from the ports contributed a large fraction of the BC, this source contributed only 2% of the CO and 5% of the NO_X at the sampling site. The Port 2 sources was associated with traffic from the Ports which were high emitters of CO and NO_X. An important point in these results for the MATES program is that essentially all BC measured in the study was associated with diesel traffic emissions.

Source apportionment of 1 h semi-continuous data during the 2005 Study of Organic Aerosols in Riverside (SOAR) using positive matrix factorization (July-August, Riverside)

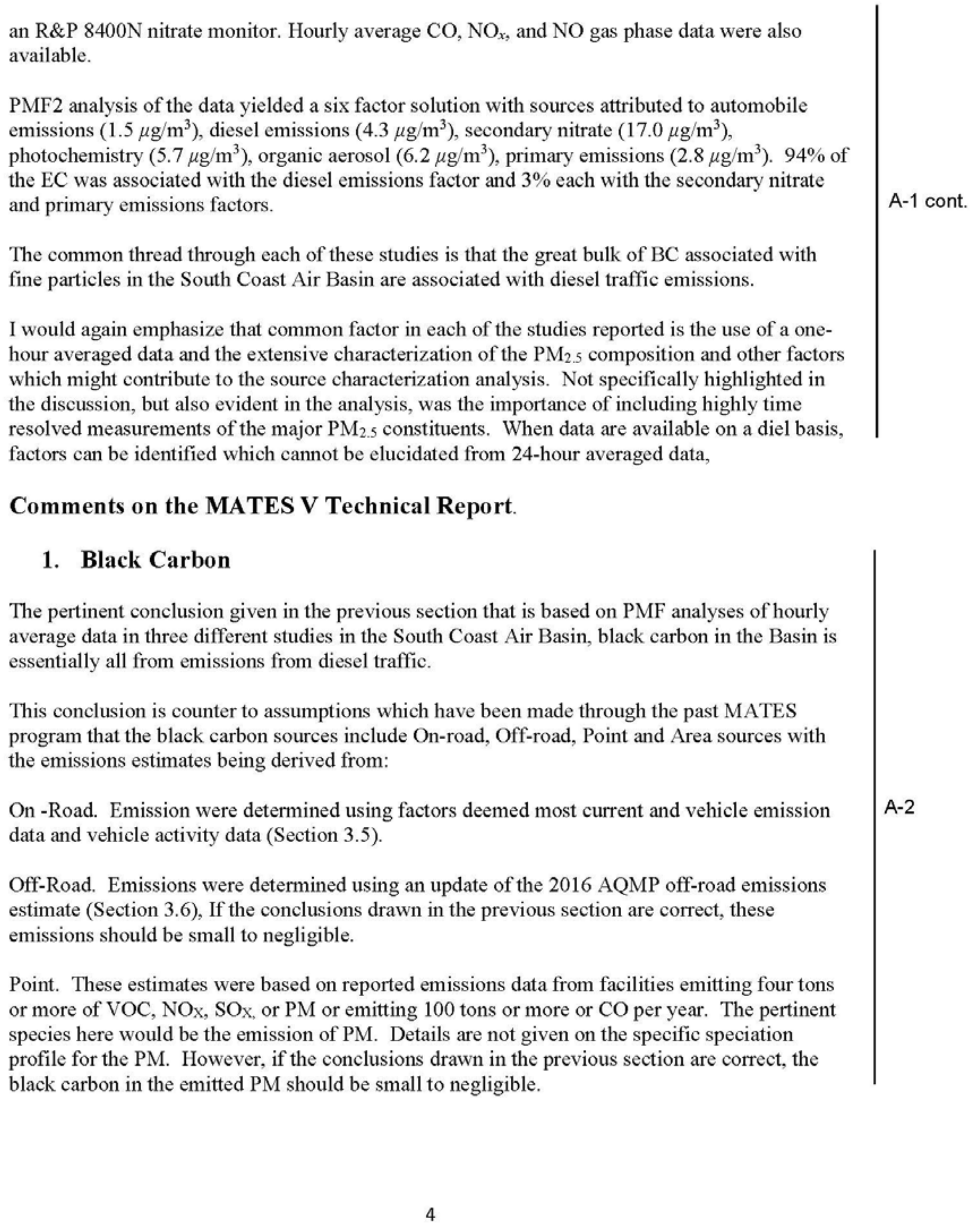
Positive matrix factorization (PMF2) was used to elucidate sources of fine particulate material ($PM_{2.5}$) for a study conducted during July and August 2005, in Riverside, CA. One-hour averaged semi-continuous measurements were made with a suite of instruments to provide $PM_{2.5}$ mass and chemical composition data. Total $PM_{2.5}$ mass concentrations (non-volatile plus semi-volatile) were measured with an R&P filter dynamic measurement system (FDMS TEOM) and a conventional TEOM monitor was used to measure non-volatile mass concentrations. $PM_{2.5}$ chemical species monitors included a dual-oven Sunset monitor to measure both non-volatile and semi-volatile carbonaceous material, an ion chromatographic-based monitor to measure sulfate and nitrate and an Anderson Aethalometer to measure black carbon (BC). Gas phase data including CO, NO_2, NO_x and O_3 were also collected during the sampling period. In addition, single-particle measurements were made using aerosol time-of-flight mass spectrometry (ATOFMS).

A-1 cont.

All the data except for the ATOFMS and ToF-AMS data were used in an initial evaluation of sources at Riverside during the study. PMF2 was able to identify six factors from the data set corresponding to both primary and secondary sources, primarily from automobile emissions (0% if BC), diesel emissions (78% of BC), secondary nitrate formation (7% of BC), a secondary photochemical associated source (0% of BC), organic emissions (7% of BC) and Basin transported pollutants (8% of BC). Again, diesel emission account for the bulk of the BC.

Source Apportionment of One-Hour Semi-Continuous Data Using Positive Matrix Factorization with Total Mass (Nonvolatile plus Semi-Volatile) Measured by the R&P FDMS Monitor (July 2003, Rubidoux)

Semi-continuous monitoring data have been shown to greatly improve the power of receptor models to determine sources because the data include information on diurnal changes in the atmosphere. Such variation assist in the factor analysis identification of sources (or atmospheric processes) which vary diurnally. In this first study by us un the South Coast Air Basin, PMF2 was used to deduce source contributions from a sampling campaign conducted at the SCAQMD station in Rubidoux, CA during July 2003. Semi-continuous measurements (1-h average) were made using an FDMS TEOM (total fine particulate mass), a conventional TEOM (nonvolatile fine particulate mass), an R&P 5400 Carbon monitor (elemental and organic carbon), an Aethalometer (black carbon), and



an R&P 8400N nitrate monitor. Hourly average CO, NO_x, and NO gas phase data were also available.

PMF2 analysis of the data yielded a six factor solution with sources attributed to automobile emissions (1.5 $\mu g/m^3$), diesel emissions (4.3 $\mu g/m^3$), secondary nitrate (17.0 $\mu g/m^3$), photochemistry (5.7 $\mu g/m^3$), organic aerosol (6.2 $\mu g/m^3$), primary emissions (2.8 $\mu g/m^3$). 94% of the EC was associated with the diesel emissions factor and 3% each with the secondary nitrate and primary emissions factors.

A-1 cont.

The common thread through each of these studies is that the great bulk of BC associated with fine particles in the South Coast Air Basin are associated with diesel traffic emissions.

I would again emphasize that common factor in each of the studies reported is the use of a one-hour averaged data and the extensive characterization of the $PM_{2.5}$ composition and other factors which might contribute to the source characterization analysis. Not specifically highlighted in the discussion, but also evident in the analysis, was the importance of including highly time resolved measurements of the major $PM_{2.5}$ constituents. When data are available on a diel basis, factors can be identified which cannot be elucidated from 24-hour averaged data,

Comments on the MATES V Technical Report.

1. Black Carbon

The pertinent conclusion given in the previous section that is based on PMF analyses of hourly average data in three different studies in the South Coast Air Basin, black carbon in the Basin is essentially all from emissions from diesel traffic.

This conclusion is counter to assumptions which have been made through the past MATES program that the black carbon sources include On-road, Off-road, Point and Area sources with the emissions estimates being derived from:

On -Road. Emission were determined using factors deemed most current and vehicle emission data and vehicle activity data (Section 3.5).

A-2

Off-Road. Emissions were determined using an update of the 2016 AQMP off-road emissions estimate (Section 3.6), If the conclusions drawn in the previous section are correct, these emissions should be small to negligible.

Point. These estimates were based on reported emissions data from facilities emitting four tons or more of VOC, NO_X, SO_X, or PM or emitting 100 tons or more or CO per year. The pertinent species here would be the emission of PM. Details are not given on the specific speciation profile for the PM. However, if the conclusions drawn in the previous section are correct, the black carbon in the emitted PM should be small to negligible.

Area. Since the area source estimates are based on the above outline emission types, again the conclusions based on results in the first section would be that are associate black carbon is small to negligible.

The actual distribution for sources of black carbon given in Table 3.4 of the MATES V report is

On-road	Off-road	Point	Area
25%	26%	6%	>1%

A-2 cont.

If the conclusions given in the previous section are correct, then the Off-road contribution to black carbon is way over estimated and assumptions will be made about future controls on potential Off-road sources which are not needed for black carbon control and the effort to improve diesel traffic emission might be somewhat reduced. In this connection, the I710 study outlined in the previous section looked specifically for evidence of black carbon at the sampling site from ships at sea or ships entering the harbor and could not find evidence for these two sources being important in that road-side study.

I suggest that SCAQMD consider modifying the MATES V report to reflect the probable overriding important of black carbon from diesel traffic on the overall cancer health impacts identified in the program.

2. Benzene

I have one observation in connection with possible sources of benzene. We recently conducted a source apportionment study in cooperation with the State of Utah Division of Air Quality on sources of dichloromethane at a sampling site in Bountiful, Utah, just north of several oil refineries. We identified the refineries as the probable primary source of the dichloromethane, with an important parameter in the PMF analysis being BTEX, the combination of benzene, toluene, ethylbenzene, and xylene.

Among chemical industries, petroleum refineries have been identified as large emitters of a wide variety of pollutants. Benzene, toluene, ethylbenzene, and xylene (BTEX) form an important group of aromatic volatile organic compounds (VOCs) emitted from petroleum refineries because of their role in the troposphere chemistry and the risk posed to human health. A-3

It would be expected that refineries in the South Coast Air Basin will emit this group of compounds. Toluene was a second compound in this group routinely measured in MATES. It might be worthwhile to look at the correlation between benzene and toluene to see if they are related at sites closer to refineries, such as the Compton site and to consider adding the other two members of this group to the next MATES effort. This may give clues as to the possible importance of benzene from petroleum refineries.

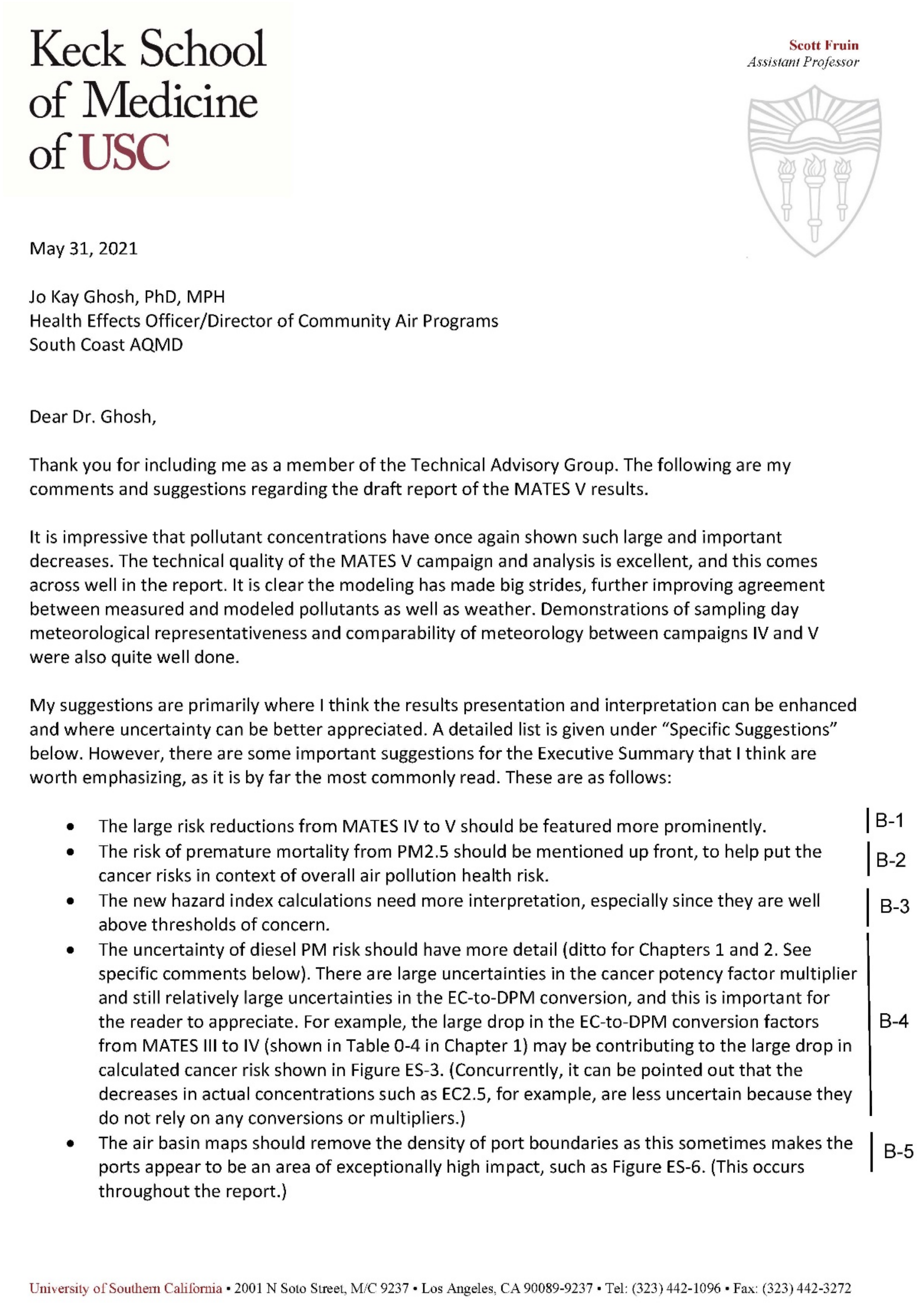
The commenter also submitted the following publications as part of the comment. Since these publications are copyrighted materials, these copyrighted materials are not reprinted here, and instead, we are providing a list of the publications received and links to websites where such materials may be available for viewing and download.

Grover BD and Eatough DJ. (2006). Source Apportionment of One-Hour Semi-Continuous Data Using Positive Matrix Factorization with Total Mass (Nonvolatile plus Semi-Volatile) Measured by the R&P FDMS Monitor. Aerosol Science and Technology, Volume 42, 2008 (1), 28-39. https://www.tandfonline.com/doi/full/10.1080/02786820701787910

Eatough DJ, Grover BD, Woolwind WR, Eatough NL, Long R, Farber R. (2008). Source apportionment of 1 h semi-continuous data during the 2005 Study of Organic Aerosols in Riverside (SOAR) using positive matrix factorization. Atmospheric Environment, Volume 42 (11), 2706-2719. https://www.sciencedirect.com/science/article/abs/pii/S1352231007006516

Eatough DJ, Cropper P, Keeton W, Burrell E, Hansen JC, Farber R. (2020). Apportionment of PM2.5 adjacent to the I-710 Harbor Freeway in Long Beach, CA. Journal of the Air & Waste Management Association, Volume 70, 2020 (3), 260-282. https://www.tandfonline.com/doi/full/10.1080/10962247.2019.1705436

Comment Letter B from Scott Fruin



Keck School
of Medicine
of USC

Scott Fruin
Assistant Professor

May 31, 2021

Jo Kay Ghosh, PhD, MPH
Health Effects Officer/Director of Community Air Programs
South Coast AQMD

Dear Dr. Ghosh,

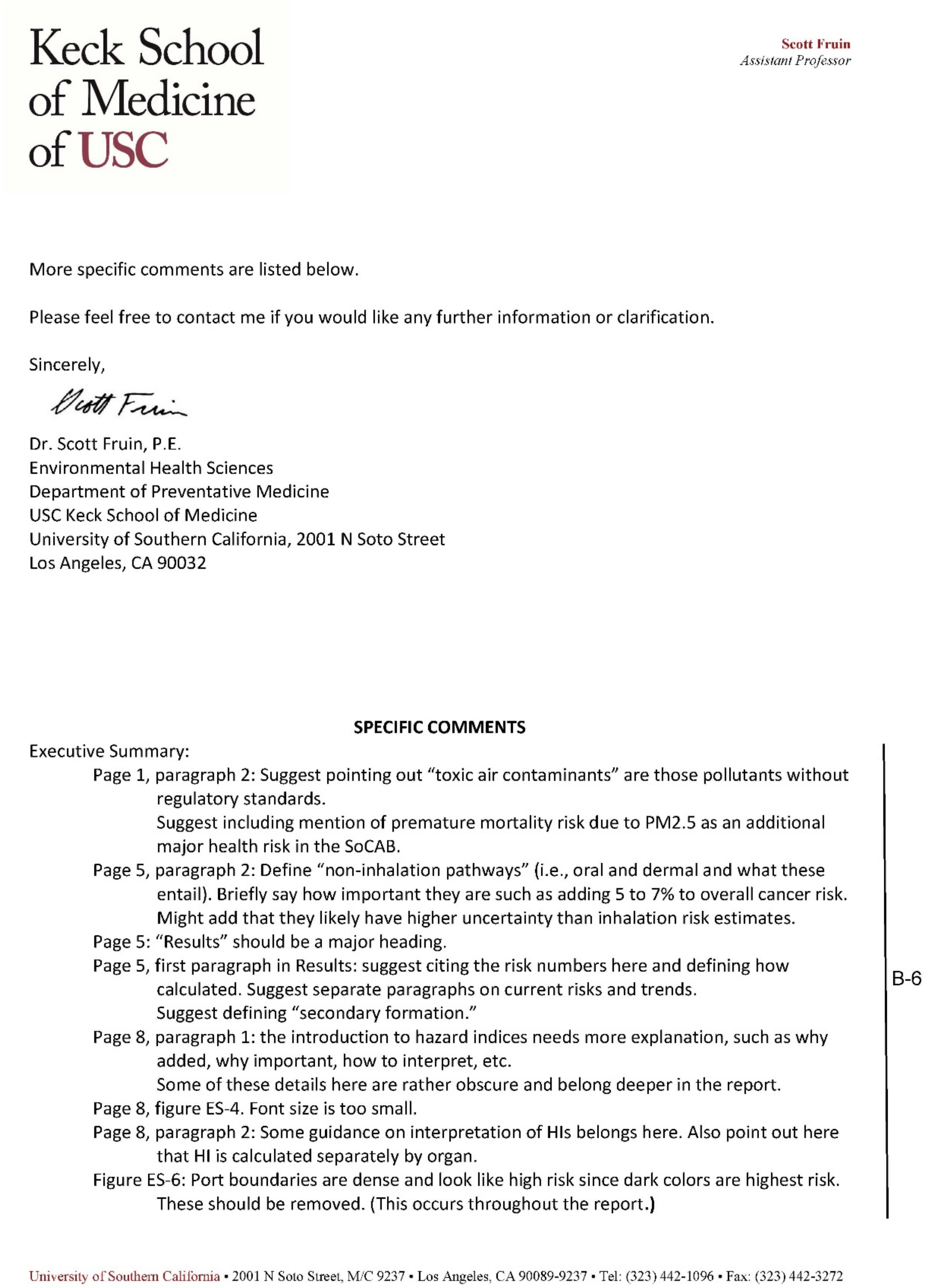
Thank you for including me as a member of the Technical Advisory Group. The following are my comments and suggestions regarding the draft report of the MATES V results.

It is impressive that pollutant concentrations have once again shown such large and important decreases. The technical quality of the MATES V campaign and analysis is excellent, and this comes across well in the report. It is clear the modeling has made big strides, further improving agreement between measured and modeled pollutants as well as weather. Demonstrations of sampling day meteorological representativeness and comparability of meteorology between campaigns IV and V were also quite well done.

My suggestions are primarily where I think the results presentation and interpretation can be enhanced and where uncertainty can be better appreciated. A detailed list is given under "Specific Suggestions" below. However, there are some important suggestions for the Executive Summary that I think are worth emphasizing, as it is by far the most commonly read. These are as follows:

- The large risk reductions from MATES IV to V should be featured more prominently. B-1
- The risk of premature mortality from PM2.5 should be mentioned up front, to help put the cancer risks in context of overall air pollution health risk. B-2
- The new hazard index calculations need more interpretation, especially since they are well above thresholds of concern. B-3
- The uncertainty of diesel PM risk should have more detail (ditto for Chapters 1 and 2. See specific comments below). There are large uncertainties in the cancer potency factor multiplier and still relatively large uncertainties in the EC-to-DPM conversion, and this is important for the reader to appreciate. For example, the large drop in the EC-to-DPM conversion factors from MATES III to IV (shown in Table 0-4 in Chapter 1) may be contributing to the large drop in calculated cancer risk shown in Figure ES-3. (Concurrently, it can be pointed out that the decreases in actual concentrations such as EC2.5, for example, are less uncertain because they do not rely on any conversions or multipliers.) B-4
- The air basin maps should remove the density of port boundaries as this sometimes makes the ports appear to be an area of exceptionally high impact, such as Figure ES-6. (This occurs throughout the report.) B-5

University of Southern California • 2001 N Soto Street, M/C 9237 • Los Angeles, CA 90089-9237 • Tel: (323) 442-1096 • Fax: (323) 442-3272



Keck School
of Medicine
of USC

Scott Fruin
Assistant Professor

More specific comments are listed below.

Please feel free to contact me if you would like any further information or clarification.

Sincerely,

Scott Fruin

Dr. Scott Fruin, P.E.
Environmental Health Sciences
Department of Preventative Medicine
USC Keck School of Medicine
University of Southern California, 2001 N Soto Street
Los Angeles, CA 90032

SPECIFIC COMMENTS

Executive Summary:

Page 1, paragraph 2: Suggest pointing out "toxic air contaminants" are those pollutants without regulatory standards.
Suggest including mention of premature mortality risk due to PM2.5 as an additional major health risk in the SoCAB.

Page 5, paragraph 2: Define "non-inhalation pathways" (i.e., oral and dermal and what these entail). Briefly say how important they are such as adding 5 to 7% to overall cancer risk. Might add that they likely have higher uncertainty than inhalation risk estimates.

Page 5: "Results" should be a major heading.

Page 5, first paragraph in Results: suggest citing the risk numbers here and defining how calculated. Suggest separate paragraphs on current risks and trends.
Suggest defining "secondary formation."

Page 8, paragraph 1: the introduction to hazard indices needs more explanation, such as why added, why important, how to interpret, etc.
Some of these details here are rather obscure and belong deeper in the report.

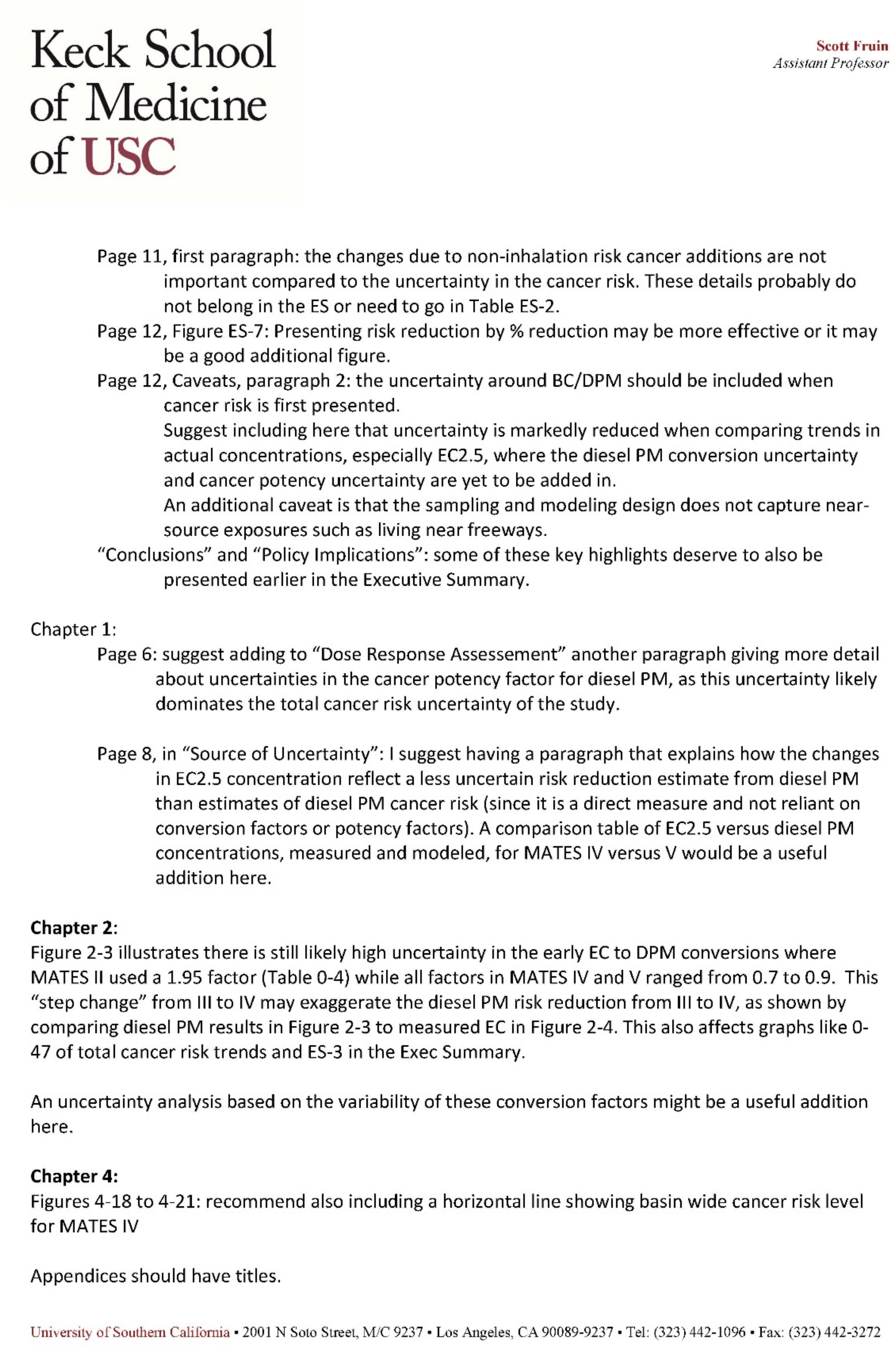
Page 8, figure ES-4. Font size is too small.

Page 8, paragraph 2: Some guidance on interpretation of HIs belongs here. Also point out here that HI is calculated separately by organ.

Figure ES-6: Port boundaries are dense and look like high risk since dark colors are highest risk. These should be removed. (This occurs throughout the report.)

B-6

University of Southern California • 2001 N Soto Street, M/C 9237 • Los Angeles, CA 90089-9237 • Tel: (323) 442-1096 • Fax: (323) 442-3272



Keck School
of Medicine
of USC

Scott Fruin
Assistant Professor

Page 11, first paragraph: the changes due to non-inhalation risk cancer additions are not important compared to the uncertainty in the cancer risk. These details probably do not belong in the ES or need to go in Table ES-2.

Page 12, Figure ES-7: Presenting risk reduction by % reduction may be more effective or it may be a good additional figure.

Page 12, Caveats, paragraph 2: the uncertainty around BC/DPM should be included when cancer risk is first presented.

Suggest including here that uncertainty is markedly reduced when comparing trends in actual concentrations, especially EC2.5, where the diesel PM conversion uncertainty and cancer potency uncertainty are yet to be added in.

An additional caveat is that the sampling and modeling design does not capture near-source exposures such as living near freeways.

“Conclusions” and “Policy Implications”: some of these key highlights deserve to also be presented earlier in the Executive Summary.

B-6 cont.

Chapter 1:

Page 6: suggest adding to “Dose Response Assessement” another paragraph giving more detail about uncertainties in the cancer potency factor for diesel PM, as this uncertainty likely dominates the total cancer risk uncertainty of the study.

Page 8, in “Source of Uncertainty”: I suggest having a paragraph that explains how the changes in EC2.5 concentration reflect a less uncertain risk reduction estimate from diesel PM than estimates of diesel PM cancer risk (since it is a direct measure and not reliant on conversion factors or potency factors). A comparison table of EC2.5 versus diesel PM concentrations, measured and modeled, for MATES IV versus V would be a useful addition here.

B-7

Chapter 2:

Figure 2-3 illustrates there is still likely high uncertainty in the early EC to DPM conversions where MATES II used a 1.95 factor (Table 0-4) while all factors in MATES IV and V ranged from 0.7 to 0.9. This “step change” from III to IV may exaggerate the diesel PM risk reduction from III to IV, as shown by comparing diesel PM results in Figure 2-3 to measured EC in Figure 2-4. This also affects graphs like 0-47 of total cancer risk trends and ES-3 in the Exec Summary.

An uncertainty analysis based on the variability of these conversion factors might be a useful addition here.

B-8

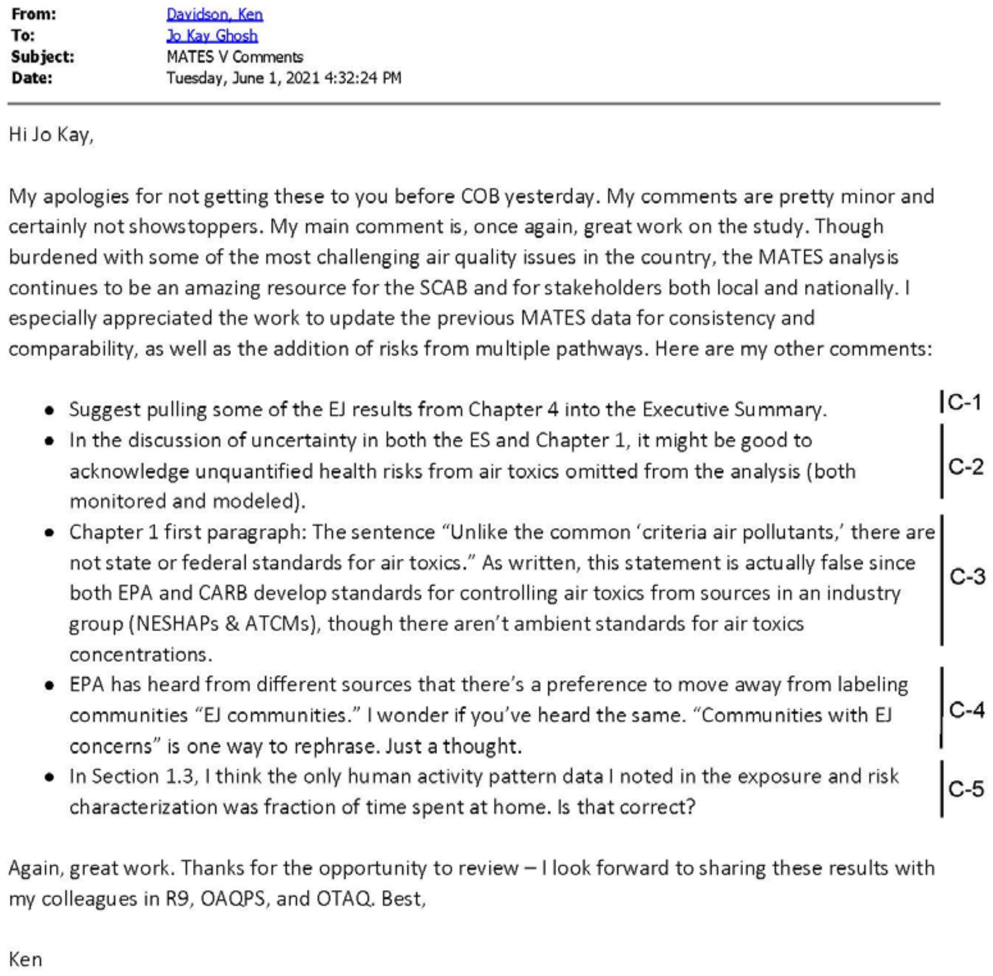
Chapter 4:

Figures 4-18 to 4-21: recommend also including a horizontal line showing basin wide cancer risk level for MATES IV

Appendices should have titles.

B-9

Comment Letter C from Ken Davidson



From: Davidson, Ken
To: Jo Kay Ghosh
Subject: MATES V Comments
Date: Tuesday, June 1, 2021 4:32:24 PM

Hi Jo Kay,

My apologies for not getting these to you before COB yesterday. My comments are pretty minor and certainly not showstoppers. My main comment is, once again, great work on the study. Though burdened with some of the most challenging air quality issues in the country, the MATES analysis continues to be an amazing resource for the SCAB and for stakeholders both local and nationally. I especially appreciated the work to update the previous MATES data for consistency and comparability, as well as the addition of risks from multiple pathways. Here are my other comments:

- Suggest pulling some of the EJ results from Chapter 4 into the Executive Summary. C-1
- In the discussion of uncertainty in both the ES and Chapter 1, it might be good to acknowledge unquantified health risks from air toxics omitted from the analysis (both monitored and modeled). C-2
- Chapter 1 first paragraph: The sentence "Unlike the common 'criteria air pollutants,' there are not state or federal standards for air toxics." As written, this statement is actually false since both EPA and CARB develop standards for controlling air toxics from sources in an industry group (NESHAPs & ATCMs), though there aren't ambient standards for air toxics concentrations. C-3
- EPA has heard from different sources that there's a preference to move away from labeling communities "EJ communities." I wonder if you've heard the same. "Communities with EJ concerns" is one way to rephrase. Just a thought. C-4
- In Section 1.3, I think the only human activity pattern data I noted in the exposure and risk characterization was fraction of time spent at home. Is that correct? C-5

Again, great work. Thanks for the opportunity to review – I look forward to sharing these results with my colleagues in R9, OAQPS, and OTAQ. Best,

Ken

Comment Letter D from John Budroe

John Budroe – Comments on MATES V Report

Content Comments

2.9 Chronic Non-Cancer Risk Estimates
Chronic non-cancer risks are long-term non-cancer health impacts from exposure to toxic air contaminants that have a defined Reference Exposure Levels (REL). A REL is defined as the concentration at which no adverse non-cancer health effects are anticipated for one or more target organ systems (reference: OEHHA Hot Spots, section 8.3). Similar to cancer risks, risks from both inhalation and non-inhalation pathways were calculated and reported for this study.

A cancer inhalation unit risk (IUR) is used to calculate a cancer risk resulting from a specific carcinogen air concentration. In that case, the cancer IUR is calculated from the slope of a non-threshold dose-response for that carcinogen.

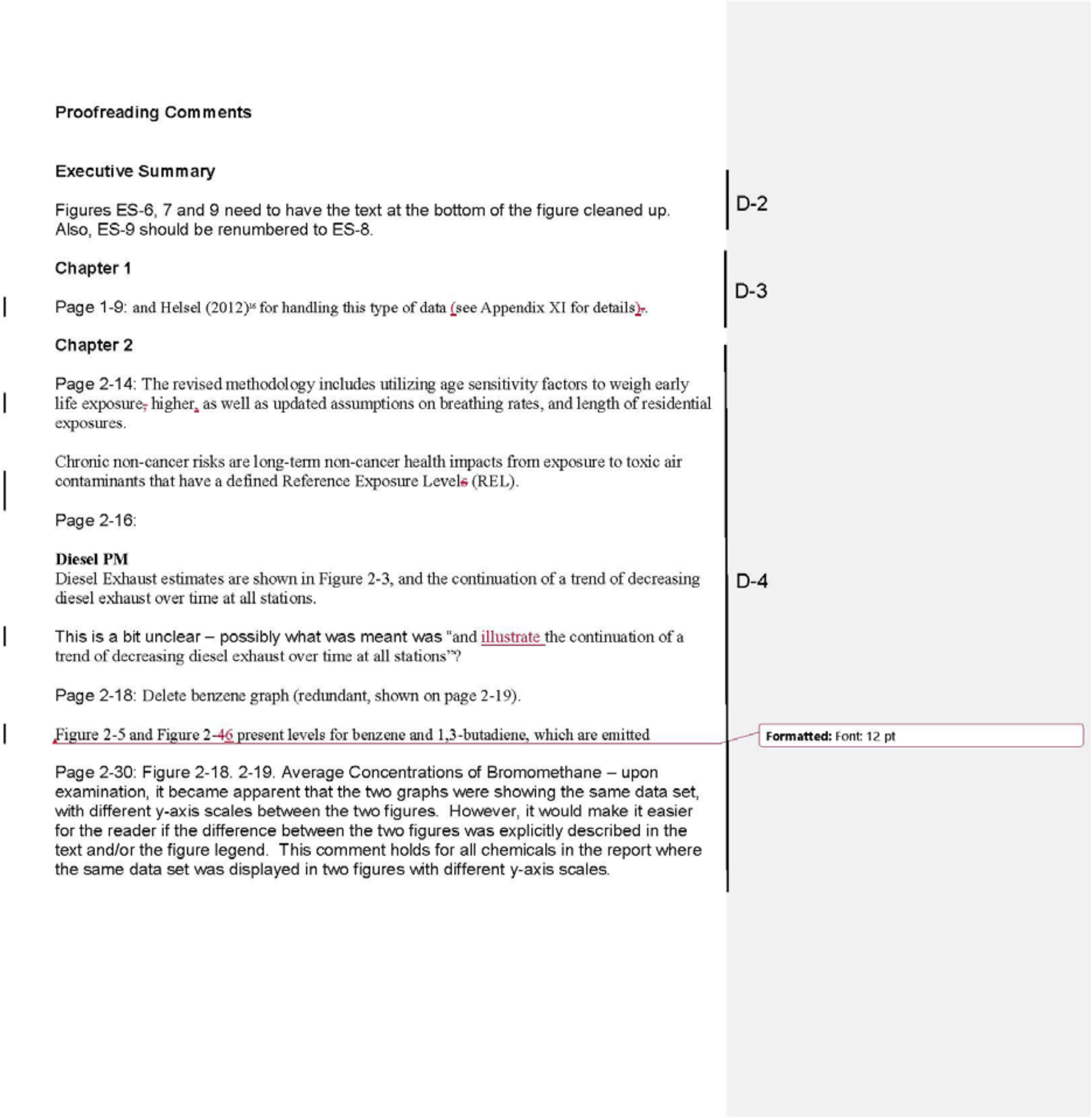
However, a comparison of an air toxic concentration to a chronic REL would generally not be used to derive a probabilistic noncancer risk estimate. Unlike cancer IUR derivations, chronic REL derivation methodology assumes the existence of a threshold for adverse health effects. Additionally, this methodology uses uncertainty factors (UFs) to extrapolate from chemical adverse health effect data to a chronic REL. The magnitude of these UFs differs between chronic RELs. An air toxic concentration that results in a Hazard Quotient (HQ) of two may not produce twice the risk of causing an adverse health effect compared to a concentration resulting in a HQ of one. The likelihood that a concentration of an air toxic will result in an adverse health effect does increase as the HQ increases, but that increase cannot be depended upon to display linearity.

Section 8.3.1 (Calculation of Noncancer Inhalation Hazard Quotient and Hazard Index) of the 2015 Hot Spots Guidance Manual states: "An HQ of 1.0 or less indicates that adverse health effects are not expected to result from exposure to emissions of that substance. As the HQ increases above one, the probability of human health effects increases by an undefined amount. However, it should be noted that a HQ above one is not necessarily indicative of health impacts due to the application of uncertainty factors in deriving the RELs." It should be noted that this section of the Guidance Manual discusses "adverse health effects" and "health impacts", not risks.

It would be more accurate to say that HQs were calculated for air toxics which have existing chronic RELs, and the likelihood of experiencing an adverse health effect increases as the HQ increases.

These comments also generally apply to **Estimates of Chronic Non-Cancer Risk based on Monitoring Data,** starting on page 2-64.

D-1



Proofreading Comments

Executive Summary

Figures ES-6, 7 and 9 need to have the text at the bottom of the figure cleaned up. Also, ES-9 should be renumbered to ES-8.

D-2

Chapter 1

Page 1-9: and Helsel (2012)[16] for handling this type of data (see Appendix XI for details)~~.~~.

D-3

Chapter 2

Page 2-14: 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.

Chronic non-cancer risks are long-term non-cancer health impacts from exposure to toxic air contaminants that have a defined Reference Exposure Level~~s~~ (REL).

Page 2-16:

Diesel PM
Diesel Exhaust estimates are shown in Figure 2-3, and the continuation of a trend of decreasing diesel exhaust over time at all stations.

D-4

This is a bit unclear – possibly what was meant was "and illustrate the continuation of a trend of decreasing diesel exhaust over time at all stations"?

Page 2-18: Delete benzene graph (redundant, shown on page 2-19).

Figure 2-5 and Figure 2-~~4~~6 present levels for benzene and 1,3-butadiene, which are emitted

Formatted: Font: 12 pt

Page 2-30: Figure 2-18. 2-19. Average Concentrations of Bromomethane – upon examination, it became apparent that the two graphs were showing the same data set, with different y-axis scales between the two figures. However, it would make it easier for the reader if the difference between the two figures was explicitly described in the text and/or the figure legend. This comment holds for all chemicals in the report where the same data set was displayed in two figures with different y-axis scales.

Comment Letter E from Janet Whittick

California Council for Environmental and Economic Balance
101 Mission Street, Suite 1440, San Francisco, California 94105
415-512-7890 phone, 415-512-7897 fax, www.cceeb.org

June 7, 2021

Dr. Jo Kay Ghosh
Health Effects Officer and Director of Community Air Programs
South Coast Air Quality Management District
Submitted Electronically to jghosh@aqmd.gov

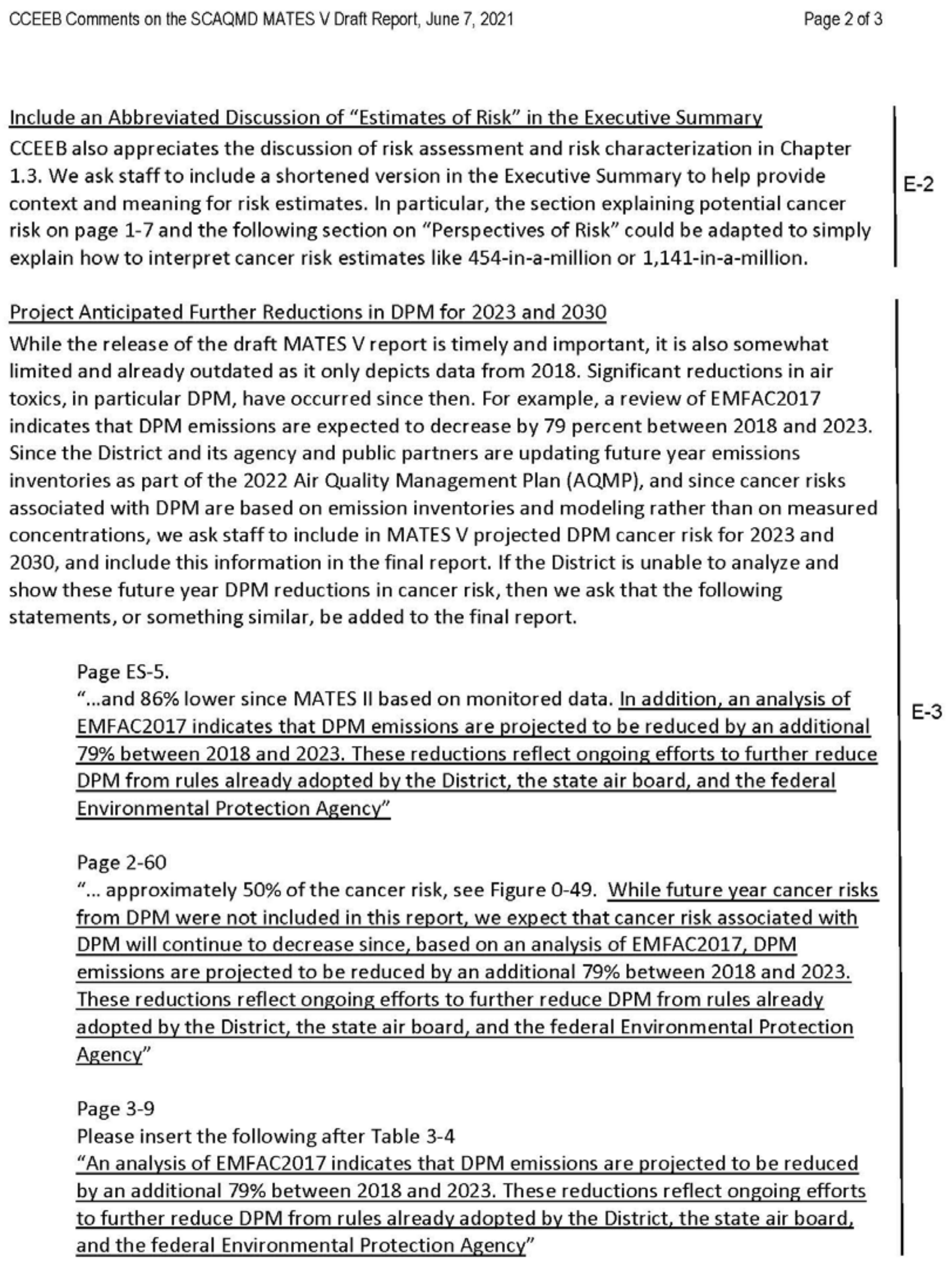
RE: MATES V Draft Report

Dear Dr. Ghosh,

On behalf of the California Council for Environmental and Economic Balance (CCEEB), we appreciate the opportunity to comment on the fifth and most recent iteration of the Multiple Air Toxics Exposure Study (MATES V) and accompanying draft report. CCEEB has been an active stakeholder at the South Coast Air Quality Management District (SCAQMD) for many years, and has seen the progress made by the District and its partners since the first MATES was conducted in 1986. We believe MATES V is a major achievement, both in terms of the technical and scientific rigor of monitoring and modeling by District staff, but also, most importantly, the significant reductions in toxic emissions and exposures that have occurred throughout the air basin. The draft MATES V report shows a 54 percent reduction in cancer risk since MATES IV in 2012, along with decreases in on-road, off-road, and point source carcinogenic emissions of 59 percent, 39 percent, and 49 percent, respectively, over the same time period.

Use MATES V to Help Inform AB 617 and Other Community-based Actions

CCEEB believes MATES V marks an important milestone in the District's clean air and public health history; while a 454-in-a-million cancer risk is still unacceptably high, it is roughly half the risk from MATES IV in 2012, and 82 percent lower than MATES II in 1998. Alongside these critical risk reductions, MATES V shows similar rates of reduction in diesel particulate matter (DPM) emissions. Over the same period and, in part, as a result of outreach and community discussions stemming from MATES, the District's understanding of localized impacts and environmental injustices has grown. CCEEB appreciates the analysis shown in Chapter 4 that quantifies benefits in SB 535 and AB 617 communities, and believes that data and lessons from MATES V can and should augment the District's community-specific investigations and engagement. Particularly for AB 617, understanding the drivers of risk can help communities formulate targeted actions that achieve even greater reductions. MATES V also helps us understand what areas – both in terms of geography and sources – call for more attention, and suggests which programs and policies have contributed most to success. E-1



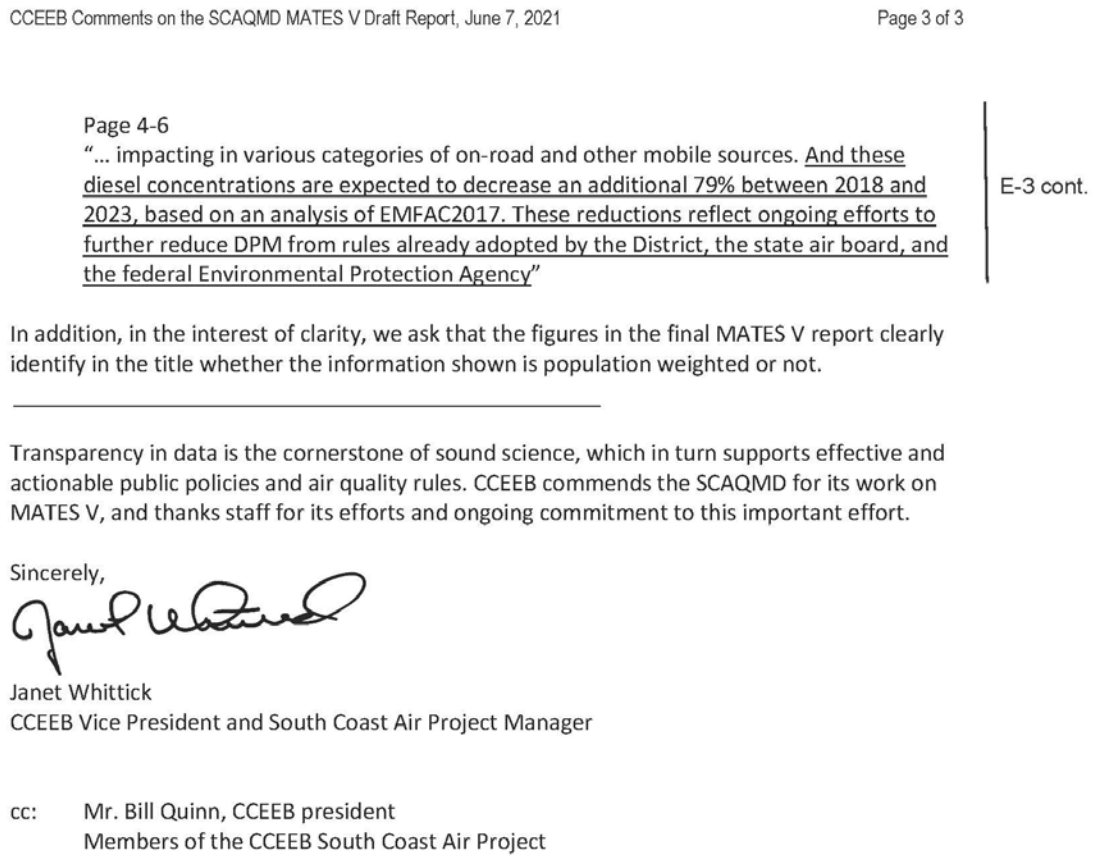
Include an Abbreviated Discussion of "Estimates of Risk" in the Executive Summary

CCEEB also appreciates the discussion of risk assessment and risk characterization in Chapter 1.3. We ask staff to include a shortened version in the Executive Summary to help provide context and meaning for risk estimates. In particular, the section explaining potential cancer risk on page 1-7 and the following section on "Perspectives of Risk" could be adapted to simply explain how to interpret cancer risk estimates like 454-in-a-million or 1,141-in-a-million. E-2

Project Anticipated Further Reductions in DPM for 2023 and 2030

While the release of the draft MATES V report is timely and important, it is also somewhat limited and already outdated as it only depicts data from 2018. Significant reductions in air toxics, in particular DPM, have occurred since then. For example, a review of EMFAC2017 indicates that DPM emissions are expected to decrease by 79 percent between 2018 and 2023. Since the District and its agency and public partners are updating future year emissions inventories as part of the 2022 Air Quality Management Plan (AQMP), and since cancer risks associated with DPM are based on emission inventories and modeling rather than on measured concentrations, we ask staff to include in MATES V projected DPM cancer risk for 2023 and 2030, and include this information in the final report. If the District is unable to analyze and show these future year DPM reductions in cancer risk, then we ask that the following statements, or something similar, be added to the final report.

> Page ES-5.
> "…and 86% lower since MATES II based on monitored data. In addition, an analysis of EMFAC2017 indicates that DPM emissions are projected to be reduced by an additional 79% between 2018 and 2023. These reductions reflect ongoing efforts to further reduce DPM from rules already adopted by the District, the state air board, and the federal Environmental Protection Agency" E-3
>
> Page 2-60
> "… approximately 50% of the cancer risk, see Figure 0-49. While future year cancer risks from DPM were not included in this report, we expect that cancer risk associated with DPM will continue to decrease since, based on an analysis of EMFAC2017, DPM emissions are projected to be reduced by an additional 79% between 2018 and 2023. These reductions reflect ongoing efforts to further reduce DPM from rules already adopted by the District, the state air board, and the federal Environmental Protection Agency"
>
> Page 3-9
> Please insert the following after Table 3-4
> "An analysis of EMFAC2017 indicates that DPM emissions are projected to be reduced by an additional 79% between 2018 and 2023. These reductions reflect ongoing efforts to further reduce DPM from rules already adopted by the District, the state air board, and the federal Environmental Protection Agency"



> Page 4-6
> "… impacting in various categories of on-road and other mobile sources. And these diesel concentrations are expected to decrease an additional 79% between 2018 and 2023, based on an analysis of EMFAC2017. These reductions reflect ongoing efforts to further reduce DPM from rules already adopted by the District, the state air board, and the federal Environmental Protection Agency"

E-3 cont.

In addition, in the interest of clarity, we ask that the figures in the final MATES V report clearly identify in the title whether the information shown is population weighted or not.

Transparency in data is the cornerstone of sound science, which in turn supports effective and actionable public policies and air quality rules. CCEEB commends the SCAQMD for its work on MATES V, and thanks staff for its efforts and ongoing commitment to this important effort.

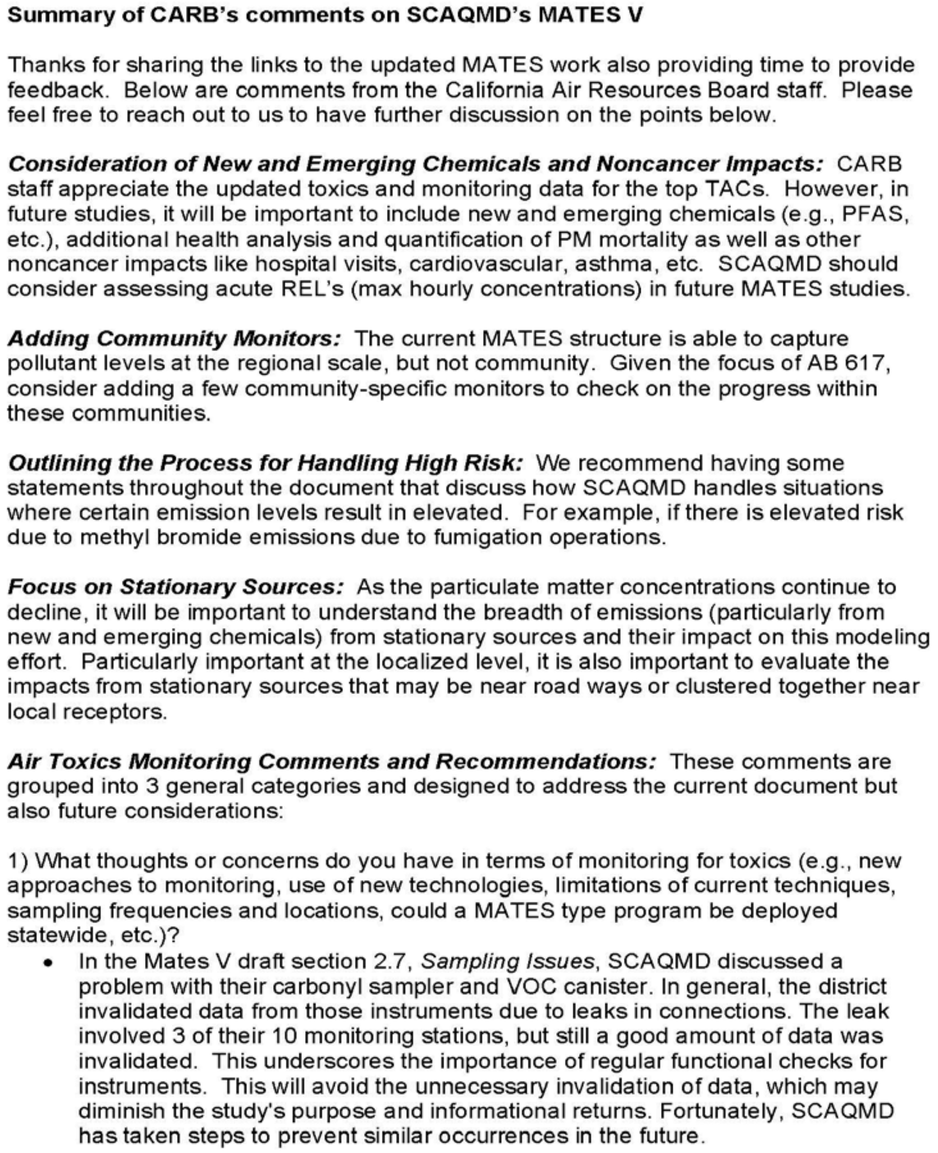
Sincerely,

Janet Whittick
CCEEB Vice President and South Coast Air Project Manager

cc: Mr. Bill Quinn, CCEEB president
Members of the CCEEB South Coast Air Project

Additional Comment Letters Received After the Comment Deadline

Comment Letter from Michael Benjamin



Summary of CARB's comments on SCAQMD's MATES V

Thanks for sharing the links to the updated MATES work also providing time to provide feedback. Below are comments from the California Air Resources Board staff. Please feel free to reach out to us to have further discussion on the points below.

Consideration of New and Emerging Chemicals and Noncancer Impacts: CARB staff appreciate the updated toxics and monitoring data for the top TACs. However, in future studies, it will be important to include new and emerging chemicals (e.g., PFAS, etc.), additional health analysis and quantification of PM mortality as well as other noncancer impacts like hospital visits, cardiovascular, asthma, etc. SCAQMD should consider assessing acute REL's (max hourly concentrations) in future MATES studies.

Adding Community Monitors: The current MATES structure is able to capture pollutant levels at the regional scale, but not community. Given the focus of AB 617, consider adding a few community-specific monitors to check on the progress within these communities.

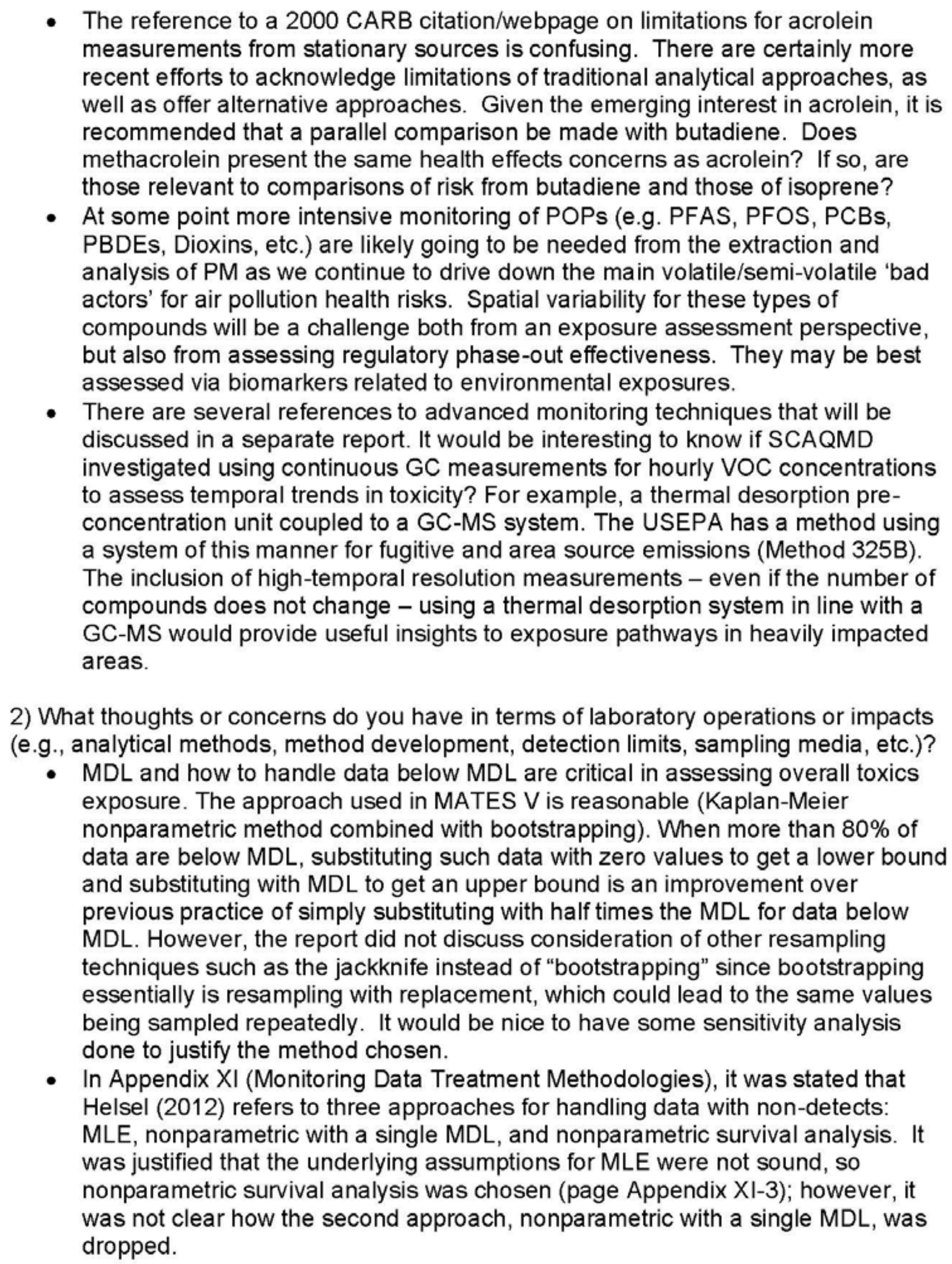
Outlining the Process for Handling High Risk: We recommend having some statements throughout the document that discuss how SCAQMD handles situations where certain emission levels result in elevated. For example, if there is elevated risk due to methyl bromide emissions due to fumigation operations.

Focus on Stationary Sources: As the particulate matter concentrations continue to decline, it will be important to understand the breadth of emissions (particularly from new and emerging chemicals) from stationary sources and their impact on this modeling effort. Particularly important at the localized level, it is also important to evaluate the impacts from stationary sources that may be near road ways or clustered together near local receptors.

Air Toxics Monitoring Comments and Recommendations: These comments are grouped into 3 general categories and designed to address the current document but also future considerations:

1) What thoughts or concerns do you have in terms of monitoring for toxics (e.g., new approaches to monitoring, use of new technologies, limitations of current techniques, sampling frequencies and locations, could a MATES type program be deployed statewide, etc.)?

- In the Mates V draft section 2.7, *Sampling Issues*, SCAQMD discussed a problem with their carbonyl sampler and VOC canister. In general, the district invalidated data from those instruments due to leaks in connections. The leak involved 3 of their 10 monitoring stations, but still a good amount of data was invalidated. This underscores the importance of regular functional checks for instruments. This will avoid the unnecessary invalidation of data, which may diminish the study's purpose and informational returns. Fortunately, SCAQMD has taken steps to prevent similar occurrences in the future.



- The reference to a 2000 CARB citation/webpage on limitations for acrolein measurements from stationary sources is confusing. There are certainly more recent efforts to acknowledge limitations of traditional analytical approaches, as well as offer alternative approaches. Given the emerging interest in acrolein, it is recommended that a parallel comparison be made with butadiene. Does methacrolein present the same health effects concerns as acrolein? If so, are those relevant to comparisons of risk from butadiene and those of isoprene?
- At some point more intensive monitoring of POPs (e.g. PFAS, PFOS, PCBs, PBDEs, Dioxins, etc.) are likely going to be needed from the extraction and analysis of PM as we continue to drive down the main volatile/semi-volatile 'bad actors' for air pollution health risks. Spatial variability for these types of compounds will be a challenge both from an exposure assessment perspective, but also from assessing regulatory phase-out effectiveness. They may be best assessed via biomarkers related to environmental exposures.
- There are several references to advanced monitoring techniques that will be discussed in a separate report. It would be interesting to know if SCAQMD investigated using continuous GC measurements for hourly VOC concentrations to assess temporal trends in toxicity? For example, a thermal desorption pre-concentration unit coupled to a GC-MS system. The USEPA has a method using a system of this manner for fugitive and area source emissions (Method 325B). The inclusion of high-temporal resolution measurements – even if the number of compounds does not change – using a thermal desorption system in line with a GC-MS would provide useful insights to exposure pathways in heavily impacted areas.

2) What thoughts or concerns do you have in terms of laboratory operations or impacts (e.g., analytical methods, method development, detection limits, sampling media, etc.)?

- MDL and how to handle data below MDL are critical in assessing overall toxics exposure. The approach used in MATES V is reasonable (Kaplan-Meier nonparametric method combined with bootstrapping). When more than 80% of data are below MDL, substituting such data with zero values to get a lower bound and substituting with MDL to get an upper bound is an improvement over previous practice of simply substituting with half times the MDL for data below MDL. However, the report did not discuss consideration of other resampling techniques such as the jackknife instead of "bootstrapping" since bootstrapping essentially is resampling with replacement, which could lead to the same values being sampled repeatedly. It would be nice to have some sensitivity analysis done to justify the method chosen.
- In Appendix XI (Monitoring Data Treatment Methodologies), it was stated that Helsel (2012) refers to three approaches for handling data with non-detects: MLE, nonparametric with a single MDL, and nonparametric survival analysis. It was justified that the underlying assumptions for MLE were not sound, so nonparametric survival analysis was chosen (page Appendix XI-3); however, it was not clear how the second approach, nonparametric with a single MDL, was dropped.

- Data completeness requirements are said to be included in the monitoring QAPPs. For greater transparency, we would suggest showing the total number of samples and overall data completeness for each of the species and methods sampled as a supporting figure. This would apply both to South Coast in this report as well as any future toxics based report CARB may lead.
- There is a definite emerging need for more reliable methods to accurately quantify acrolein. A sensitive real-time method overcomes many of the existing limitations, but it comes with a hefty price or more intensive sampling/analytical approaches.
- Need to better quantify the uncertainties associated with different methods used to estimate diesel PM. Are we biasing the current surrogate methodologies based on correlations to attributes relevant to on-road emissions, if off-road emissions are substantially different from the on-road profiles and the regulatory cycles grow farther apart?

3) What thoughts or concerns do you have in terms of data management/validation (e.g., quality assurance/quality control, data storage, data messaging)?

- One suggestion is to include the process on how data was collected from instruments (i.e., a data logger, commercial software application, manually, etc., and how they stored it for later analysis (in-house database, commercial vendor, spread sheets, etc.)). Setting up instruments in a station is one hurdle and collecting the data from instruments is another. For instance, getting instrument data to a network or connecting an air monitoring station to the internet "in the middle of nowhere" is not a trivial task.
- In Chapter 2 regarding manifold leakage issue, which was also mentioned above, it is not clear how the data before 5/1/2018 was verified. If a leak check was performed that day, it should be stated in the document. It would also be helpful to mention what might cause the leakage at three locations at the same time (i.e., operation error, calibration, etc.).

Acetaldehyde and Formaldehyde: The increase of formaldehyde and acetaldehyde is interesting (CARB's iADAM statewide data also shows an increase in the formaldehyde concentration). Emissions from combustion sources are clearly decreasing as evident from the decrease in aromatics and PAHs emissions. Are there any indications from ambient data that secondary formation is somehow enhanced over the last few years (i.e., photochemical reaction pathways have shifted to form more aldehydes due to the reduction of NOx in air, or climate change has contributed to enhanced photochemistry due to high average temp)? It would be beneficial to state in Chapter 2 (2-22) whether there is any seasonal difference in the rate of increase (summer vs. winter) or if there is any spatial difference. Has the use of any consumer products that release aldehydes increased over the last several years?

Black Carbon, Elemental Carbon, Diesel PM:

Diesel exhaust vs Diesel PM: Throughout the document there are numerous references to diesel exhaust (Table 0-4 in Chapter 2) and diesel PM (Figures 0-44-0-47, Chapter 2), are these two considered to be the same? For example, does the diesel exhaust include gaseous or semi-volatile species as well as PM? If so, how were these chemicals separated in the health risk or monitoring?

Black Carbon vs Elemental Carbon: EC and BC is measured at all of the 10 fixed sites as part of MATES V monitoring. EC is stated to be used in the diesel exhaust/PM calculation, but there is not a discussion of the relationship between EC and BC at the same stationary site. A comparison between the two measurement techniques at the same site may provide insight into using BC measurements, rather than EC, in future toxics analysis.

Elemental Carbon to Diesel PM Ratio, Chapter 2, page 2- 9: The method in which the modeled EC:DieselPM is unclear. How is the modeled EC:DieselPM calculated at each site? Specifically, the methods to calculate the individual modeled EC and modeled diesel PM values to calculate the ratios in Table 0-4.

Edits and Clarifications: Below are minor edits and clarifications needed to improve the clarity of the document:

Overall:
in the text discussion, Roman numerals are used to differentiate MATES I, II, III, IV and V; however, in graphics, the numbers 1, 2, 3, 4, and 5 are used. There should be some consistency with the use of numerals or a statement correlating the uses. Also, page 2-13, Table 0-4 should be corrected to be 2-4; page 2-48 and subsequent pages, Figures 0-36 through 0-55 should be corrected to be Figures 2-36 through 2-55.

Executive Summary
Page ES-3: “cancer risks in *tall* these...”: Typo, should read “all”

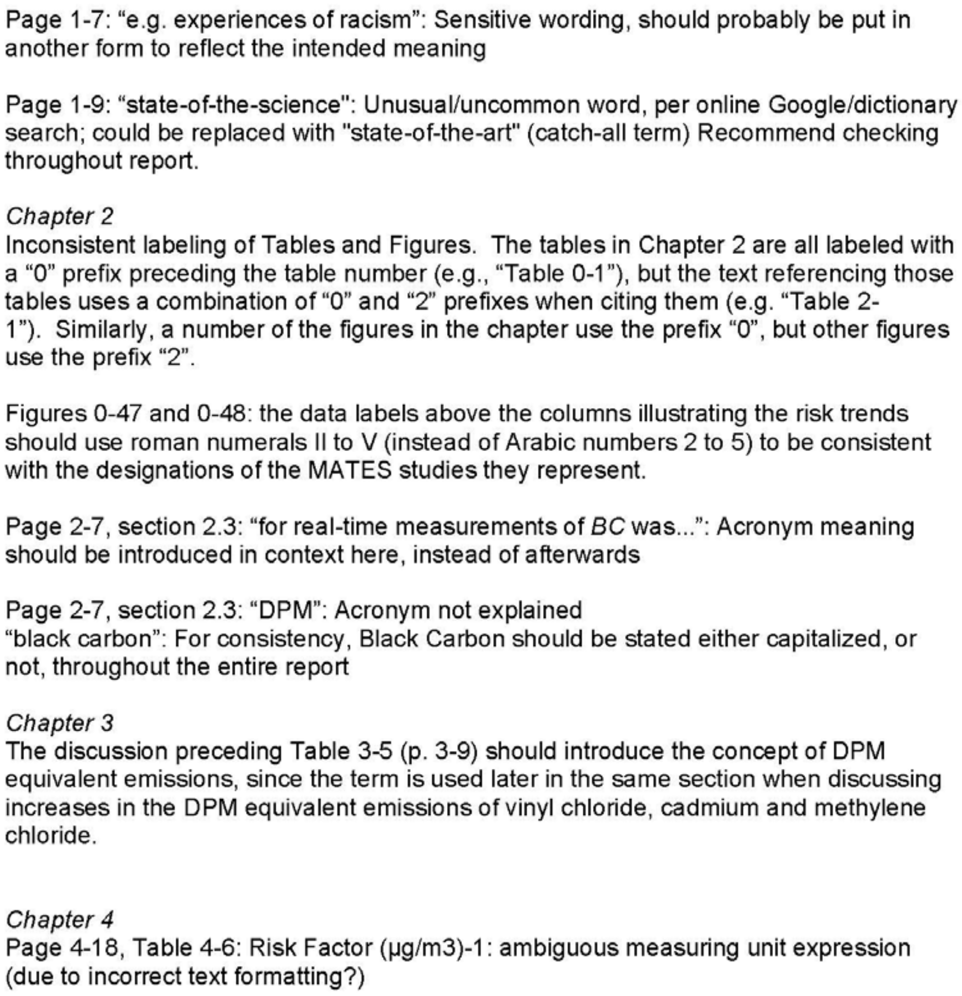
Page ES-5: “CEQA”: Acronym introduced without description

Page ES-6: Figure ES-2: Odd pie-chart drawing I was unable to understand

For clarity, the data labels above the columns illustrating the risk trends in Figures ES-3 and ES-5 should use Roman numerals II to V (instead of Arabic numbers 2 to 5) to be consistent with the designations of the MATES studies they represent.

The discussion preceding Table ES-2 cites numbers that are slightly inconsistent with those presented in the table. Specifically, the discussion cites a 51% reduction in population weighted risk in the basin and 33% reduction in the Coachella Valley, but the table shows reductions of 54% and 30% (respectively) for multi-pathway exposure assessments, and 53% and 30% (respectively) for inhalation pathway only.

Chapter 1
Page 1-7: “Risk Management Policy (RMP) *Using* the Derived...”: typo, should be “using”



Page 1-7: “e.g. experiences of racism”: Sensitive wording, should probably be put in another form to reflect the intended meaning

Page 1-9: “state-of-the-science": Unusual/uncommon word, per online Google/dictionary search; could be replaced with "state-of-the-art" (catch-all term) Recommend checking throughout report.

Chapter 2

Inconsistent labeling of Tables and Figures. The tables in Chapter 2 are all labeled with a “0” prefix preceding the table number (e.g., “Table 0-1”), but the text referencing those tables uses a combination of “0” and “2” prefixes when citing them (e.g. “Table 2-1”). Similarly, a number of the figures in the chapter use the prefix “0”, but other figures use the prefix “2”.

Figures 0-47 and 0-48: the data labels above the columns illustrating the risk trends should use roman numerals II to V (instead of Arabic numbers 2 to 5) to be consistent with the designations of the MATES studies they represent.

Page 2-7, section 2.3: “for real-time measurements of *BC* was...”: Acronym meaning should be introduced in context here, instead of afterwards

Page 2-7, section 2.3: “DPM”: Acronym not explained
“black carbon”: For consistency, Black Carbon should be stated either capitalized, or not, throughout the entire report

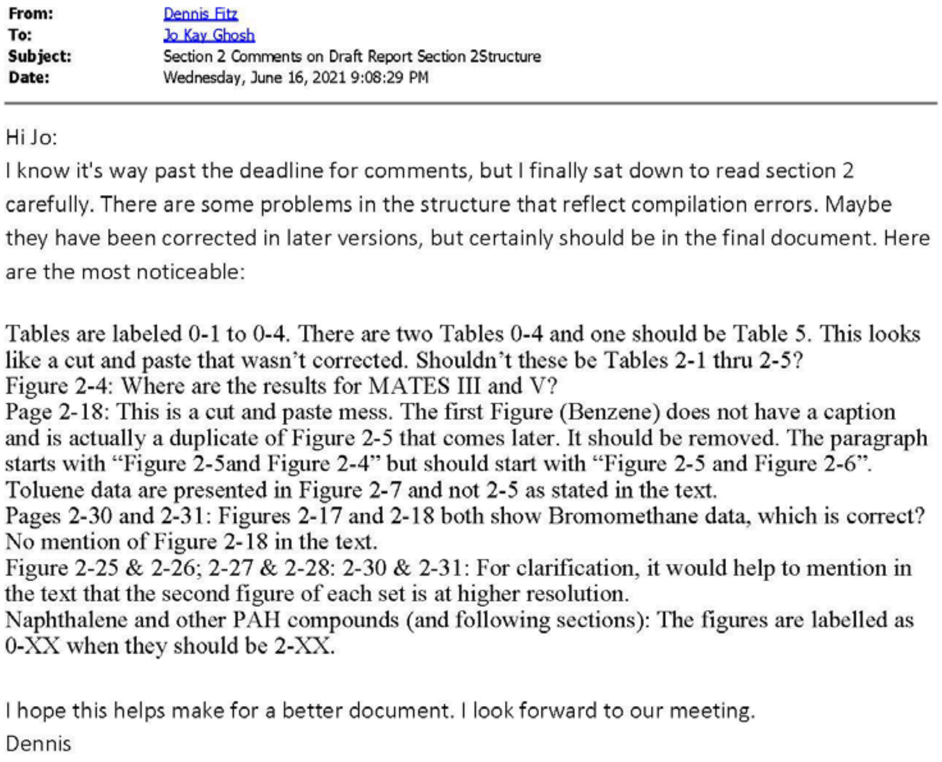
Chapter 3

The discussion preceding Table 3-5 (p. 3-9) should introduce the concept of DPM equivalent emissions, since the term is used later in the same section when discussing increases in the DPM equivalent emissions of vinyl chloride, cadmium and methylene chloride.

Chapter 4

Page 4-18, Table 4-6: Risk Factor (µg/m3)-1: ambiguous measuring unit expression (due to incorrect text formatting?)

Comment Letter from Dennis Fitz



From: Dennis Fitz
To: Jo Kay Ghosh
Subject: Section 2 Comments on Draft Report Section 2Structure
Date: Wednesday, June 16, 2021 9:08:29 PM

Hi Jo:

I know it's way past the deadline for comments, but I finally sat down to read section 2 carefully. There are some problems in the structure that reflect compilation errors. Maybe they have been corrected in later versions, but certainly should be in the final document. Here are the most noticeable:

Tables are labeled 0-1 to 0-4. There are two Tables 0-4 and one should be Table 5. This looks like a cut and paste that wasn't corrected. Shouldn't these be Tables 2-1 thru 2-5?
Figure 2-4: Where are the results for MATES III and V?
Page 2-18: This is a cut and paste mess. The first Figure (Benzene) does not have a caption and is actually a duplicate of Figure 2-5 that comes later. It should be removed. The paragraph starts with "Figure 2-5and Figure 2-4" but should start with "Figure 2-5 and Figure 2-6".
Toluene data are presented in Figure 2-7 and not 2-5 as stated in the text.
Pages 2-30 and 2-31: Figures 2-17 and 2-18 both show Bromomethane data, which is correct? No mention of Figure 2-18 in the text.
Figure 2-25 & 2-26; 2-27 & 2-28: 2-30 & 2-31: For clarification, it would help to mention in the text that the second figure of each set is at higher resolution.
Naphthalene and other PAH compounds (and following sections): The figures are labelled as 0-XX when they should be 2-XX.

I hope this helps make for a better document. I look forward to our meeting.
Dennis

APPENDIX XV

MATES V

DRAFT FINAL REPORT

Response to Comments on MATES V Draft Report

Appendix XV

Response to Comments on MATES V Draft Report

Responses to Comment Letter A from Delbert Eatough

Response to Comment A-1:
Staff appreciate the commenter providing the information derived from the source apportionment studies.

Response to Comment A-2:
While it is true that the MATES studies have consistently showed that diesel PM is a major contributor to air toxics cancer risk, neither South Coast AQMD nor CARB specifically attributes this risk to the black carbon (BC) present in the diesel PM emissions. CARB has determined that total diesel exhaust, including both gaseous and particulate emissions, was carcinogenic while diesel PM was designated as a surrogate to total diesel exhaust.

Staff disagree with the assertion that off-road and stationary sources have negligible contributions to the overall BC emissions in the South Coast Air Basin. The studies cited by the commenter were unable to identify a contribution from ships near the Ports of Long Beach and Los Angeles at a sampling site near I-710 and Long Beach Blvd. The inability of those studies to identify contribution of ship emissions to measured PM2.5 or BC concentration at a site downwind of the ports does not in itself indicate those emissions from ships do not travel on land.

While BC measurements were performed during MATES studies, these measurements were not factored in our risk analyses because the OEHHA risk assessment guidance does not have health risk assessment values for BC. In our analyses, we tracked PM emissions from diesel engines for each source category without regard to the speciation of the emissions. Emissions were inventoried from the top-down approach based on reported or estimated activity, vehicle/equipment population, or fuel consumption data, and established emission factors. For example, the diesel PM emissions from point sources were reported by facilities based on the hours of operations and engine size or diesel fuel consumption; the emission factors for this equipment were then applied to calculate the pollutant emissions. As the regulatory agency with primary authority over mobile sources, CARB has developed various tools to calculate mobile source emissions, based on their wealth of data on mobile source engines in California. The emissions inventory employed in MATES V is consistent with a regulatory inventory included in an AQMP/SIP which were developed via public process by multiple agencies, including CARB. While new data and methodology will likely continue to improve the accuracy of emissions inventories, any changes in the inventory and the underlying assumptions would need to go through an appropriate public process.

Response to Comment A-3:

We note that all BTEX compounds (benzene, toluene, ethylbenzene, o-xylene, m+p-xylenes) were measured in MATES V and previous MATES. During MATES V, benzene and toluene were generally well-correlated at all MATES sites ($r^2 = 0.62-0.94$), with linear regression slopes (toluene/benzene) ranging from 1.7-3.9. The toluene/benzene ratio has been used to differentiate between key BTEX sources such as vehicle exhaust and refinery emissions in some regions (e.g., Halliday et al., 2016), but assessing the refinery signal in the MATES V BTEX data is very difficult due to the location of refineries within a major urban area with other large sources of these compounds, including gasoline-powered mobile sources. However, the MATES V Advanced Monitoring report expected to be released within the next year will include results from targeted studies of toxic emissions from refineries. Furthermore, South Coast AQMD currently has several monitoring programs focused on characterizing refinery emissions and impacts, including the Rule 1180 (continuous fenceline monitoring) and AB 617 (community monitoring) programs. These higher spatial and temporal resolution datasets will be used in conjunction with baseline MATES V BTEX data to understand the impact of refineries on community and regional scales.

Reference:

Halliday, H. S., A. M. Thompson, A. Wisthaler, D. R. Blake, R. S. Hornbrook, T. Mikoviny, M. Müller, P. Eichler, E. C. Apel, and A. J. Hills. “Atmospheric benzene observations from oil and gas production in the Denver-Julesburg Basin in July and August 2014.” *J. Geophys. Res. Atmos.* 121 (2016): 11,055-11,074.

Responses to Comment Letter B from Scott Fruin

Response to Comment B-1:
The executive summary states that "The carcinogenic risk from air toxics in the Basin, based on the average concentrations at the 10 monitoring sites, is approximately 38% lower than the monitored average in MATES IV and 82% lower than the average in MATES II." and describes the changes in chronic HI from IV to V. In order to keep the executive summary at a reasonable length, staff believe that this level of detail is sufficient to highlight the large reductions in cancer risk.

Response to Comment B-2:
In Chapter 1, staff have added a description of the links between PM2.5 exposures and risk of premature mortality. In future work, staff may consider adding information to the Data Visualization Tool to highlight the impact of PM2.5 on premature mortality.

Response to Comment B-3:
Staff have added text in the chapters to provide additional interpretation of the hazard indices.

Response to Comment B-4:
The air toxics cancer risk associated with diesel PM was calculated using both the modeling results as well as the monitoring results. Uncertainties in the risk estimates stemming from the uncertainties in the cancer potency factor are noted in the Executive Summary and Chapter 1.

Uncertainties in Modeled Air Toxics Cancer Risk Associated with Diesel PM

The modeling-based cancer-risk used CAMx-predicted diesel PM to calculate cancer risk. The air toxics cancer risks presented in the MATES III and IV reports also used model-based predictions that did not rely on a conversion factor. However, the EC-to-diesel PM ratio was used in the measurement-based risk calculations in MATES V as well as earlier iterations. 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 uncertainties in modeled EC concentrations were from the individual model components, I.e., emissions inputs and air quality and meteorological models. The CAMx model used for the MATES analysis is a state-of-the-art, comprehensive 3-dimensional model that utilizes 3-dimensional meteorological models, complex chemical mechanisms that accurately simulate ambient reactions of pollutants, and sophisticated numerical methods to solve complex mathematical equations that lead to the prediction of ambient air quality concentrations. While air quality models progressively became more sophisticated in employing improved chemical reaction modules that more accurately simulate the complex ambient chemical reaction mechanisms of the various pollutants, such improved modules are still based on limited experimental data that carry associated uncertainties. In order to predict ambient air quality concentrations, air quality models rely on the application of sophisticated numerical methods to solve complex mathematical equations that govern the highly complex physical and chemical processes that also have associated uncertainties. Layer averaging of model output reduces the sensitivity of the model to changing patterns in the vertical structure.

While significant improvements have been realized in mobile source emissions models, uncertainties continue to exist in the mobile source emissions inventory estimates. EMFAC2017 on-road mobile source emission estimates have improved with each new EMFAC release. On-road mobile source emissions have inherent uncertainties with the current methodologies used to estimate vehicle miles traveled and the impacts of fuel additives such as ethanol. Stationary (or point) source emission estimates generally have less associated uncertainty compared to area source emission estimates. Major stationary point sources report emissions annually whereas minor stationary and area source emissions are, in general, estimated based on a top down approach that relies on state-total to county-total production, usage or activity information. Area source emissions including paved road dust and fugitive dust have significant uncertainties in the estimation of particulate (PM2.5) emissions due to the methodologies used for estimation, temporal loading and weather impacts. In addition to uncertainties in PM emissions, EC emissions relied on speciation profiles and large uncertainties in those profiles were expected. Nevertheless, the modeled EC concentrations compared reasonably well with the measured EC concentrations throughout MATES II to MATES V. The model performance for EC provides reasonable confidence for both the EC emissions inventory and the modeling system.

Since diesel PM behaves similarly to EC in the atmosphere and diesel PM comes from fewer sources than EC and its modeling inventory does not need to be speciated, it is expected that the uncertainties in the modeled diesel PM concentrations are less than the modeled EC concentrations.

Uncertainties in Air Toxics Cancer Risk Associated with Diesel PM Calculated with Measured EC

Uncertainties in estimating diesel PM risk from the measured EC concentrations are related to uncertainties in measured EC concentrations and uncertainties in the ratio of modeled EC and diesel PM. Additional text has been added in Chapter 2 to better describe these uncertainties. In addition, staff added error bars to the monitor-based calculation of diesel risk, which were based on uncertainties inherent in deriving the ratio of modeled diesel PM and EC along with uncertainties in the EC measurements. Although there are uncertainties in converting ambient EC concentrations into ambient diesel PM concentrations, it is worth noting that converted diesel PM concentrations compared reasonably well with modeled diesel PM concentrations.

Staff also added a figure showing the EC2.5 trend to Chapter 2; EC2.5 shows a steady decrease in concentrations from MATES III through MATES V.

Response to Comment B-5:
Staff reduced the density of basin boundaries in risk maps throughout the report to avoid misinterpretation of risk in the port area.

Response to Comment B-6:
(part 1) Staff have added text in this paragraph to clarify that air toxics are those pollutants that do not have ambient regulatory standards. However, federal, state, and local agencies do have regulatory standards that do control emissions of air toxics.

(part 2) Chapter 1 includes an explanation of the exposure pathways. Staff have added text to describe that the estimated multi-pathway cancer risk is ~8% higher than the inhalation-only estimate. The multi-pathway non-cancer chronic HI is approximately twice the inhalation-only estimate. Staff added text in Chapter 1 to describe the uncertainties in estimating health impacts from non-inhalation exposure pathways.

(part 3) Staff added "Results" to the "Fixed Monitoring" and "Modeling" headings.

(part 4) The risk results included in this section have been moved toward the beginning of the paragraph, along with a brief description of the basis of these calculations and the interpretation. Chapter 1 includes a more detailed description of how these cancer risks were calculated. A definition of secondary formation has been added.

(part 5) Staff have added text to the Executive Summary as well as Chapter 2 to provide more explanation and interpretation of the chronic HI.

(part 6) Staff fixed the font size in Figure ES-4.

(part 7) Staff have added clarifying text to the Executive Summary.

(part 8) Staff reduced the density of basin boundaries in risk maps throughout the report.

(part 9) Because previous MATES iterations utilized inhalation-only exposure pathways to calculate risk, and because a reader may be looking for the same information in the MATES V report, staff believe it is important to keep this information in the Executive Summary. Staff also concur that there is uncertainty in the calculation of cancer risks and discuss these uncertainties in the Executive Summary and Chapter 1.

(part 10) Although staff agree that presenting risk reduction by percentage may be useful, there is also value in consistently showing the change in absolute cancer risk across MATES iterations. However, the percentage reductions are described within the text of the report. Error bars have been added to the plot for diesel PM for MATES IV and V.

(part 11) Staff added text to the Caveats section of the Executive Summary to note that the conversion of BC to diesel PM is a source of uncertainty. This section also includes comments about the analysis not being designed to reflect near-source exposures. The analysis of the EC2.5 concentrations is included in Chapter 2. See also Response to Comment B-4.

(part 12) In an effort to keep the Executive Summary as short as possible, staff prefer to keep the conclusions at the end of the Executive Summary. However, staff will highlight such conclusions in infographics and outreach presentations.

Response to Comment B-7:
Uncertainties in the estimation of diesel PM health risks are addressed in the Executive Summary and Chapter 1. See Response to Comment B-4. Error bars have been added to the figure for diesel PM for MATES IV and V to help convey some uncertainties in these estimates.

Response to Comment B-8:
MATES IV and V diesel PM estimates were calculated with station-specific EC to diesel PM ratio calculated from modeled concentrations. As discussed above, uncertainties in the station-specific conversion factors were calculated for MATES IV and V and were combined with the EC measurement uncertainty to capture the diesel PM estimation uncertainty. MATES II and III diesel PM estimates were calculated with a basin-wide conversion factor calculated from modeled emissions. While it is not possible to calculate the uncertainty of these emission-based conversion factors, staff derived them for MATES IV and V to ensure that the methodology did not contribute to the large apparent decrease in diesel PM. Using these emission-based conversion factors led to a very similar trend in diesel PM throughout each MATES study. A paragraph was added to Chapter 2 to address this point.

Response to Comment B-9:
We have added horizontal lines showing the MATES IV average risk in the basin and Coachella Valley to figures 4-18 through 4-21. Appendix titles are shown on the cover pages of the appendices and in the List of Appendices.

Responses to Comment Letter C from Ken Davidson

Response to Comment C-1:

Staff added text to the Executive Summary detailing the change in population-weighted cancer risk within the SB535 designated communities compared to the rest of the Basin in MATES IV and MATES V.

Response to Comment C-2:
Staff added a couple of sentences acknowledging that unmeasured air toxics could contribute to health risks, but that the MATES studies have included the known air toxics that primarily drive health risks from air pollution.

Response to Comment C-3:
Staff added "ambient concentrations" for clarification.

Response to Comment C-4:
Staff revised the report so that the term "EJ Community" is first defined as “communities experiencing environmental injustices". The term “EJ Community” is subsequently used for the remainder of the chapter or appendix.

Response to Comment C-5:
Per OEHHA guidelines, residential health risks are calculated assuming that 100% of the time is spent at home. This is a conservative estimate of the impacts in a single location.

Responses to Comment Letter D from John Budroe

Response to Comment D-1:
Staff have incorporated additional language in the Executive Summary, Chapter 1 and Chapter 2 to clarify the terminology and interpretation of chronic non-cancer health impacts.

Response to Comment D-2:
Staff have made the suggested revisions.

Response to Comment D-3:
Staff have made the suggested revision.

Response to Comment D-4:
Page 2-14: Staff have made the suggested revisions.

Page 2-16: Staff have made the suggested revision.

Page 2-18: Staff have deleted the redundant graph and fixed the figure numbering.

Page 2-30: Staff have added text explaining that the two bromomethane figures show the same data with different vertical axes. Staff have added similar clarification for similar figure pairings throughout Chapter 2.

Responses to Comment Letter E from Janet Whittick

Response to Comment E-1:

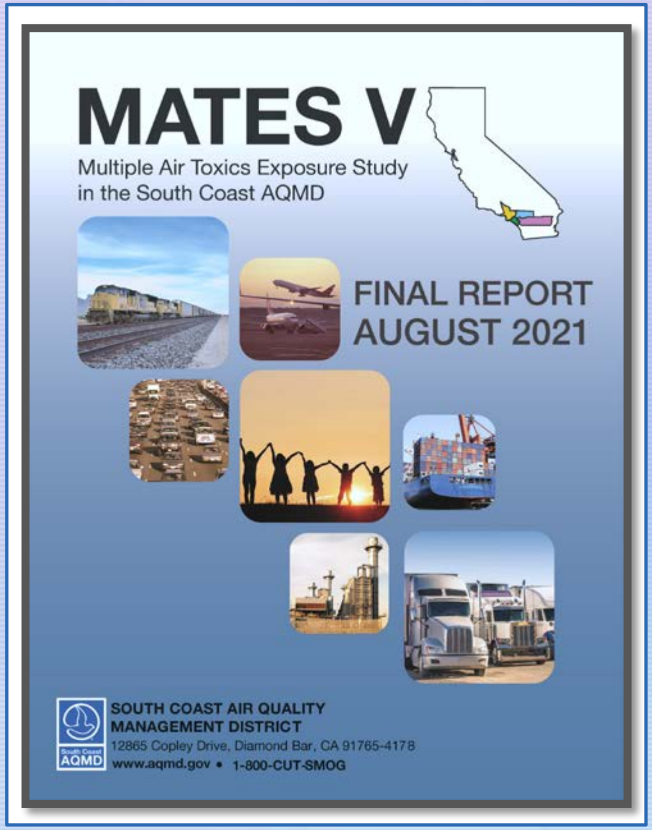
Staff appreciate the comments about using MATES data to enhance our understanding of air toxics risk drivers, especially in environmental justice communities. The MATES data have already been used to inform AB 617 community efforts. For example, the MATES IV data was one of the main technical data sources that was used to inform community identification and prioritization efforts for AB 617. Additionally, the emissions inventory is a key part of the Source Attribution analysis portion of the AB 617 Community Emissions Reduction Plans (CERPs). These data, along with community knowledge and other information (e.g. near-source monitoring studies, other data sources), help to inform the priorities and actions of the CERPs. Staff intend to use MATES V data for similar purposes once the data are finalized.

Response to Comment E-2:
In order to keep the Executive Summary at a reasonable length and minimize redundancy, staff prefer not to include a discussion of the perspectives on risk that is currently described in Chapter 1. However, staff added text in the Executive Summary explicitly defining cancer risk and chronic non-cancer health impacts to improve clarity.

Response to Comment E-3:
Staff agree that it is reasonable to expect future trends of decreasing air toxics emissions, since criteria pollutants such as NOx, VOC and combustion-related PM emissions are also expected to decrease due to various regulations by the District, State and Federal agencies. These planning projections can already be found in other South Coast AQMD publications, such as the Air Quality Management Plans. For example, 2016 AQMP includes projected diesel PM emissions in the future year (2016 AQMP Appendix III). The Source Attribution analyses completed for the designated AB 617 communities also show significant decreases in air toxics emissions (including diesel emissions) from the 2017 baseline year to the target years 2024 and 2029 (source-attribution-methodology.pdf). Given that the MATES analysis has always been anchored on measurement data and serves as a platform to measure the progress in air toxics and associated health risks, staff do not believe that an analysis of projected future emissions and associated health risks would be a good fit. Staff have added text to the Executive Summary and Chapters 2, 3, and 4 to cite the existing data from the 2016 AQMP and the AB 617 source attribution analysis.

Staff have added text to clarify when information shown in figures is based on population-weighted data.

Multiple Air Toxics Exposure Study V (MATES V) Final Report



MATES V

Multiple Air Toxics Exposure Study
in the South Coast AQMD

FINAL REPORT
AUGUST 2021

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

Board Meeting

August 6, 2021

MATES Program Overview

- Board Environmental Justice Initiative
- Focuses on regional air toxics impacts

How MATES data is used:

- Provide public information about air toxics and health risks
- Evaluate progress in reducing air toxics exposure
- Provide direction to future toxics control programs

JUNE 1987

THE MAGNITUDE OF
AMBIENT AIR TOXICS IMPACTS
FROM EXISTING SOURCES IN THE
SOUTH COAST AIR BASIN

1987 AIR QUALITY
MANAGEMENT PLAN REVISION
WORKING PAPER NO. 3

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

FINAL REPORT
Multiple Air Toxics Exposure Study
in the South Coast Air Basin
MATES-II
MARCH 2000

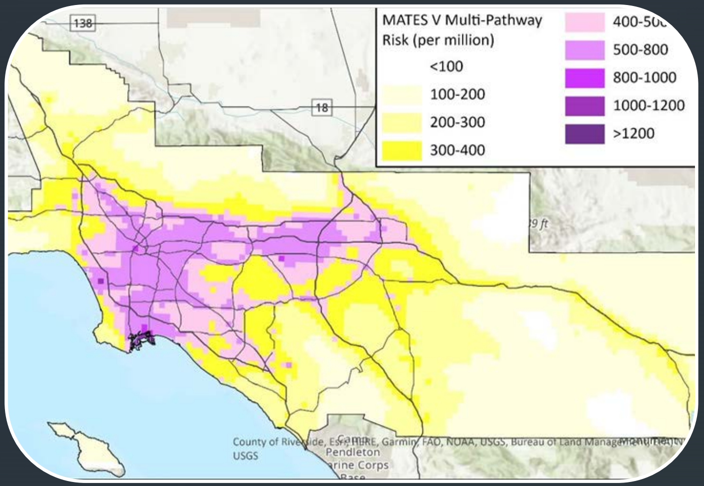
FINAL REPORT
Multiple Air Toxics Exposure Study
in the South Coast Air Basin
MATES-III
September 2008
South Coast
Air Quality
Management District
21865 Copley Drive
Diamond Bar, CA 91765
Cleaning the air that we breathe...™

FINAL REPORT
Multiple Air Toxics Exposure Study
in the South Coast Air Basin
MATES-IV
MAY 2015
SOUTH COAST
AIR QUALITY MANAGEMENT DISTRICT
1-800-CUT-SMOG • www.aqmd.gov
Cleaning the air that we breathe...

MATES V Report Components

Air Monitoring

Emissions Inventory



Health Risk Modeling

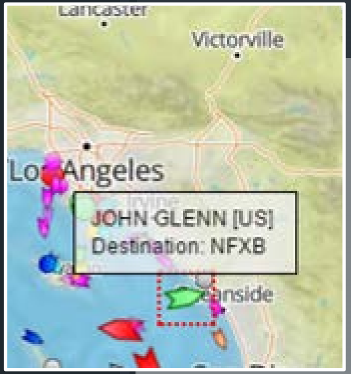
MATES V Advanced Monitoring will be described in a separate report

MATES V Overview

- Time period:
    - May 1, 2018-April 30, 2019
- Modeling domain:
    - SCAB
    - Most of Coachella Valley
- Monitoring stations:
    - 10 fixed sites
    - >100 pollutants measured

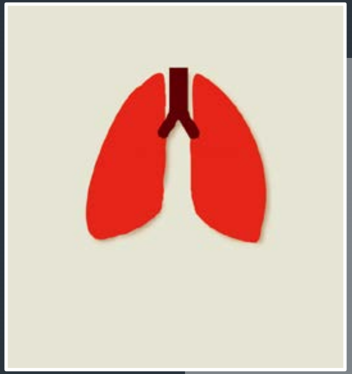
Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

What’s New in MATES V



Modeling improvements

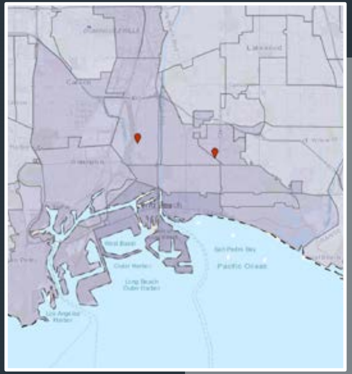
- Real-time sensor data for on-road traffic and ocean-going vessels
- Emissions from biogenic sources



Health risk estimates

- Multiple exposure pathways
- Chronic non-cancer health impacts (hazard index)

Improved statistical methods for trend analysis



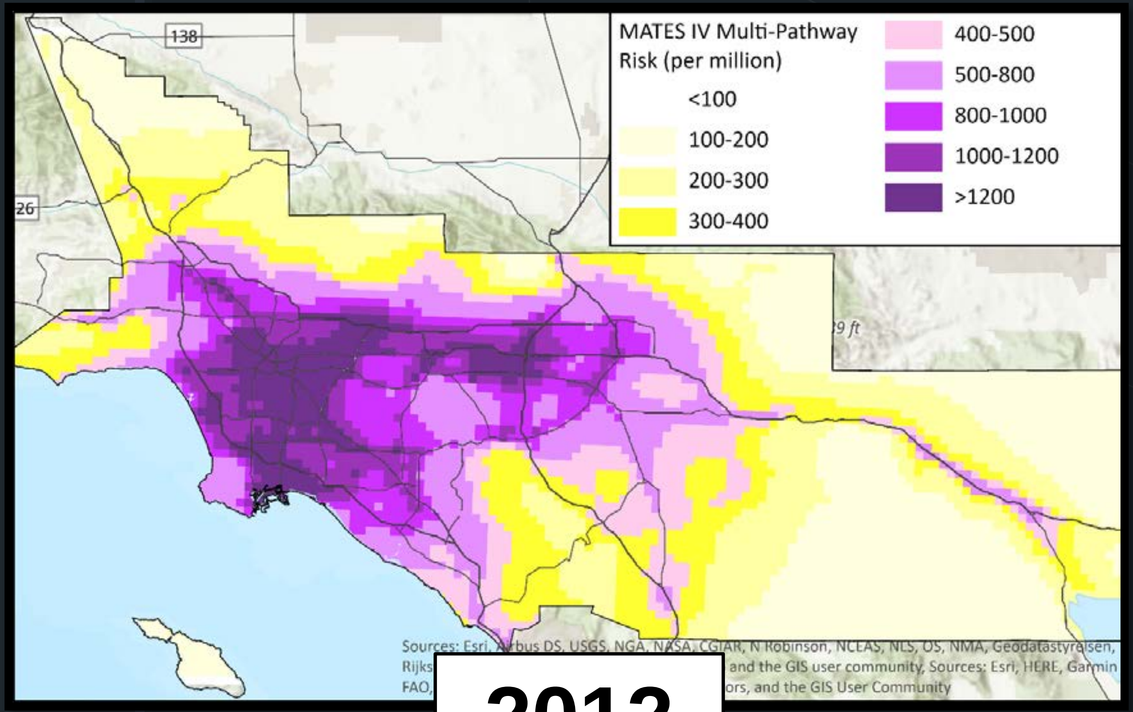
Data visualization tools

- Monitoring data dashboard
- Interactive tools

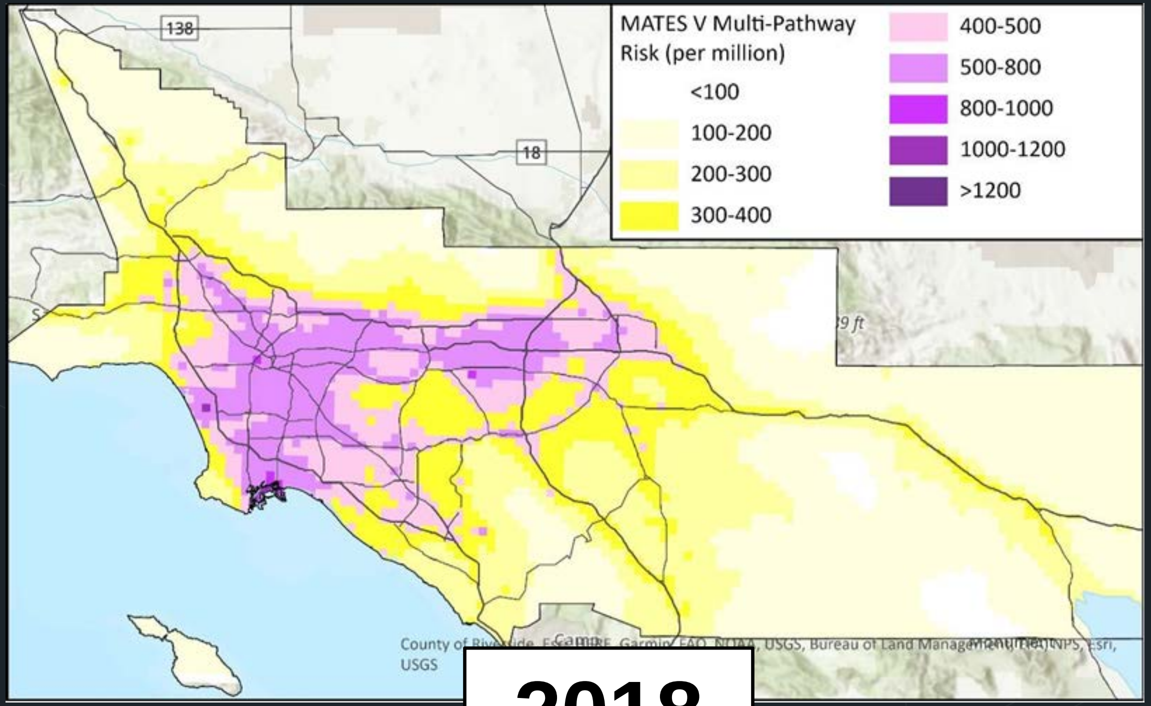
Air Toxics Cancer Risk – Modeling Data

MATES IV (population-weighted):
South Coast Air Basin: **997-in-a-million**
Coachella Valley: **357-in-a-million**

MATES V (population-weighted):
South Coast Air Basin: **455-in-a-million**
Coachella Valley: **250-in-a-million**

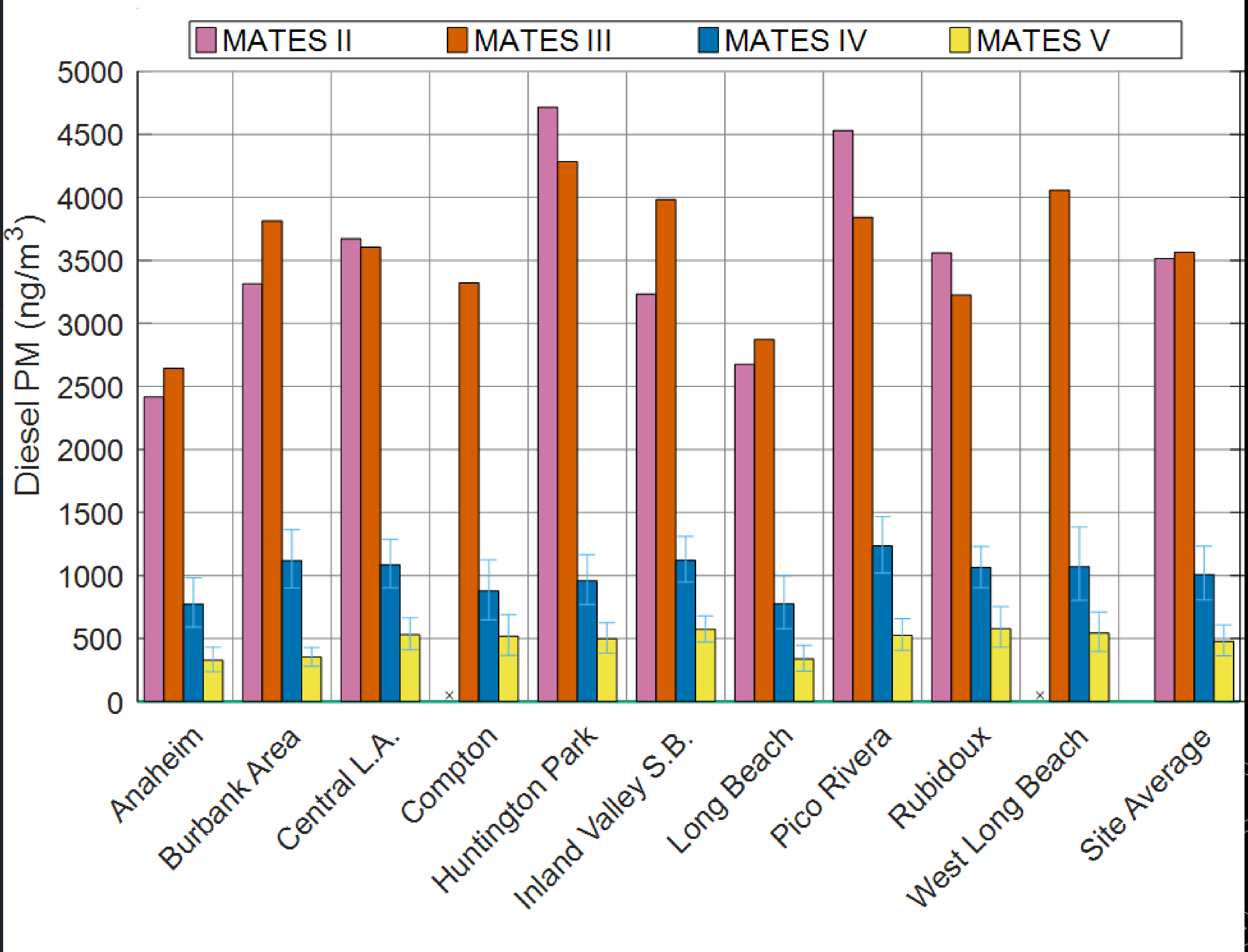


2012



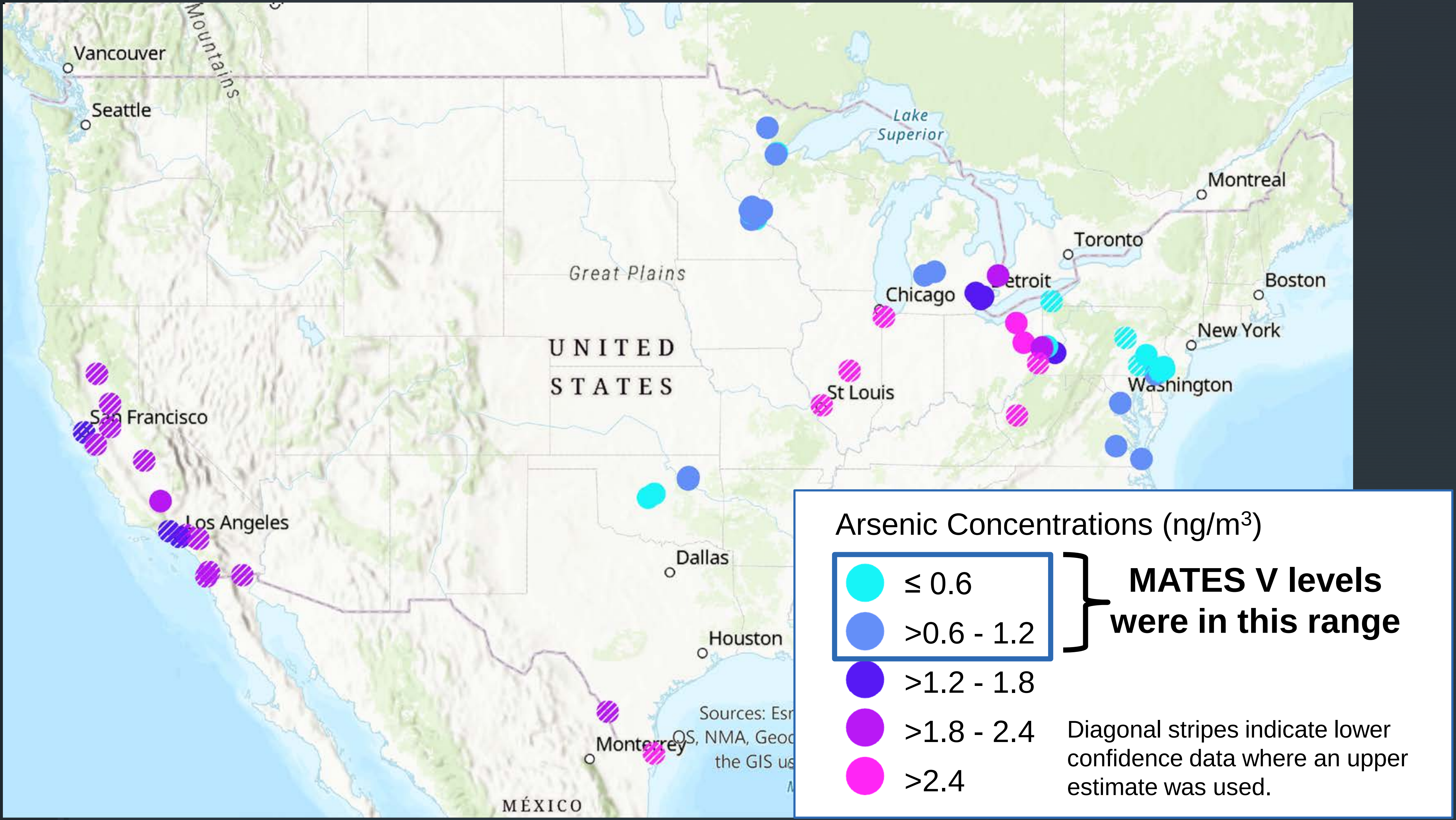
2018

Diesel Particulate Matter Trends (based on monitoring data)



Chronic Non-Cancer Risk – Monitoring Data

Arsenic Levels from Other Studies in the US



MATES V levels were in this range

Diagonal stripes indicate lower confidence data where an upper estimate was used.

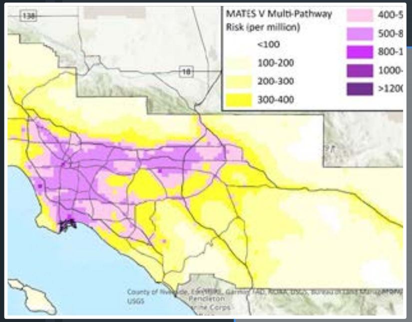
Public Process and Comments Received

- Technical Advisory Group
- April – June: Draft Report released, comment period
- Received 7 comment letters – mostly technical comments
    - Acknowledge uncertainties, especially with diesel PM estimates
    - Add interpretation of results
    - Ideas for future studies

MATES V webpage: http://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-v

MATES V Data Visualization Tool

MATES V: Summary of Results



Air toxics cancer risk decreased by ~50% since 2012, but risks are still high

EJ communities also had decreased air toxics levels, but still higher compared to Basin averages

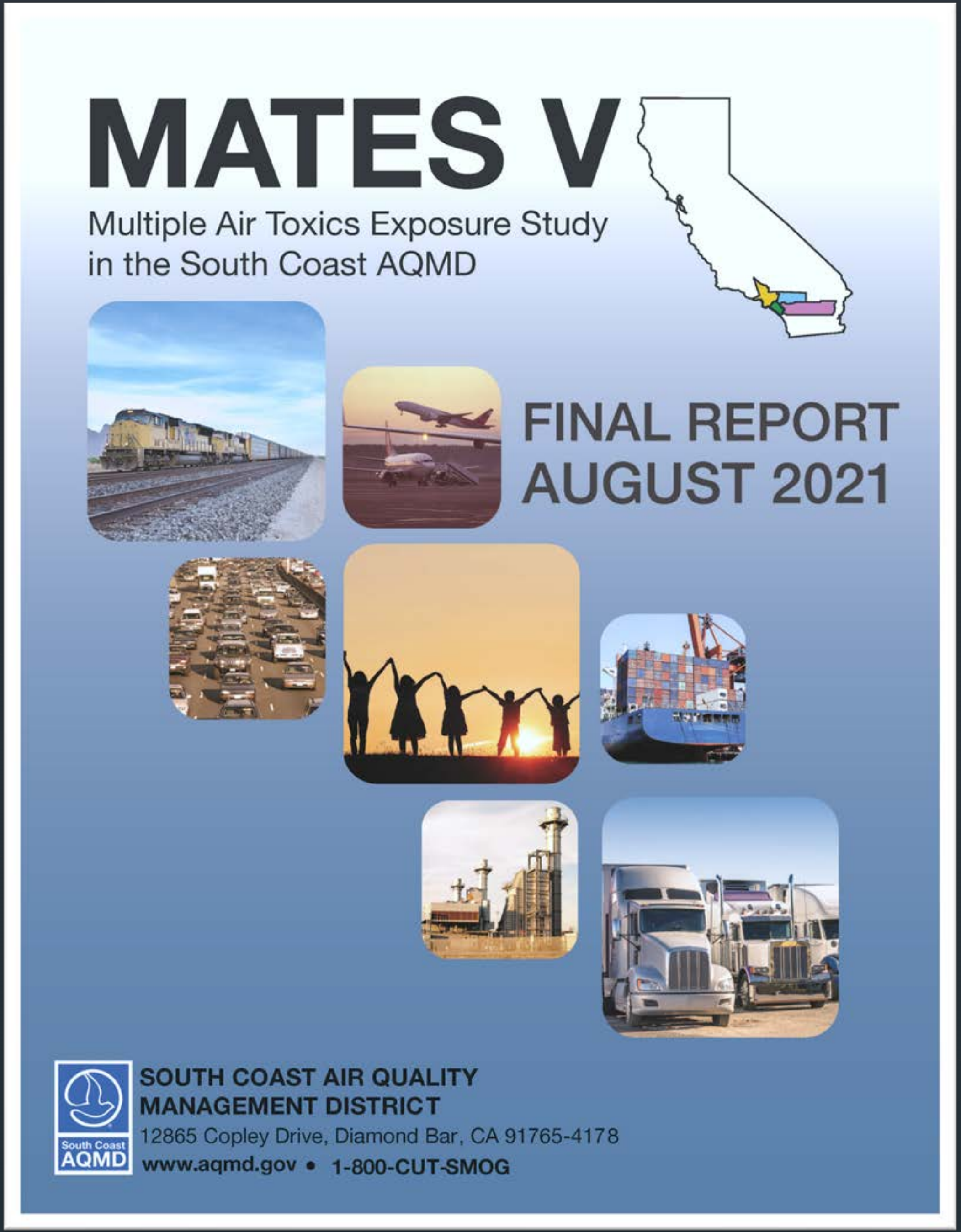
Diesel PM is the main contributor to air toxics cancer risk

Air toxics cancer risks were higher along goods movement corridors and major freeways

Chronic non-cancer health impacts were estimated for the first time, with a chronic hazard index of 5-9 across the 10 stations

Recommended Action

- Receive and file
  MATES V Final Report



MATES V

Multiple Air Toxics Exposure Study
in the South Coast AQMD

FINAL REPORT
AUGUST 2021

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