Methodology for Source Attribution Analyses for the first year AB 617 Communities in the South Coast Air Basin
(Technical Report)

South Coast Air Quality Management District

Nov 2019

Version 111919

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1. Introduction

1.1. Background: AB 617 Requirements and Community Air Protection Blueprint Guidelines

The South Coast Air Quality Management District (South Coast AQMD) is implementing the AB 617 program, which aims to align actions by local air districts and the California Air Resources Board (CARB) to achieve emission reductions in disproportionately burdened communities, improve accountability and transparency, and promote collaborative partnerships with community stakeholders. In September 2018, CARB designated three communities in the South Coast AQMD to implement Community Emissions Reduction Plans (CERPs). Communities designated for CERP development are also required to have an analysis of the air pollution sources in the community. Specifically, the AB 617 statutory requirements are as follows:

> *California Health and Safety Code § 44391.2 (b) (2) directs CARB to provide "[a] methodology for assessing and identifying the contributing sources or categories of sources, including, but not limited to, stationary and mobile sources, and an estimate of their relative contribution to elevated exposure to air pollution in impacted communities…"*

These technical assessments are completed as part of the development of the CERPs.

The CARB Community Air Protection Program Blueprint (CARB, 2018) and associated documents provide guidelines for the accounting of sources and their resulting emissions as part of the AB 617 program. This rigorous accounting of sources, their emissions, and their contribution to cumulative exposure burden is what the CARB guidelines identify as "source attribution". The South Coast AQMD has traditionally conducted source attribution analyses and developed emissions inventories at a regional level, but AB 617 requires a finer resolution down to the community level with more detailed source category identification in the analysis of emissions. This report describes in detail the methodology used to develop the community-level emissions inventories and to conduct source attribution analyses.

1.2. Source Attribution

Per the direction of CARB guidelines, the results of source attribution are important to inform the CERPs and help track progress in the implementation of these plans. The CERPs include actions to reduce air pollution emissions and impacts from specific sources that contribute to a community's air quality burden. CARB guidance includes five options for technical approaches to conduct source attribution analysis:

(1) <u>Community inventory ratios:</u> requires the calculation and comparison of ratios of source-specific emissions or comparable activity data inside and external to a community.

(2) Community-specific air quality modeling: requires sensitivity simulations to estimate the impact and contributions of emission sources or categories in a community
(3) Targeted air monitoring/back trajectory/pollution roses/inverse modeling: requires combining emissions, air quality monitoring, and meteorology (e.g., prevailing wind speed and direction) data to describe the sources affecting air quality at the monitoring locations.
(4) Chemical mass balance (CMB): requires the use of detailed chemically speciated air quality monitoring data to attribute emissions based on source test measurements of chemical species from emission sources.
(5) Positive matrix factorization (PMF): requires a multivariate factor analysis to determine factor profiles and contributions composed of species identified from the same sources.

Amongst the five technical approaches, South Coast AQMD used (1) inventory ratios and (2) air quality modeling for the South Coast Air Basin developed for the Multiple Air Toxics Exposure Studies (MATES IV), (South Coast AQMD, 2015) described in Section 2.2, with a heavier focus on developing detailed emissions inventories for the three first-year communities: (1) East Los Angeles, Boyle Heights, West Commerce, (2) Wilmington, Carson, West Long Beach, and (3) San Bernardino and Muscoy.

The development of emissions inventories builds upon methodologies used in previous efforts, which are documented in Section 2. Section 3 describes the methodology to develop baseline and future emissions inventories in each AB 617 community, for both criteria pollutants and air toxic contaminants.

Detailed emission inventories for each community are required to conduct any of the five technical approaches. Community-specific air quality modeling requires a detailed inventory and significant computing resources. Modeling is not included in the first year community emissions reduction plan due to time and resource limitations, but it will be used to assist subsequent years' community emission reduction plans. Inverse modeling can shed light on the sources that contribute to a 'hot' spot. This approach depends on the number of available samples and the temporal and spatial resolution of the monitoring data. Inverse modeling can be computationally expensive by employing both air quality/dispersion modeling and statistical calculations in addition to ambient monitoring which needs to be strategically located to capture the sources that are targeted. CMB requires comprehensive and representative chemical profiles for the sources to be analyzed. Data for such comprehensive chemical profiles is scarce and outdated, which would produce erroneous source apportionment results. PMF is based on detailed chemical speciation data monitored over an extended period. Such measurements will be available through MATES V monitoring and analysis, but are not yet available. Consequently, due to the lack of data availability and the tight statutory deadlines, the source attribution analysis for the first-year AB 617 communities focuses on emissions inventory development and community-specific inventory ratios.

2. Previous Studies

2.1. Emissions and air quality modeling used to support the Air Quality Management Plan (AQMP)

The 2016 Air Quality Management Plan (2016 AQMP) (South Coast AQMD, 2016) is a regional blueprint for achieving the federal air quality standards and healthful air. The 2016 AQMP represents a thorough analysis of existing and potential regulatory and incentive-based control options. It includes available, proven, and cost-effective strategies that seek to achieve multiple goals in partnership with other entities promoting reductions in criteria pollutants, greenhouse gases and toxic risk, as well as improve efficiencies in energy use, transportation, and goods movement. As with every AQMP, a comprehensive analysis of emissions, meteorology, atmospheric chemistry, regional growth projections, and the impact of existing and proposed control measures is conducted with the latest data and methods.

In order to determine the efficacy of emission control strategies, the AQMP incorporates emissions and air quality modeling of a domain that spans across Southern California. The modeling grid has a resolution of 4 km by 4 km, and the modeling period spans the entire year of 2012. Meteorological and air quality modeling tools used in the AQMP are state-of-the-art modeling platforms that are peer-reviewed by the scientific community. In addition, South Coast AQMD held a series of public meetings of the Scientific, Technical & Modeling Peer Review (STMPR) Advisory Group through the course of the development of the AQMP. Modeling tools are in constant development within the scientific community and South Coast AQMD staff applies the most up-to-date, validated models.

The 2016 AQMP includes an inventory of criteria pollutant emissions for the year 2012 and the annual projections for milestone years 2017 to 2028 and 2030 and 2031, which correspond to deadlines to attain various federal air quality standards for ozone and $PM_{2.5}$ and Reasonable Further Progress (RFP) milestones set by U.S. EPA. **Figure 1** presents trends in emissions of NOx and VOC in the South Coast Air Basin for area, point, on-road and off-road sources, and **Figure 2** presents trends in emissions of NOx and VOC for various vehicle categories. The baseline emissions reflect emission reductions from the rules adopted by CARB and South Coast AQMD as of December 2015. Mobile source emissions (both on-road and off-road) were projected to decline with time faster than stationary (point) and area sources. The 2016 AQMP includes control measures targeting emission reductions from stationary source facilities, which are expected to expedite the reductions from point sources in future years. Area sources are largely associated with the growth of population and economic activities, such as VOC emissions from the use of consumer products. Area source emission reductions are expected to plateau in the near future and then increase slightly. The increase is due to population growth and associated activities outpacing reductions from current regulations. The 2016 State Implementation Plan (SIP) strategy includes control measures that will further reduce emissions from consumer products in future years.

The mobile source category is the primary source of emissions in the South Coast Air Basin. Combined, on-road and off-road mobile sources account for over 80% of total NOx emissions and about 50% of VOC emissions in 2017. However, as depicted in **Figure 2**, vehicular emissions have declined substantially in the past decades and are expected to continue to decrease in the future.

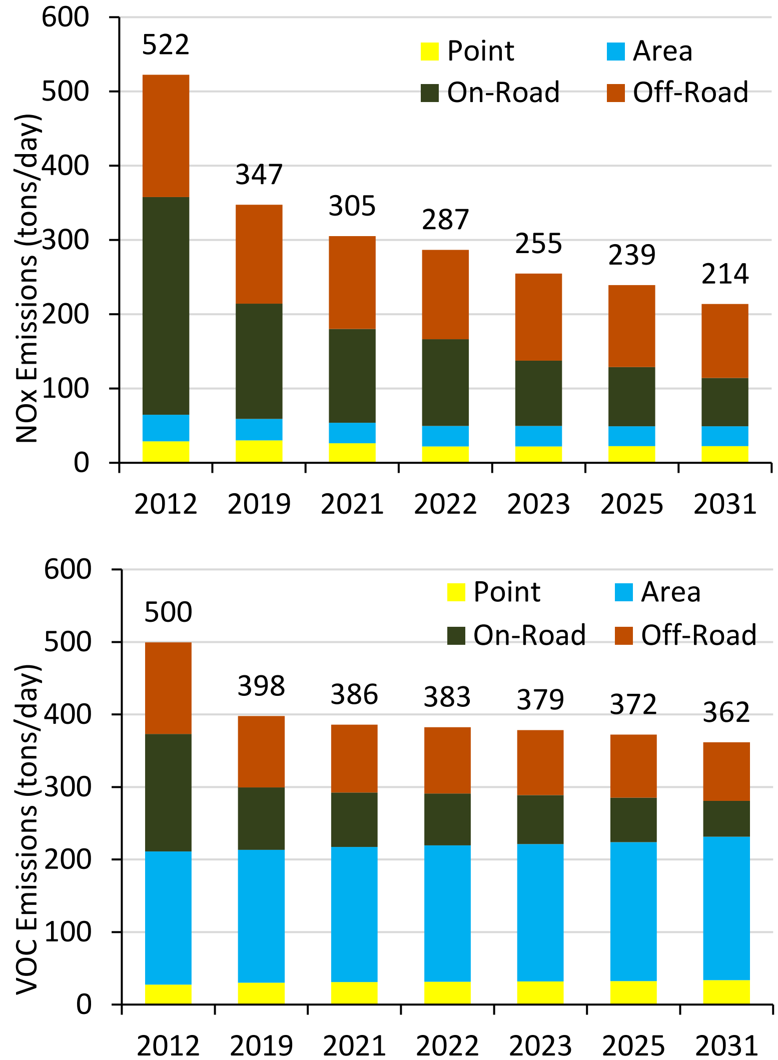


Figure 1. Emission Trends in the South Coast Air Basin Projected in the 2016 AQMP: NOx emissions (top), VOC emissions (bottom)

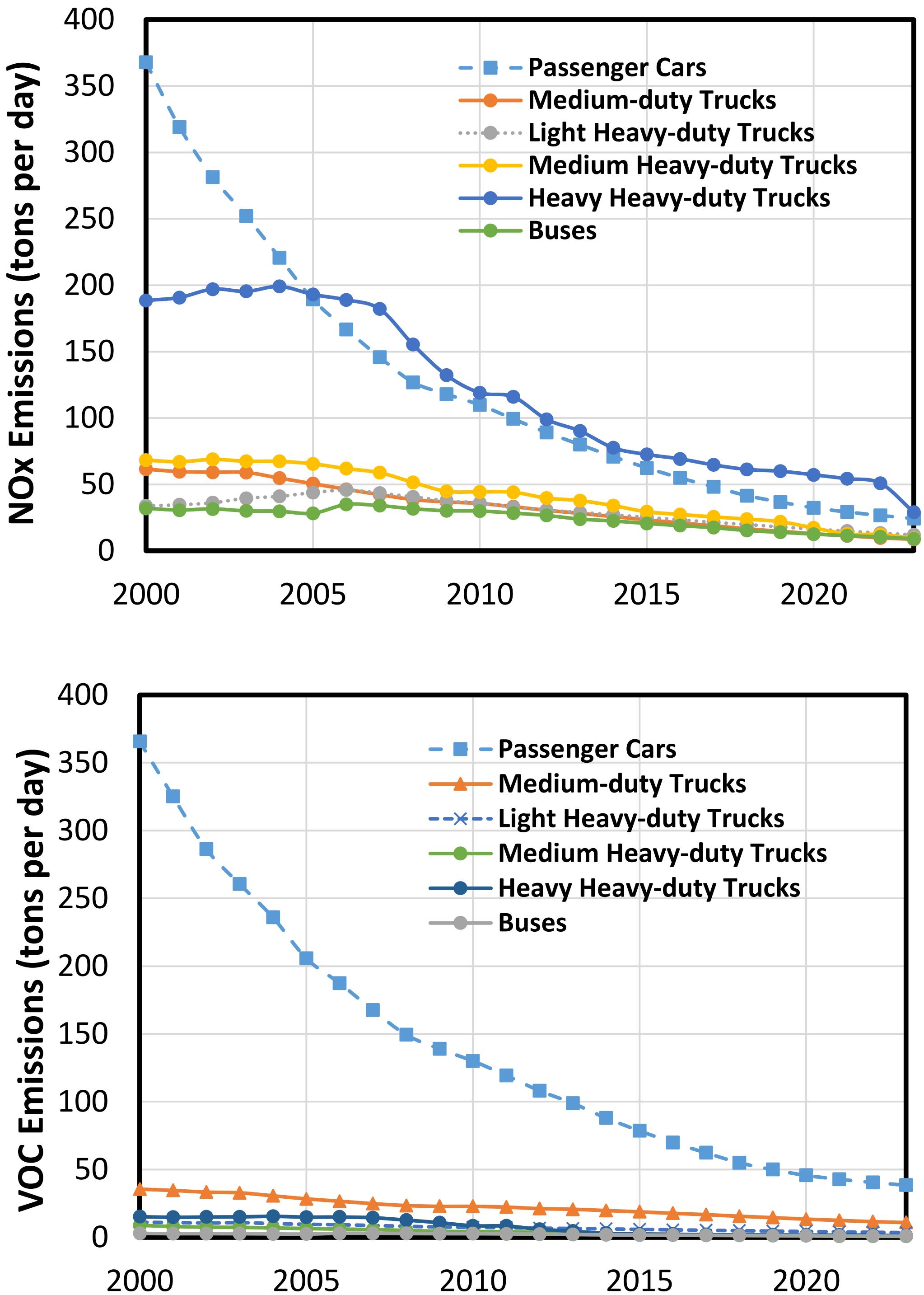


Figure 2. Emission Trends from On-Road Sources in the South Coast Air Basin projected in the 2016 AQMP: NOx emissions (top), VOC emissions (bottom)

2.2. Emissions and air quality modeling used to support the Multiple Air Toxics Exposure Study (MATES)

The Multiple Air Toxics Exposure Studies (MATES) are a series of studies that analyze the emissions, dispersion, and resulting population exposure to air toxic contaminants. MATES includes measurements of ambient air toxic concentrations, the development of a regional air toxic inventory, and regional air toxic modeling and risk assessment. MATES IV, finalized in May 2015, is the latest available study (South Coast AQMD, 2015). It includes carcinogenic risk estimation from exposure to air toxics in the year 2012. MATES IV consists of two major elements: 1) monitoring and 2) modeling of the emissions inventory, air toxic concentrations, and exposure to characterize risk across the basin.

Monitoring: A network of 10 fixed monitoring stations were used to measure air toxics once every six days for one year. Most stations were located in the same locations as in previous MATES studies to allow for comparisons over time.

Modeling: emissions and air toxics modeling was conducted on a domain that encompassed the South Coast Air Basin, Coachella Valley, and the coastal shipping lanes using a 2 km by 2 km grid size. Emissions were projected from 2008 to the year 2012 based on the 2012 AQMP growth forecasts. Modeling was conducted using the Comprehensive Air Quality Model with Extensions (CAMx). This model, enhanced with a reactive tracer modeling capability (RTRAC), is able to track the contribution of toxics from major sources, and simulate the transport and chemical transformation of air toxics in the atmosphere.

Table 1 presents the contribution of air toxics to the total emissions weighted by their cancer unit risk factors. The weighting allows for a consistent, impact-based comparison amongst air toxics, and provides a scale that compares air toxics combining emissions and cancer risk. The weighted emissions were calculated using the methodology adopted by OEHHA.[1] As shown in **Table 1**, based on 2012 emissions used in the MATES IV study (South Coast AQMD, 2015), diesel particulate matter (DPM) was the largest contributor to air toxics cancer risk (hereafter referred to as cancer risk) among all air toxic contaminants, followed by hexavalent chromium, 1,3 butadiene and benzene. The largest contributor to these toxic air contaminants (TACs) is mobile sources, as shown in **Figure 3**. On-road and off-road sources combined account for over 90% of the cancer risk in the South Coast Air Basin. Air quality modeling conducted in MATES IV (South Coast AQMD, 2015) showed that some air toxic concentrations were produced by chemical reactions in the atmosphere and transported from a source area to other areas. Concentrations of DPM tend to be higher near the ports and along the main transportation corridors where heavy-duty truck transport occurs, as shown in **Figure 4**. The resulting air quality was used to analyze the potential effect on population exposure, and the contribution of air toxics to the overall cancer risk in the

[1] Values for unit risk are developed from OEHHA/ARB Approved Risk Assessment Health Values available at http://www.arb.ca.gov/toxics/healthval/healthval.htm. The Unit Risk Values were calculated using the updated methodology adopted by OEHHA in February 2015 assuming an exposure value of 1 µg/m3, 90th percentile breathing rates for age groups up to 2 years and 80th percentile breathing rates for age groups above 2 years, fraction of time at home of 1 for ages up to 16 years and 0.73 for age above 16 years, and 30 year exposures.

basin. **Figure 5** presents the simulated cancer risk obtained during the MATES IV study (South Coast AQMD, 2015). The values of cancer risk depend on air toxic contaminant concentrations in the area and the corresponding unit risk factors. Results showed that communities near the ports and along the main transportation corridors were the most affected by air toxic pollutants, due to the presence of diesel emissions.

Table 1. Toxicity Weighted Species Apportionment for 2012 Emissions

Toxic	Contribution (%)	Toxic	Contribution (%)
Diesel particulate (DPM)	79.61	Methylene chloride	0.12
Hexavalent chromium	5.66	Trichloroethylene	0.04
1,3-butadiene	5.46	Lead	0.02
Benzene	4.25	Ethylene dichloride	0.02
Formaldehyde	1.4	Ethylene oxide	<0.01
Arsenic	1.03	Carbon tetrachloride	<0.01
Perchloroethylene	0.5	1,1-Dichloroethane	<0.01
Cadmium	0.46	Chloroform	<0.001
p-dichlorobenzene	0.43	Ethylene dibromide	<0.0001
Nickel	0.3	Propylene oxide	<0.0001
Naphthalene	0.3	1,3-Dioxane	<0.00001
Acetaldehyde	0.23	MTBE	<0.00001
Vinyl Chloride	0.16		

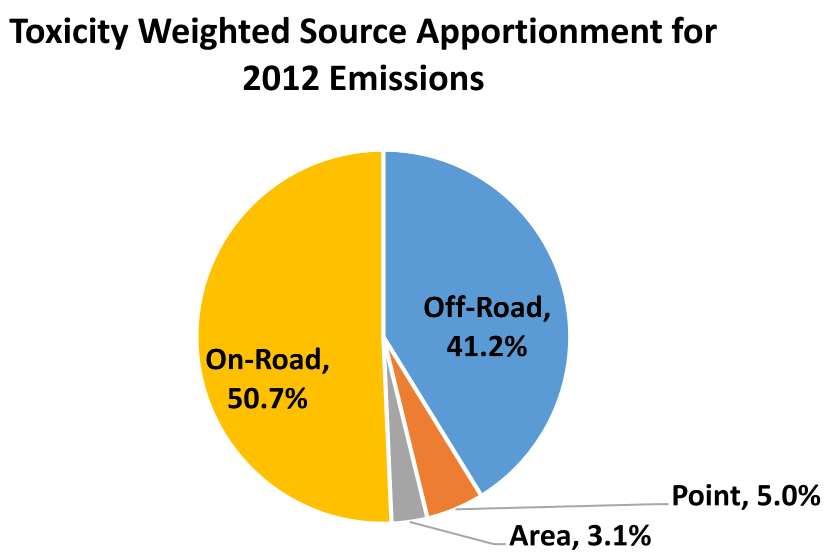


Figure 3. Toxicity Weighted Source Apportionment for 2012 Emissions

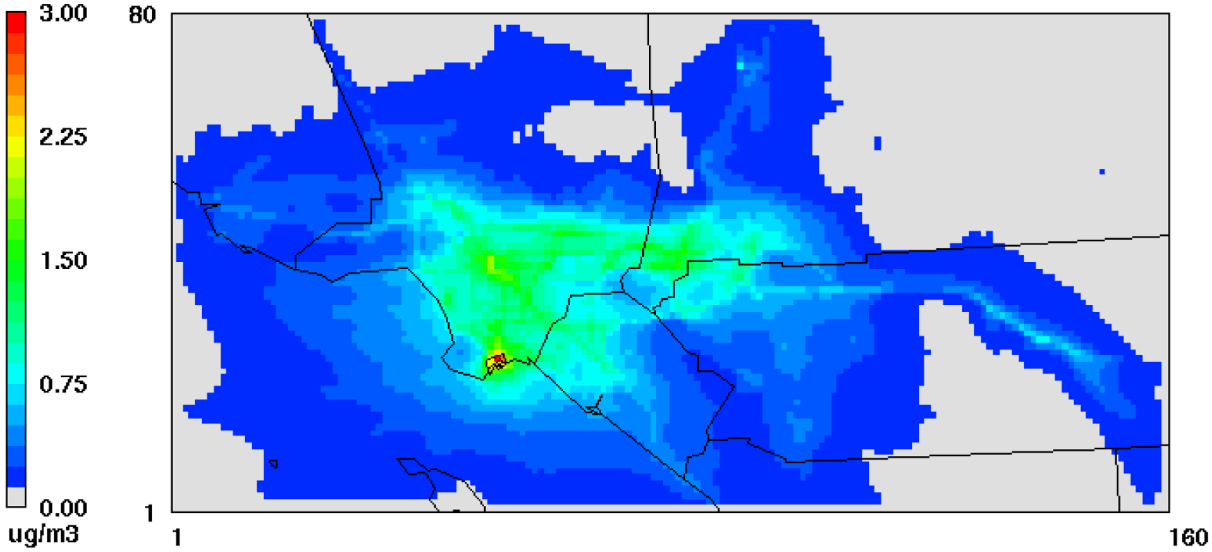


Figure 4. Annual Average Concentration Pattern for Diesel $PM_{2.5}$ for 2012, from MATES IV (South Coast AQMD, 2015)

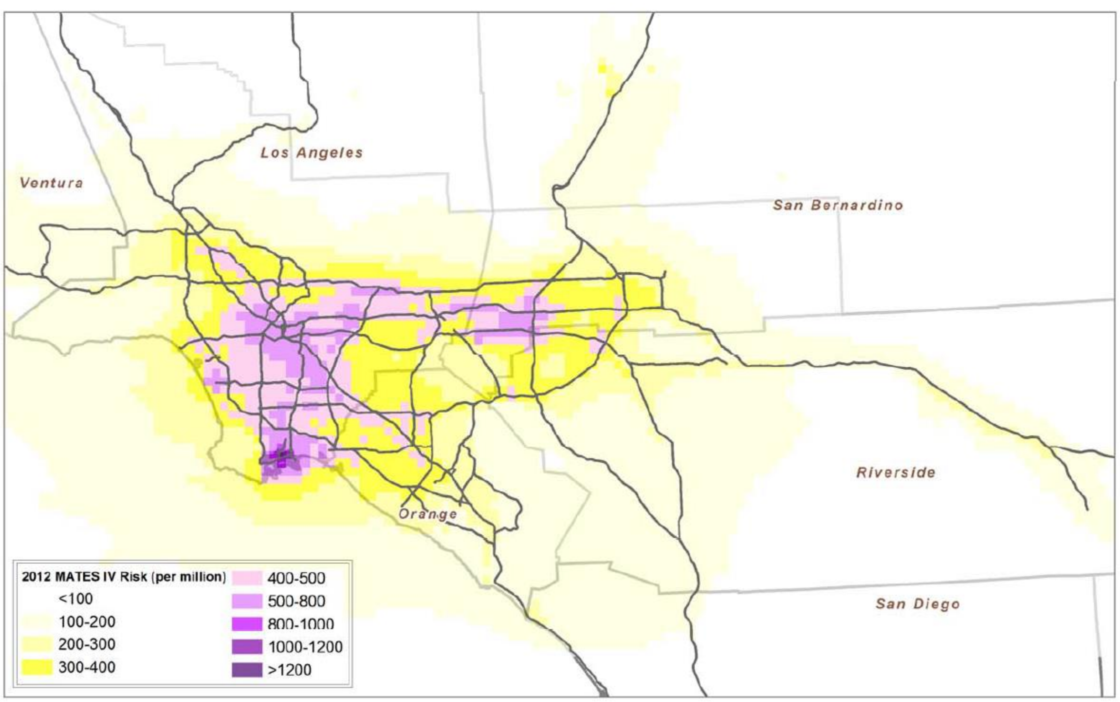


Figure 5. MATES IV CAMx RTRAC Simulated Air Toxics Cancer Risk, from MATES IV (South Coast AQMD, 2015)

3. Methodology for Emissions Inventory

3.1. Background

CARB's guidelines require emissions inventory of criteria air pollutants (CAPs) and TACs for base and future milestone years. Per the source attribution guidelines from CARB (CARB, 2019), 2017 was selected as the base year and 2024 and 2029 as future milestone years, marking five and ten years from the time the CERPs are adopted by the air districts. Both base and future years' community inventories are required to include all CAPs and TACs. The criteria pollutants are NOx, SOx, CO, $PM_{2.5}$, PM_{10} and lead. In addition, reactive organic gases (ROG) and ammonia need to be included as they are precursors for ozone and PM formation, respectively. The methodology to calculate CAPs emissions in this AB 617 source attribution analysis is similar to the approach used in the 2016 AQMP. Where individual toxics are not reported, toxic air pollutants are calculated using chemical speciation profiles applied to Total Organic Gases (TOG) and total Particulate Matter (PM). In order to ensure correct estimation of air toxic emissions, the guidelines require the following criteria pollutants to be included: 1) TOG and PM; particulate matter 10 micrometers or less in aerodynamic diameter (PM_{10}); or particulate matter 2.5 micrometers or less in aerodynamic diameter ($PM_{2.5}$). In addition to the above criteria pollutants, stationary point sources must also include lead (Pb) and ammonia (NH3). Toxic pollutant emissions from processes, devices, or facility activities listed in Appendix D of the AB 2588 Air Toxics "Hot Spots" Emission Inventory Criteria and Guidelines must be measured in accordance with the CARB-approved testing methods specified therein. Other pollutant emissions can be quantified using appropriate methods, which may include using CARB chemical speciation profiles (found at: https://www.arb.ca.gov/ei/speciate/speciate.htm), emission factors, material mass balance, or other comparable methods approved by an air district. Where available, measured toxic pollutant emissions are preferred over the speciation profiles.

In this inventory, emissions of air toxics from point sources are based on reported emissions to the Annual Emissions Reporting (AER) Program, whereas for the rest of sources (area, on-road, off-road sources), toxic air pollutant emissions are estimated using chemical speciation profiles. Chemical speciation profiles disaggregate total emissions of TOG and PM into individual species. The individual species in the chemical speciation profile for both TOG and PM are used to determine the emissions of individual components that are considered TACs. **Figure 6** presents a sample chemical speciation profile for TOG emissions from a natural gas boiler. Toxic emissions of formaldehyde and benzene emissions are calculated by applying their fraction in the speciation profile to the total reported/estimated TOG emissions. There are hundreds of speciation profiles that correspond to specific emissions sources. The assignments of speciation profiles to the corresponding source category are based on the emission inventory category code (EIC) and/or Source Classification Code (SCC).

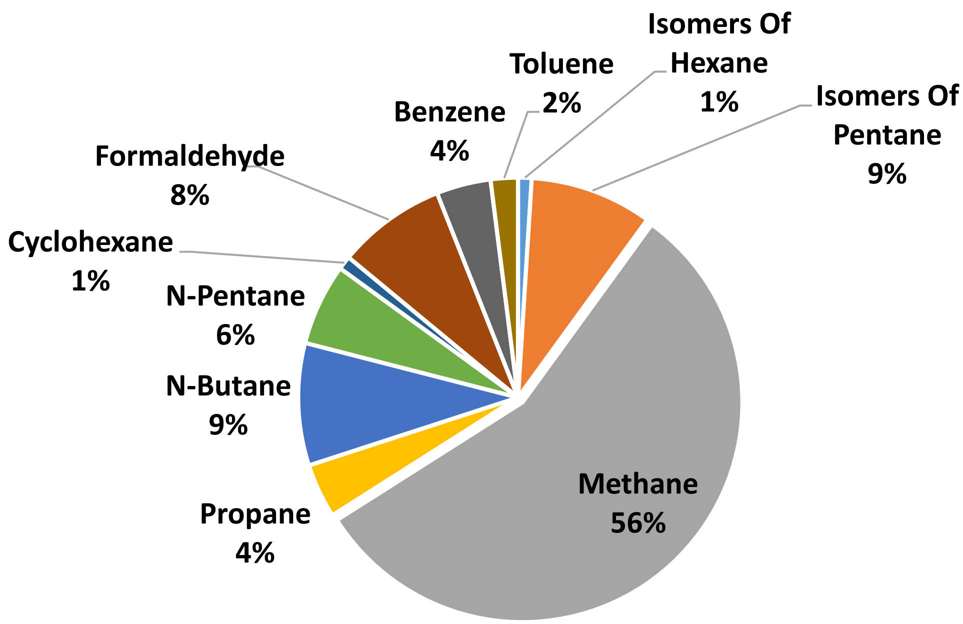


Figure 6. Example of a TOG Speciation Profile for a Natural Gas Boiler (extracted from https://www.arb.ca.gov/ei/speciate/speciate.htm)

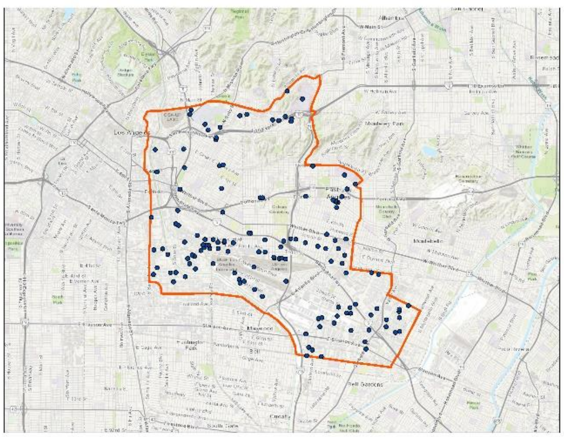
3.2. Methodology to Develop Criteria Air Pollutants Emissions for Base Year (2017)

3.2.1. Point Source Emissions

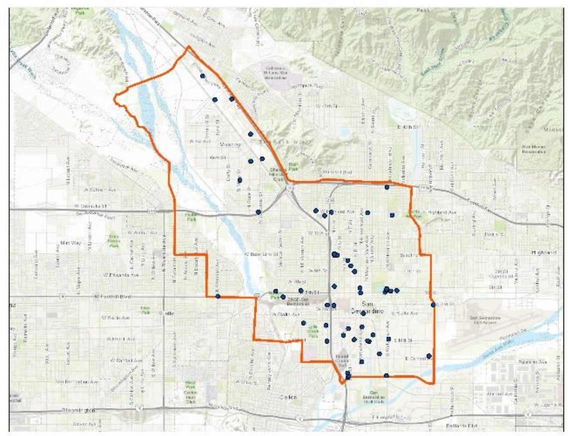
The 2017 point source emission inventory is based on the emissions data reported by point source facilities in the 2017 AER Program. This program applies to facilities emitting four tons per year (TPY) or more of VOC, NOx, SOx, or PM or emitting more than 100 TPY of CO, as specified in Rule 301(e). Facilities subject to the AER Program calculate and report their emissions primarily based on their throughput data (e.g., fuel usage, material usage), appropriate emission factors or source tests, and control efficiency (if applicable). Under the 2017 AER Program, 1,378 facilities reported their annual emissions to South Coast AQMD. The smaller industrial facilities with emissions below the reporting thresholds are not subject to the AER program. The emissions from those facilities are instead included as part of the area source inventory.

In order to prepare the point source inventory, emissions data for each facility were categorized based on U.S. EPA's Source Classification Codes (SCCs) for each emission source category. Since the AER program collects emissions data on an aggregate basis (i.e., similar equipment and processes with the same emission factor are grouped and reported together), facilities' equipment permit data were used in conjunction with the reported data to assign the appropriate SCC codes and develop the inventory at the SCC level. For modeling purposes, facility location (in latitude and longitude) is specified. Business operation activity profiles are also recorded. The facility business type is assigned to the facilities based on the North American Industry Classification System (NAICS) Code according to their primary activity.

The location of each facility is geocoded and placed in the South Coast Air Basin map, and the facilities falling within the community boundaries are extracted and included in each community's inventory (**Figure 7**). However, there are limitations to this approach. In some instances, large operations such as refineries have multiple point sources associated with the same coordinates of the facility. Currently, their emissions are assumed to emanate from this single location. This is not a problem for the regional modeling used in the AQMP or MATES as long as all the stacks are located within one computational grid, which is equal to or larger than a 2 km by 2 km block, respectively. However, the spatial resolution desired for the AB 617 analysis is higher than the currently available data, and may require further refinement in the future.



(a)



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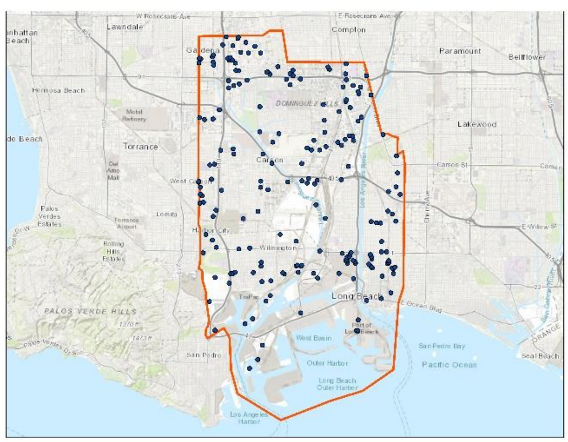

(c)

Figure 7. Location of AER facilities in each of the first year communities: (a) East Los Angeles, Boyle Heights, West Commerce, (b) San Bernardino and Muscoy, (c) Wilmington, Carson, West Long Beach

3.2.2. Area Sources

The 2016 AQMP emissions inventory was the primary platform to develop community specific emissions for area sources. This was a joint effort between the South Coast AQMD staff and CARB staff. The area source emissions inventory includes approximately 400 area source categories. Specifically, South Coast AQMD is responsible for developing the area source inventory for about 150 categories whereas CARB developed the remaining area source categories (such as consumer products and degreasing). For each area source category, a specific methodology is used to estimate emissions. For example, natural gas combustion categories associated with residential and commercial space heating, water heating, and other uses were estimated and based on annual consumption data from Southern California Gas Company and California Energy Commission's annual report. County total consumption was broken down to the end user appliance level and, for each appliance, corresponding emission factors from U.S. EPA's AP-42 were applied to calculate emissions. Area source emissions are the remaining portion after the AER reported point source emissions are subtracted from the total stationary emissions.

Area sources are estimated at a county level based on aggregated emission estimates and socioeconomic factors. For modeling purposes, the county-wide emissions need to be gridded to the desired model resolution. For the 2016 AQMP, model resolution was set at 4 km by 4 km grid cells. In order to apportion county-level emissions to grid cells, spatial surrogates based on land use data are typically used. There are over 100 spatial surrogates used for area and off-road sources. Examples of spatial surrogates include population distribution, location of roads, total housing, agricultural land cover, length of rail tracks per cell, total employment, and industrial employment. The resulting gridded emissions are then trimmed to extract area sources that belong to a specific community.

Figure 8 shows a sample of gridded emissions from area sources for the first year AB 617 communities. The resolution of the emissions grid determines the accuracy of the emissions that fall within each community. For the grid cells lying partially within the community boundaries, only a fraction of the emissions from these grid cells within the community are assigned to the community. The fraction of the emissions is based on the fraction of the area of the cell lying within the community.

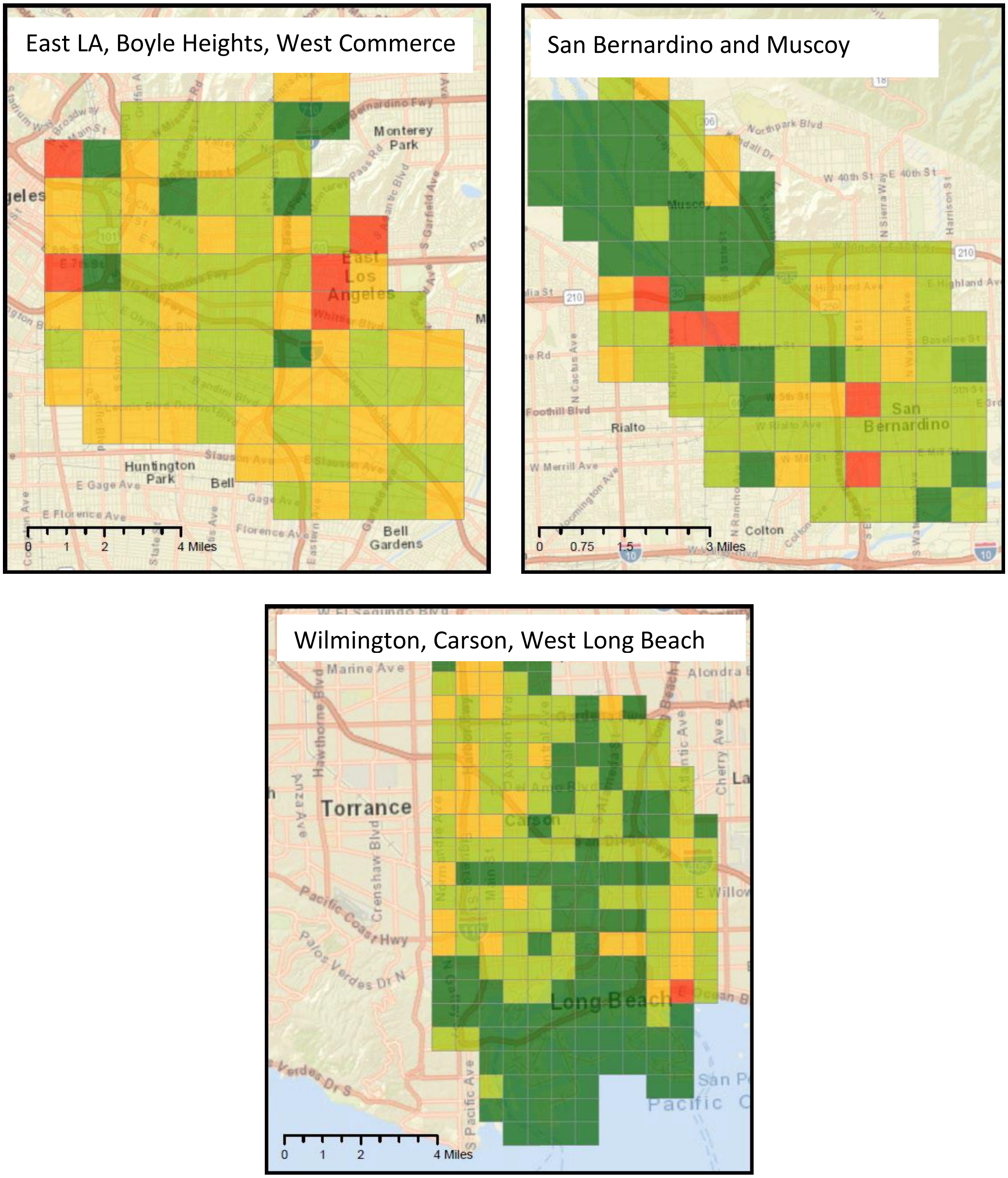

Figure 8. Emission grids overlaid on the three communities. Emissions illustrated by color are for illustrative purposes only.

3.2.3 On-road Mobile Sources

The baseline emission estimates for on-road motor vehicles are calculated by applying the emission rates in CARB's EMFAC2017 model to the transportation activity data provided by the Southern California Association of Governments (SCAG) in its adopted 2016 Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS). The California Department of Transportation (Caltrans), the Department of Motor Vehicles (DMV), and SCAG supply CARB with data necessary to develop the on-road mobile source emissions inventory. The California DMV maintains a count of registered vehicles and Caltrans provides highway network, traffic counts and road capacity data. SCAG maintains the regional transportation model containing the temporal and spatial distribution of motor vehicle activity (travel time, travel speed, and volume of traffic for AM-peak, mid-day, PM-peak, evening and night hours). In addition, SCAG periodically conducts origin and destination surveys to validate the regional transportation model. SCAG also updates a demographic database for population, housing, employment, and patterns of land use within its jurisdiction. **Figure 9** presents a sample of data provided by SCAG that is used to determine air pollutant emissions.

(a) (b)

Figure 9. Illustration of data available from SCAG for travel demand activity at the community level for East Los Angeles, Boyle Heights, and West Commerce: (a) vehicle volume, (b) trip distribution

Emission rate data in EMFAC2017 is collected from various sources, such as individual vehicles in a laboratory setting, tunnel studies, and certification data. Vehicle activity data is obtained from regional planning agencies (i.e. SCAG). EMFAC2017 calculates exhaust and evaporative emission rates by vehicle type for different vehicle speeds and environmental conditions. Temperature and humidity profiles are used to produce monthly, annual, and episodic inventories.

Parameters accounted for by EMFAC2017 include the following: type of emissions control technology, fuel type, distribution of operating speeds, speed and temperature correction factors, and the reduction in emissions resulting from the State's motor vehicle regulatory programs.

EMFAC2017 includes the following mobile source data:

(1) Eight vehicle classes (light-duty passenger, light-duty trucks under 3,750 pounds, light-duty trucks between 3,750 pounds and 5,750 pounds, medium-duty trucks between 5,751 pounds and 8,500 pounds, light-heavy-duty trucks between 8,501 pounds and 10,000 pounds, light-heavy-duty trucks between 10,001 pounds and 14,000 pounds, medium-heavy-duty trucks between 14,001 pounds and 33,000 pounds, and heavy-heavy-duty-trucks for over 33,000 pounds);

(2) Four vehicle fuel types (gasoline, diesel, electricity and natural gas);

(3) Truck types (ports, agriculture, construction, interstate, out-of-state, public fleet, utility fleet, power take off, tractor);

(4) In-state and out-of-state;

(5) Fifty calendar years (2000-2050);

(6) Two vehicle exhaust processes (start and running);

(7) Four evaporative processes (diurnal, hot soak, running loss, and resting loss);

(8) Seven pollutants (TOG, ROG, CO, CO2, NOx, PM, SOx) and greenhouse gases; and

(9) Fuel consumption.

To develop spatially-resolved emissions that are allocated in each AB 617 community, emissions from on-road motor vehicles are estimated at the grid level using Caltrans' Direct Travel Impact Model (DTIM). DTIM calculates emissions based on detailed information regarding each link (roadway segment) in an area for each hour of the day. Traffic volume, traffic speed, vehicle fleet characteristics, ambient temperature and humidity, and emission factors of vehicle fleets are all implemented in DTIM.

EMFAC2017 includes more subcategories than EMFAC2014 for some of the major vehicle class categories (i.e., medium-heavy-duty diesel trucks & heavy-heavy diesel trucks) based on their weights (heavy or small), types (agricultural, construction, CA international registration plan), road type (in-state or out-of-state), etc. However, the on-road mobile sources emissions in the 2016 AQMP are reported by major vehicle class categories to compare with previous inventory reporting.

The characteristics of DTIM include:

(1) Emission calculations based on specific information, such as link speed, link volume, and temperature and humidity;

(2) Spatial and temporal distribution of emissions to provide hourly gridded emissions; and

(3) Emission impacts of various types of transportation and regional planning alternatives (e.g., changes in roadway network configuration, or public transportation services).

DTIM reformats and sorts emission rates for all vehicle classes produced by EMFAC2017. It then produces average emission rates for specific vehicle classes identified by the user. Finally, it produces regional mobile source emissions and hourly gridded mobile emissions. DTIM does this by combining emission rates with the vehicle activity estimates derived from a transportation demand model and supplemental information on temperatures and temporal patterns.

There are differences in emissions calculated from DTIM and EMFAC2017. To account for the differences, scaling factors are developed to adjust DTIM emissions so that modeling emissions are consistent with EMFAC2017 emissions.

The approach used in the community inventories uses the same vehicle activities projected in SCAG's 2016 RTP/SCS and in the 2016 AQMP. In the 2016 AQMP, on-road mobile emission factors were based on EMFAC2014. However, CARB has since updated EMFAC2014 to EMFAC2017. Therefore, EMFAC2017 emission rates are used in developing community inventories. A noteworthy change in EMFAC2017 is the increase in truck emission rates, resulting in higher NOx and DPM emissions both for the current year and for the future years. Consequently, on-road DPM emissions in the Basin increased from a previous estimate of 552 in 2017 to 871 tons per year in 2017. Since the release of EMFAC2017, CARB has adopted four additional regulations that have significant impacts on DPM emissions. Details of these updates are discussed in Section 3.4.2.

3.2.4 Off-road Mobile Sources

Mobile sources not included in the on-road mobile source emissions inventory are classified as off-road mobile sources. CARB uses a number of models to estimate emissions for more than 100 off-road equipment categories. The models account for the effects of various adopted regulations, technology types, and seasonal effects on emissions. The models combine equipment population, equipment activity, horsepower, load factors, population growth, retirement factors, and emission factors to yield the annual emissions by county, air basin, or statewide. Temporal usage profiles are used to develop seasonal emission estimates that are then spatially allocated to or within the county or air basin using surrogates such as population[2]. The off-road inventory for the first year communities was developed based on the 2016 AQMP inventory, which used a suite of category-specific models. The OFFROAD2007 model was used if a new model was not available.

The largest adjustment in the inventory since the adoption of the AQMP is the ocean-going vessels (OGV) category to reflect the rapid growth of ports' activities. The OGV emissions in the 2016 AQMP indicated that NOx emissions from the ships would decrease over time despite a larger volume of ship traffic in the future. This would have been due to the turnover to cleaner vessels (i.e., vessels meeting International Maritime Organizations' Tier 3 engine standards). However, the updated OGV inventory shows NOx emissions increasing with time (reflecting delayed

[2] More information about off-road models can be found at http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles

turnover to cleaner vessels in the near future), while $PM_{2.5}$ decreases due to the impact of existing regulations.

In addition to an updated OGV inventory, a brief description of other category-specific methodologies is listed below:

- *Oil and Gas Wells: Workover Rigs, Drill Rigs, and Support Equipment Allocation:* The allocation of drill and work-over rigs and support equipment (such as pumps) for oil and gas wells was updated to reflect the physical location of wells instead of the registration location. The physical location and count of wells was updated using Division of Oil, Gas and Geothermal Resources (DOGGR) Well Finder data from September, 2013. (DOGGR data are available at: http://www.conservation.ca.gov/dog/Pages/Wellfinder.aspx)
- Cargo Handling Equipment: The emissions inventory for the Cargo Handling Equipment category has been updated to reflect new information on equipment population, activity, recessionary impacts on growth, and engine load. The new information includes regulatory reporting data which provides an accounting of all the cargo handling equipment in the State including model year, horsepower, and activity. Additional information is available at: http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles
- Pleasure Craft and Recreational Vehicles: A new model was developed in 2011 to estimate emissions from pleasure craft and recreational vehicles. In both cases, population, activity, and emission factors were re-assessed using new surveys, registration information, and emissions testing. Additional information is available at: http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles
- In-Use Off-Road Equipment: ARB developed this model in 2010 to support the analysis for amendments to the In-Use Off-Road Diesel Fueled Fleets Regulation. Staff updated the underlying activity forecast to reflect more recent economic forecast data, which suggests a slower rate of recovery through 2024 than previously anticipated. Additional information is available at: http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles
- Transport Refrigeration Units (TRU): This model reflects updates to activity, population, growth and turn-over data, and emission factors developed to support the 2011 amendments to the Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units. Additional information is available at: http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles
- Fuel Storage and Handling: Emissions for fuel storage and handling were estimated using the OFFROAD2007 model. Additional information is available at: http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles

3.3. Summary of Base Year (2017) Criteria Air Pollutants Emissions

The base year (2017) emissions are developed for the entire Basin and then emissions for each community are extracted as a subset. **Figure 10** shows the distribution of NOx, VOC and $PM_{2.5}$ emissions from point, area, on-road, and off-road sources in the Basin. NOx emissions are dominated by mobile on-road and off-road mobile sources. The largest emitters among on-road sources are heavy-duty trucks, whereas the largest contributors to off-road sources are off-road equipment and ocean going-vessels (**Figure 11**). Area sources are the largest contributor to VOC emissions, most of which originate from consumer products (**Figure 12**). Light-duty vehicles and off-road equipment are also significant sources of VOCs. Finally, area sources dominate $PM_{2.5}$ emissions, which are generated by miscellaneous sources including commercial cooking, paved road dust, and construction dust (**Figure 13**). PM from vehicles – from both exhaust, and tire and break wear – also contributes substantially to $PM_{2.5}$ emissions.

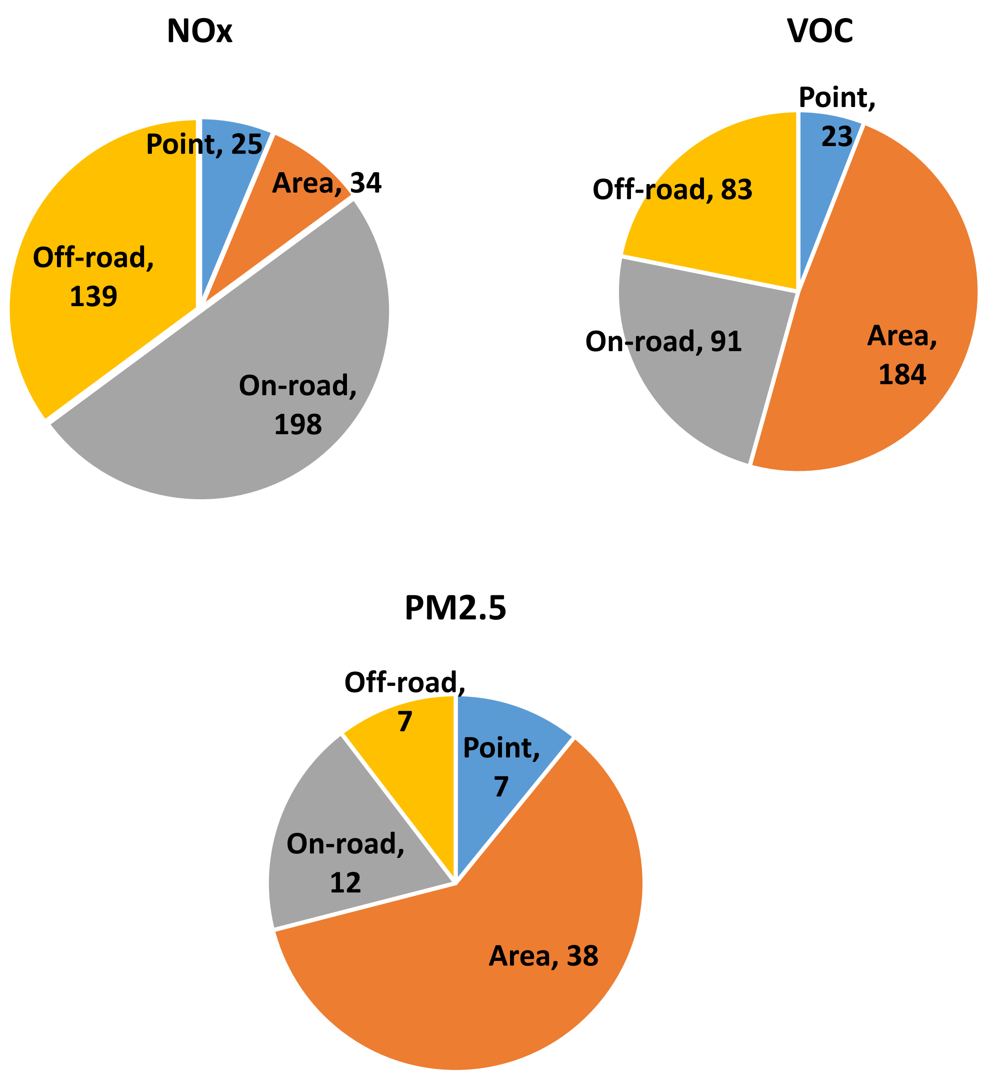

Figure 10. Emissions source distribution in the South Coast Air Basin for the year 2017 for NOx (top left), VOC (top right) and $PM_{2.5}$ (bottom). Emission values are shown in tons per day.

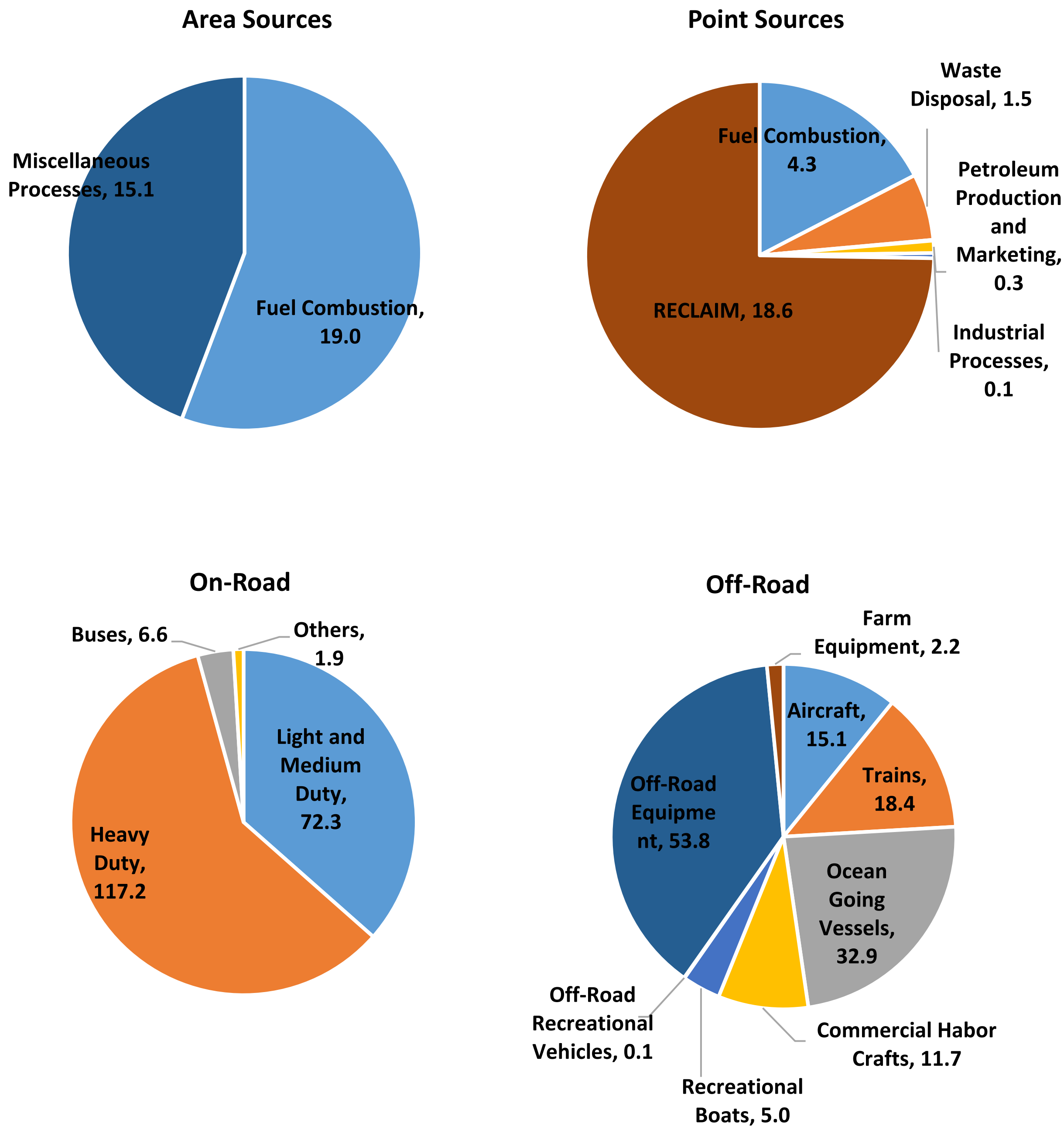

Figure 11. Source distribution of NOx emissions in the South Coast Air Basin for the year 2017: area sources (top left), point sources (top right), on-road sources (bottom left) and off-road (bottom right). Emission values are in tons per day

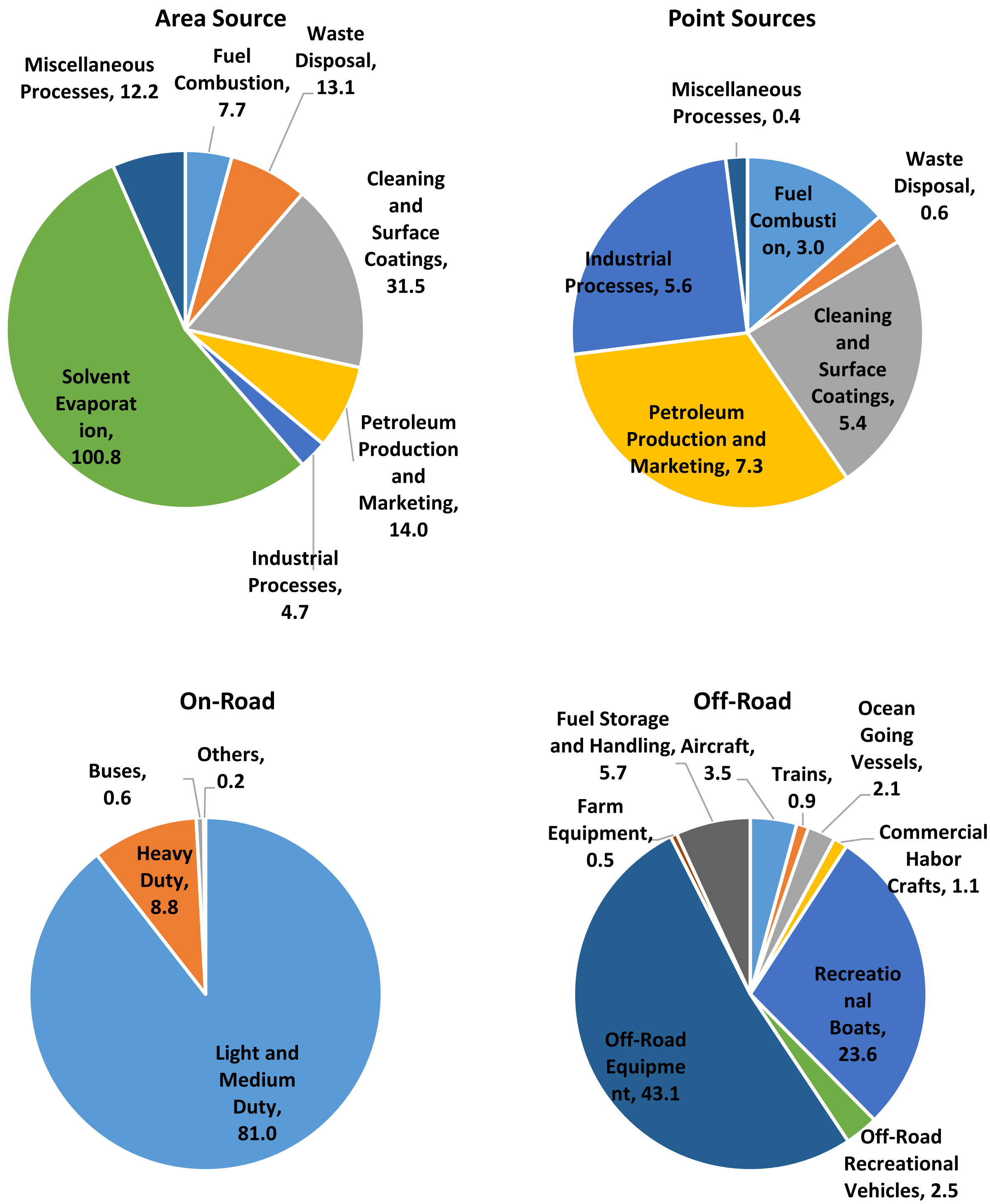

Figure 12. Source distribution of VOC emissions in the South Coast Air Basin for the year 2017: area sources (top left), point sources (top right), on-road sources (bottom left) and off-road (bottom right). Emission values are shown in tons per day.

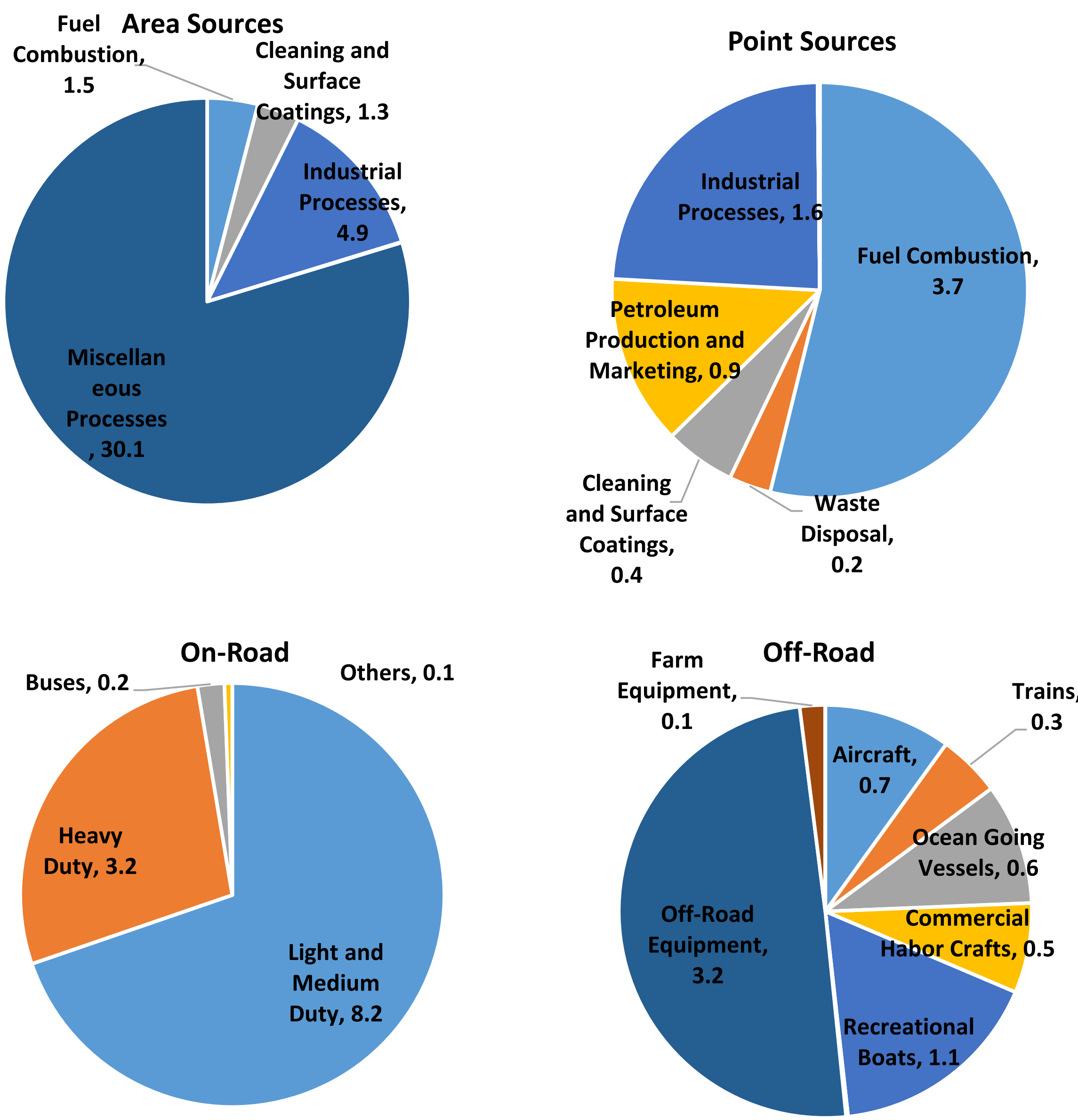

Figure 13. Source distribution of direct $PM_{2.5}$ emissions in the South Coast Air Basin for the year 2017: area sources (top left), point sources (top right), on-road sources (bottom left) and off-road (bottom right). Emission values are shown in tons per day.

3.4. Methodology to Develop Criteria Air Pollutants Emissions for Future Years

The Source Attribution analysis for the CERPs requires the projection of baseline emissions for 2024 and 2029. These projections assume that no additional air quality regulations are introduced beyond already adopted measures, establishing a baseline by which the impact of future measures can be evaluated. These emissions are forecasted from the 2017 base year by incorporating the controls implemented under South Coast AQMD rules adopted as of December, 2015, CARB rules, and a specific set of growth rates from SCAG for population, industry, and motor vehicle activity. For CARB's off-road mobile and area source regulations, CARB's rules adopted by November 2015 are reflected in the inventory. For on-road mobiles, four additional regulations adopted after the release of the EMFAC2017 were incorporated into the inventory. They are amendments to the smoke opacity regulation, amendments to HD engine warranty requirements, innovative clean transit, and zero emission airport shuttle buses. Control factors of those regulations are provided in the following section. SCAG's 2016 RTP/SCS provides estimated growth projections in population, housing, employment, industrial outputs and other socioeconomic parameters in future years. These control and growth parameters were used to project the growth of emissions. The 2016 AQMP also utilized more specific growth information where available to improve emission forecasts. For example, the 2014 California Gas Fuel Report's energy demand forecasts for natural gas, including energy efficiency, were used to forecast the emissions of those source categories.

The impact of New Source Review (NSR) and emissions budgeted for several South Coast AQMD programs are addressed in the Controlled Emission Data section. Due to the adoption of the Regional Clean Air Incentive Market (RECLAIM) program in October 1993, emissions from stationary point sources are divided into two categories, RECLAIM and non-RECLAIM. Future emissions from RECLAIM sources are estimated based on their allocations specified by South Coast AQMD Rule 2002. Amendments to Regulation XX in December 2015 established a 12 tons per day shave from the total RECLAIM Trading Credits (RTCs) for NOx by 2022. The 2016 AQMP included measure CMB-05, which further reduces emissions from the RECLAIM program by five tons per day by 2025, along with a sunset of the program. The current inventory for the AB 617 communities includes the NOx shave established in the December 2015 amendments, but not the additional cuts included in measure CMB-05. This is due to the ongoing rulemaking activities to implement CMB-05. Therefore, specific details such as implementation dates and emissions reduction schedules are not available yet. The methodology used to forecast emissions for point and area sources are described in the following sections.

3.4.1. Future emissions from stationary sources (point) and area sources

Baseline emissions for future years are obtained using the following equation:

$$\mathbf{FY_i = (BY_i)(CF_i)(GF_i)}$$

where FY_i is the forecasted emissions of an air pollutant for a future year. BY_i refers to the base year 2017 emissions of the air pollutant. The control factor, CF_i, is an indicator of the level of control on a specific source category as a result of adopted State and local air quality regulations. The GF_i is a growth factor determined for different categories of industry with socioeconomic data.

Control Factors

The impact of South Coast AQMD rules adopted or amended with compliance dates after 2012 are included in the baseline emission forecasts with control factors. Control factors were developed in reference to 2012 and applied to source categories and/or specific industries affected by the adopted rules/amendments. For industrial sources, the standard industrial codes (SIC) system is used. The U.S. EPA's SCC system is used for equipment. A control factor, CF_i, is calculated with the following equation for an individual source category:

$$\mathbf{CF_i = 1 - Control\ Efficiency}$$

Control efficiency is primarily based on the estimates projected during rulemaking. Control factors represent the remaining emissions after a rule or regulation is implemented after 2012. **Table 2** lists control factors for the years 2024 and 2029 for South Coast AQMD rules with post-2012 compliance dates. Since point sources emissions are based on 2017 AER data, control factors for point sources are normalized to 2017.

Table 2. Control Factors for South Coast AQMD Rules with Post-2012 Compliance Dates

			2024			**2029**			
Rule*	**Description**	**Full Implementation****	**NOx**	**SOx**	**PM**	**VOC**	**NOx**	**SOx**	**PM**
1110.2	Gaseous & Liquid Fuel Engines	2016	1.00	-	-	-	1.00	-	-
1111	Natural-Gas-Fired, Fan-Type Central Furnaces	2035	0.77	-	-	-	0.59	-	-
1113	Architectural Coatings	2014	-	-	-	1.00	-	-	-
1114	Petroleum Refinery Coking Operation	2018	-	-	-	0.87	-	-	-
1121	Residential - Natural-Gas-Fired Water Heaters	2015	1.00	-	-	-	1.00	-	-
1146	Large Ind/Comm Boilers, Steam Generator, & Process Heaters	2015	1.00	-	-	-	1.00	-	-
1146.1	Small Ind/Comm Boilers, Steam Generators & Process Heaters	2015	1.00	-	-	-	1.00	-	-
1146.2	Large Water Heaters & Small Boilers	2020	0.95	-	-	-	0.95	-	-
1147	NOx Reductions from Miscellaneous Sources	2023	0.94	-	-	-	0.94	-	-
1177	LPG Transfer and Dispensing	2023	-	-	-	1.00	-	-	-
444	Open Burning	2015	-	-	1.00	-	-	-	1.00
2005	Reclaim NOx		0.60	-	-	-	0.60	-	-

* Adopted or amended as of December 2015. Only rules with emissions impact after 2012 are listed above
** The year when a rule is expected to be fully implemented

Growth Factors

To quantify anticipated growth, a facility business type is assigned to the facilities based on North American Industry Classification System (NAICS) Code according to their primary activity. Growth projections by NAICS were developed by SCAG. The 2016 AQMP growth data is based on SCAG's 2016 RTP/SCS. The data was adjusted with the most recent data from the Energy Information Administration (EIA), Southern California Gas Company, Bureau of Land Management (BLM), and South Coast AQMD rule compliance records.

Each emission source in the inventory is projected to grow based on its growth surrogate. Growth surrogates include industry output growth, employment growth, demographic growth and others. The selection of the surrogate by which emission growth is projected depends on the type of activity. For instance, manufacturing sectors use output growth as a surrogate. Output growth is the product of employment and productivity. Employment growth is chosen for labor intensive sectors, such as construction and laundering. Certain emission sources use demographic data as a surrogate, such as architectural coatings (housing units as surrogate) and composting (population as surrogate). Some growth projections are from the Southern California Gas Company 2014 Gas Fuel Report for natural gas combustion related categories. A full list of the surrogates used in the future projections of emissions is provided in Appendix III of the 2016 AQMP (Table III-2-4 through Table III-2-18). The point source growth factors were normalized to 2017. Some examples of growth projections are listed in **Table 3**.

Table 3. Projected Growth of Population, Housing Units, Employment and Daily Vehicle Miles Traveled in the South Coast Air Basin

CATEGORY		2012	2019	2021	2022	2023	2025	2031
Population	Millions	15.9	16.7	16.9	17.0	17.1	17.3	17.9
	Growth (%)		4%	6%	7%	7%	9%	12%
Housing Units	Millions	5.1	5.5	5.6	5.6	5.7	5.7	6.0
	Growth (%)		7%	9%	10%	10%	12%	16%
Total Employment	Millions	6.7	7.5	7.6	7.7	7.8	7.9	8.2
	Growth (%)		12%	14%	15%	16%	18%	23%
Daily VMT	Millions	380	400	401	404	407	403	409
	Growth (%)		5%	5%	6%	7%	6%	8%

3.4.2. Future emissions from on-road sources

Projections of on-road sources are determined using projected travel demand data and projected future vehicle emission factors. Future travel demand data is obtained from SCAG's 2016 RTP/SCS, which forecasts changes in vehicle volumes and accounts for projected transportation projects, including development of new roadways. Emission factors for future years are extracted from EMFAC2017, which accounts for fleet turnover and vehicle regulations. Using the projected travel demand and future emission factors, future on-road emissions are calculated with the same approach as baseline on-road emissions.

Regulations adopted after the release of EMFAC2017 and associated emission reduction factors were provided by CARB. (**Table 4**). These control factors reduce $PM_{2.5}$ and NOx in addition to what EMFAC2017 projects for future years. The values for control factors are provided by CARB, and the adjustment of these new regulations would result in approximately 25% lower emissions of $PM_{2.5}$ and DPM in 2024 and the years thereafter.

Table 4. Control Factors for Emissions from Diesel Vehicles

		Correction Factor	
Regulation	**Pollutant**	2024	2029
Amendments to Smoke Opacity Regulation for Heavy-Duty Trucks	$PM_{2.5}$	0.754	0.748
Amendments to Heavy Duty Engine Warranty Requirement	$PM_{2.5}$	0.997	0.984
Amendments to Heavy Duty Engine Warranty Requirement	NOx	0.998	0.990
Innovative Clean Transit for Buses	$PM_{2.5}$	0.991	0.986
Zero Emission Airport Shuttle Buses	$PM_{2.5}$	insignificant	

3.4.3. Future emissions from off-road sources

Table 5 summarizes the data and methods used to forecast future-year off-road mobile source emissions by broad source category groupings.

Table 5. Growth Surrogates for Mobile Sources

Category		**Growth Methodology**
Gasoline-Fueled Equipment	Lawn & Garden	Household growth projection
	Off-Road Equipment	Employment growth projection
	Recreational Boats	Housing starts (short-term) and human population growth (long-term)
	Recreational Vehicles	Housing starts (short-term) and human population growth (long-term)
Diesel-Fueled Equipment	Commercial Harbor Craft	Growth rates provided by South Coast AQMD, except for tugs and fishing vessels. Fishing fleet growth rates were adjusted to reflect a decline in fish landings. Assumed no growth for tugboats.
	Construction and Mining	California construction employment data from U.S. Bureau of Labor Statistics
	Farm Equipment	2011 study of forecasted growth by URS Corp, with SJV Advisory Committee funding
	Industrial Equipment	California construction employment data from Bureau of Labor Statistics
	Oil Drilling	California oil and gas extraction gross domestic product from the U.S. Bureau of Economic analysis, oil company diesel fuel use published by the U.S. Energy Information Administration, California rotary rig counts from Baker Hughes, and California oil and gas extraction employment from the U.S. Bureau of Labor Statistics
	Ocean-Going Vessels	Projected commodity tonnage in the Freight Analysis Framework (FAF) Model developed by the Federal Highway Administration
	Trains (line haul)	International/premium train growth tied to OGV forecast; Domestic train growth tied truck growth
	Transport Refrigeration Units	Projection of historical Truck/Trailer TRU sales from ACT Research, adjusted for the recession

3.5. Summary of Future Years Criteria Air Pollutant Emissions

Projected emissions for the entire Basin are obtained after all the growth and control factors are applied to the 2017 emissions. **Figure *14*** shows the trends in emissions of criteria pollutants in the South Coast Air Basin. NOx emissions decline substantially due to large emission reductions from on-road vehicles. In addition, the point and off-road source NOx emissions are also expected to decline. Overall VOC emissions are expected to decline due to reductions in the on-road and off-road emissions, although the area sources are expected to increase due to an increase in consumer product emissions driven by population increase. $PM_{2.5}$ emissions are expected to remain unchanged. Reductions in $PM_{2.5}$ emissions from vehicles and off-road equipment are offset by increases in emissions from miscellaneous sources that are driven by increasing population. For example, PM emissions from on-road exhaust are expected to continue to decrease while PM emissions from paved road dust, tire and brake wear are expected to increase due to rising vehicles miles traveled (VMT).

Note that emission inventories for PM2.5 reflect only directly-emitted, primary PM2.5 emissions. The majority of ambient PM2.5 in the Basin, however, is not directly emitted but instead formed by precursor gases (NOx, SOx, VOC, and ammonia) undergoing chemical reactions in the atmosphere. Due to anticipated reductions in these precursors and the secondary PM2.5 they form, total ambient concentrations of PM2.5 are projected to drop even if future trends in primary PM2.5 emissions remain flat.

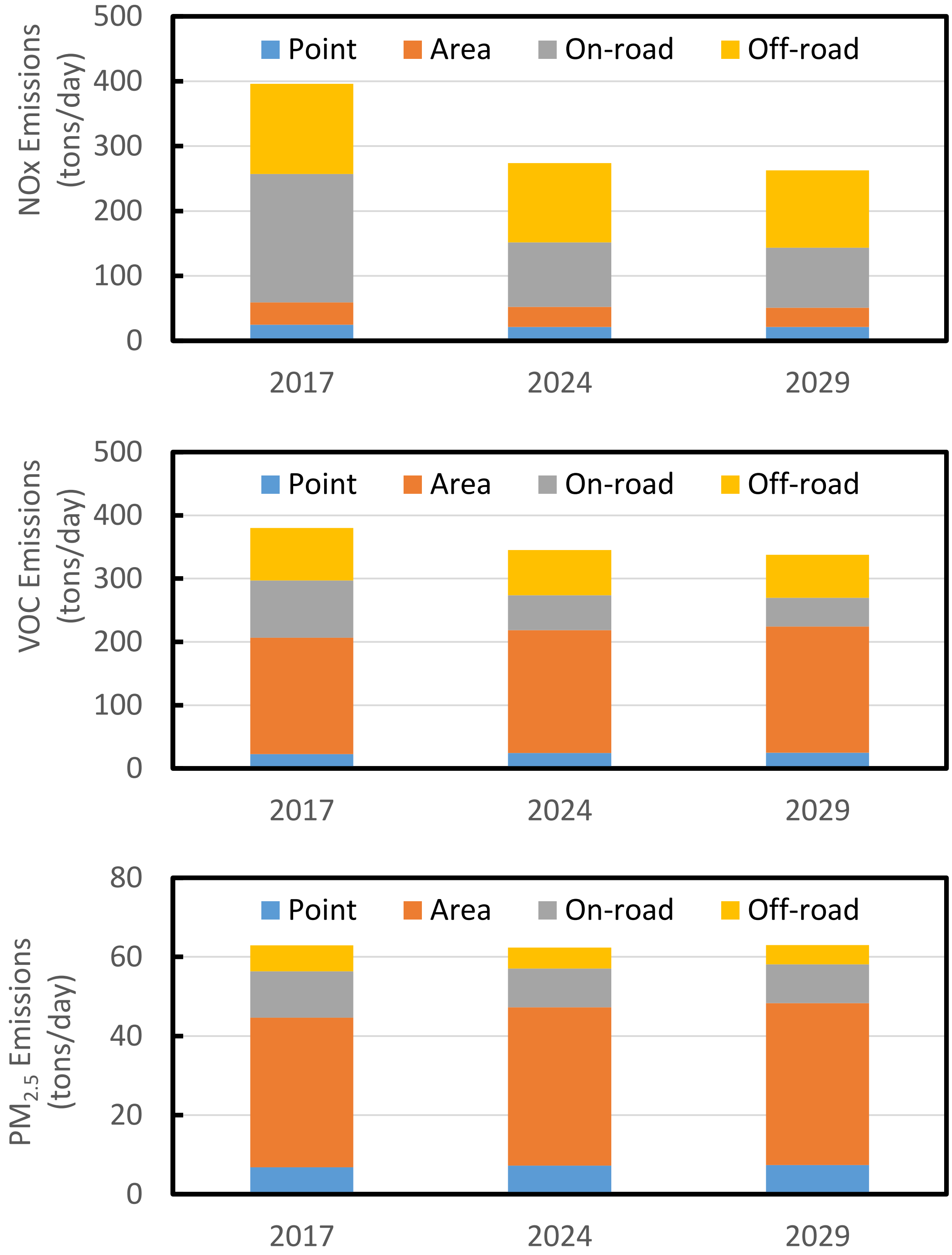

Figure 14. Trends in Criteria Pollutant Emissions in the South Coast Air Basin

3.6. Development of the Toxic Air Contaminant Emission Inventory

The inventory of air toxic emissions is built upon the methodology used for criteria pollutant emissions. Point source emissions are based on the reported data for the year 2017, whereas the rest of the sources – area, off-road and on-road emissions – are calculated using chemical speciation profiles for TOG and PM species. Speciation profiles for TOGs are used to estimate emissions of gaseous air toxics such as formaldehyde, benzene, and 1,3-butadiene. Speciation profiles for PM are used to estimate toxic compounds like metals (e.g. Cadmium, Hexavalent Chromium, Nickel, Arsenic, Lead). Exhaust PM emissions from diesel internal combustion engines are considered DPM. These speciation profiles are based on CARB's database (https://www.arb.ca.gov/ei/speciate/speciate.htm).

In total, 22 air toxic compounds were included in the base and future years' inventories. They are consistent with the basic TACs that AER facilities report to South Coast AQMD annually, except Chlorofluorocarbons (CFCs) and ammonia. CFCs do not have associated cancer risk and ammonia is a PM precursor, which is included in the CAPs table. **Table 6** lists the 22 air toxic compounds and their cancer risk factor used for the analysis in the report.

Table 6. List of Air Toxic Containments Reported in the Emission Inventory and their Associated Cancer Toxicity

		Type of pollutant	Toxicity 1/(ug/m3)*	Relative factor to DPM
1	Benzene	TOG	6.77E-05	0.09
2	Carbon tetrachloride	TOG	1.01E-04	0.14
3	Ethylene dibromide	TOG	1.69E-04	0.23
4	Ethylene dichloride	TOG	4.87E-05	0.07
5	Ethylene oxide	TOG	8.80E-05	0.12
6	Formaldehyde	TOG	1.42E-05	0.02
7	Methylene chloride	TOG	2.37E-06	0.003
8	Perchloroethylene	TOG	1.42E-05	0.02
9	1,3-Butadiene	TOG	4.06E-04	0.55
10	Vinyl chloride	TOG	1.83E-04	0.25
11	1,4 Dioxane	TOG	7.70E-06	0.01
12	Trichloroethylene	TOG	4.74E-06	0.01
13	Chlorinated dibenzofurans	TOG	N/A	
14	PAHs(Polycyclic aromatic hydrocarbon)	TOG	2.64E-03	3.55
15	Asbestos	PM	1.90E-04	0.26
16	Cadmium	PM	1.01E-02	13.58
17	Hexavalent chromium	PM	3.45E-01	463.71

18	Nickel	PM	6.16E-04	0.83
19	Arsenic	PM	8.12E-03	10.91
20	Beryllium	PM	2.40E-03	3.23
21	Lead	PM	2.84E-05	0.04
22	Diesel Particulate Matter (DPM)	PM	7.44E-04	1.00

*Toxicity values are presented in Appendix I of MATESIV (https://www.aqmd.gov/docs/default-source/air-quality/air-toxic-studies/mates-iv/a-appendix.pdf). Toxicity values are based on the updated methodology adopted by OEHHA in February, 2015 age-specific breathing rates, for age groups up to 2 years and 80th percentile breathing rates for age groups above 2 years, fraction of time at home of 1 for ages up to 16 years and 0.73 for age above 16 years, and 30 year exposures.

Future emissions of toxic air contaminants for the point and area sources are estimated using the same approach as for point and area source criteria pollutants, i.e., using growth and control factors. Additional control factors for toxic air pollutants are developed based on South Coast AQMD's toxic rules. Rules affecting future air toxic emissions are listed in **Table 7**. Rules 1420, 1420.1 and 1420.2 target lead emission reductions, Rule 1469 regulates emissions of hexavalent chromium emissions from chromium electroplating and chromic acid anodizing operations, Rule 1421 regulates emissions from dry cleaners, and Rule 1122 regulates emissions from solvent degreasers. **Table *8*** lists the overall emission reductions expected in the South Coast Air Basin in the three milestone years.

Table 7. List of South Coast AQMD Rules Affecting Toxic Air Contaminant Emissions in the South Coast Air Basin

Rule	Description
1420	Emissions standard for Lead
1420.1	Emissions standard for Lead and other toxic air contaminants from large lead-acid battery recycling facilities
1420.2	Emission standards for Lead from metal melting facilities
1469	Hexavalent Chromium emissions from Chromium electroplating and Chromic acid anodizing operations
1421	Control of perchloroethylene emissions from dry cleaning systems
1122	Solvent degreasers

Table 8. Additional Rule Impact Adjustments (Basin-wide Emission Reductions in lbs/year)

Rules	Impacted TAC	Date of Adoption or latest Amendment	2017	2024
Post EMFAC2017 Updates	DPM from On-Road Mobile Sources		1.0	0.752/ 0.991-0.998
Rules 1420, 1420.1, 1420.2	Lead from Point Sources *	12/2017, 09/2015, 10/2015	1.0	0.489
Rule 1469	Cr6+ from Point Sources Cr6+ from Area Sources	11/2018	1.0	0.10
Rules 1421 and 1122	Perchloroethylene from Area Sources	12/2002 and 05/2009	0.195	0.0
	Methylene chloride from Area Sources		0.496	0.496

* Battery recycling facilities
**0.752 for T6 and T7 truck categories and 0.991-0.998 for Buses

Note that the emissions in the following figures (**15** through **18**) are weighted based on the toxicity (hereafter referred to as toxicity-weighted emissions) of each TAC relative to diesel PM (DPM) as provided in **Table 6**. For example, a pound of Cr6+ has a cancer toxicity that is approximately 464 times higher than that of DPM. Thus, Cr6+ emissions are multiplied by 464 to estimate the toxicity-weighted emissions of Cr6+. The units in the toxicity-weighted DPM-equivalent emissions are expressed in pounds per year (lbs/year). This weighting approach enables a comparison of the contribution of each TAC to overall cancer risk using a consistent, toxicity-weighted scale. The toxicity factors are calculated using cancer potency and basin-average inhalation rates. This calculation is based in the updated methodology adopted by OEHHA in February, 2015 assuming an exposure value of 1 µg/m3, 90th percentile breathing rates for age groups up to 2 years and 80th percentile breathing rates for age groups above 2 years, fraction of time at home of 1 for ages up to 16 years and 0.73 for age above 16 years, and 30 year exposures.

Air toxic contaminant emissions in the South Coast Air Basin remain dominated by DPM emissions from on-road (**Figure 15**) and off-road sources (**Figure 16**), which is consistent with the analysis conducted for MATES IV (South Coast AQMD, 2015). DPM is expected to decrease substantially from diesel trucks, between 2017 and 2024 (**Figure 15**). Hexavalent chromium is the second largest contributor to air toxic emissions deriving from both vehicle and point sources related to fuel combustion and surface coating industries (**Figure 17**). The largest contributor to area source toxic emissions is fuel combustion in commercial and industrial processes that emit 1,3-butadiene.

Despite the large decrease in DPM emissions from heavy-duty trucks, DPM is expected to remain the highest contributor to toxicity in the Basin due to off-road equipment emissions. The impact of DPM will continue to affect communities near heavy-duty traffic, goods movement corridors, ports, and railyards. South Coast Air Basin total TACs emissions from all sources are shown in **Figure *18***

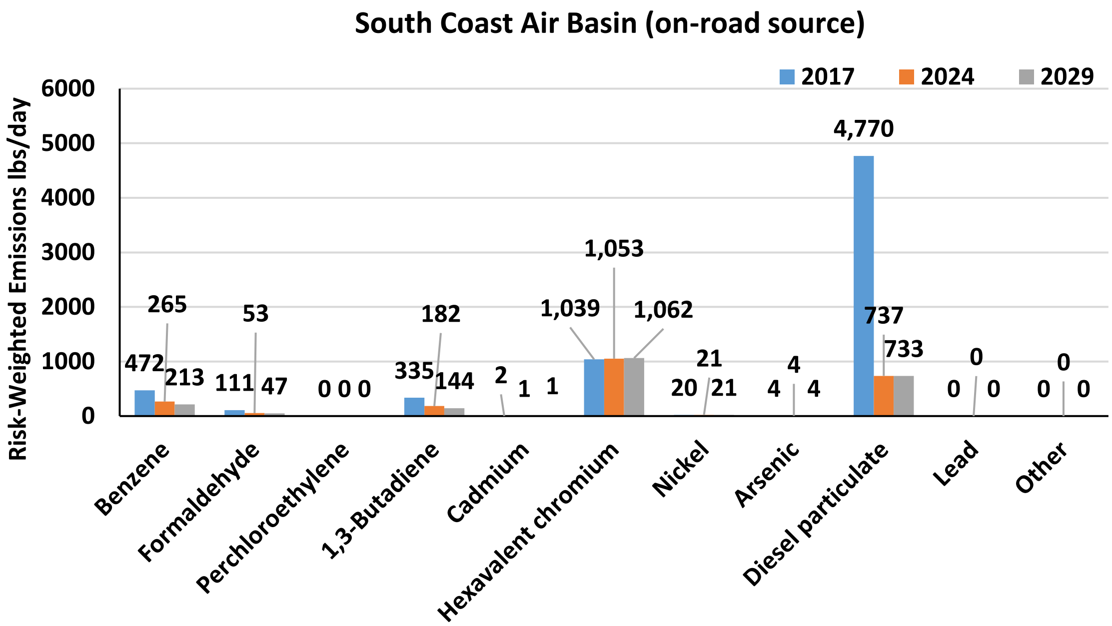

Figure 15. Toxic air contaminant emissions from on-road sources in the South Coast Air Basin. Emissions are weighted based on their toxicity relative to DPM.

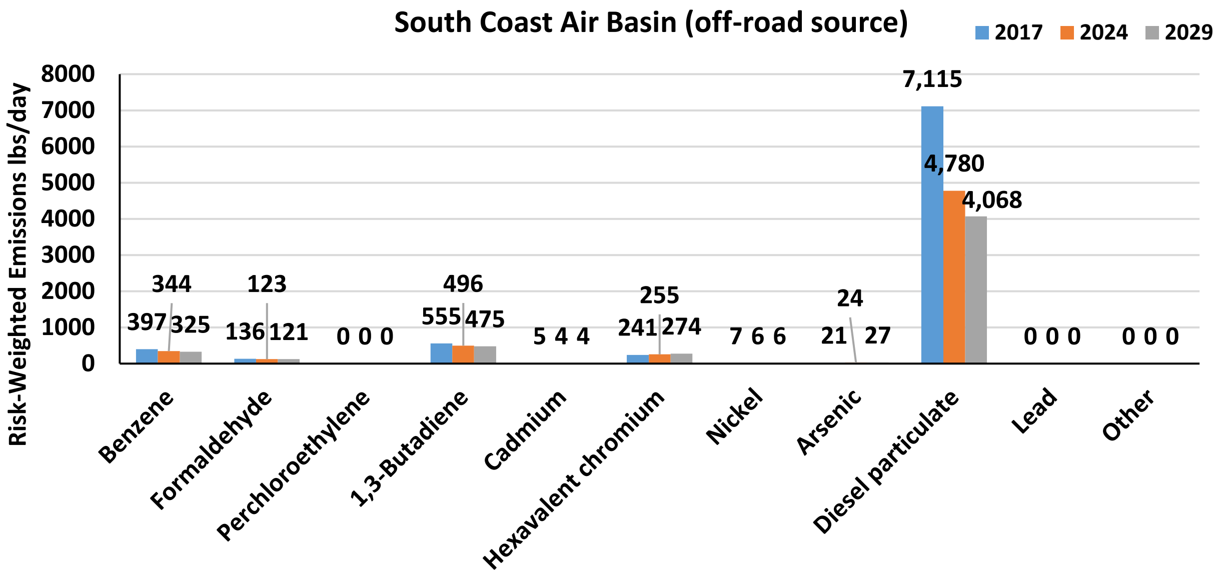

Figure 16. Toxic air contaminant emissions from off-road sources in the South Coast Air Basin. Emissions are weighted based on their toxicity relative to DPM.

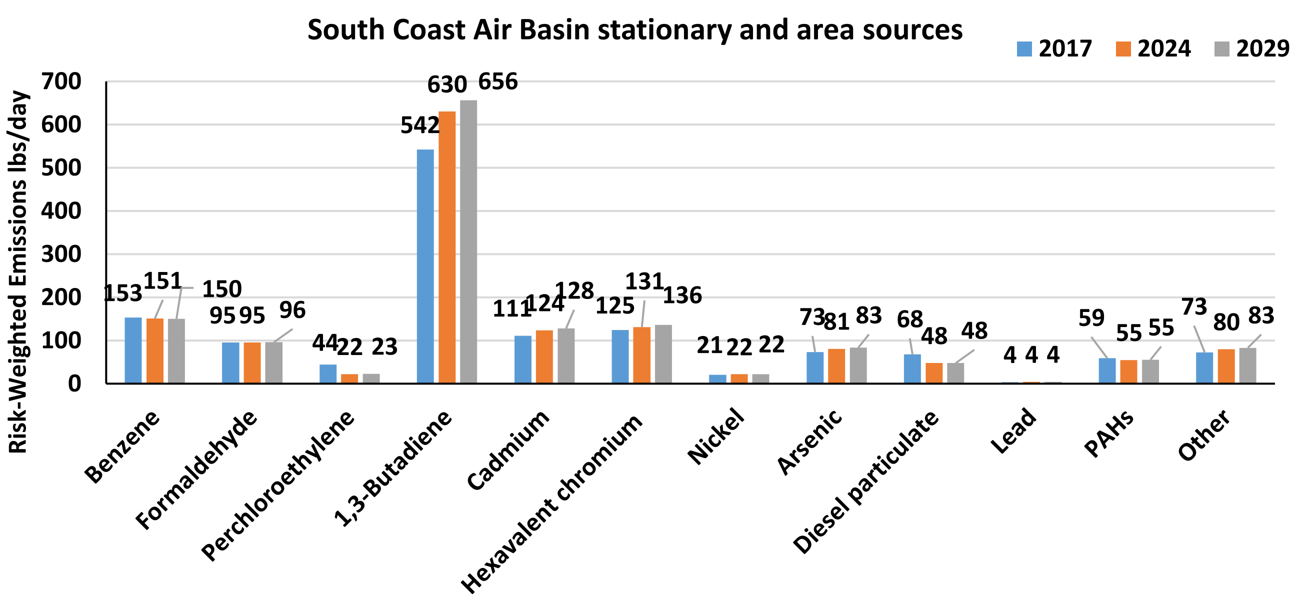

Figure 17. Toxic air contaminant emissions from area and stationary sources in the South Coast Air Basin. Emissions are weighted based on their toxicity relative to DPM.

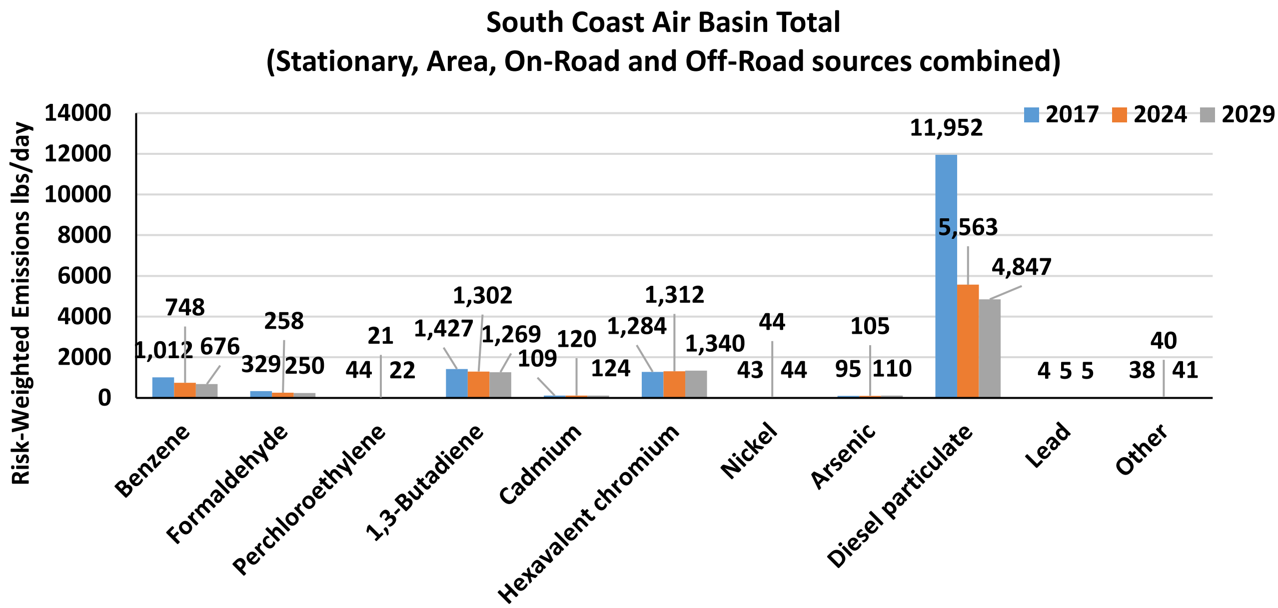

Figure 18. Toxic air contaminant emissions in the South Coast Air Basin. Emissions are weighted based on their toxicity relative to DPM.

Figure 19 presents the cumulative TAC emissions by the major categories for the three years of interest. The overall cancer-risk-weighted emissions decrease between 2017 and 2029. In particular, diesel heavy duty trucks and off-road equipment decrease substantially over the 12-year period, driving down the overall TAC emissions, despite a continuous increase in emissions from ships.

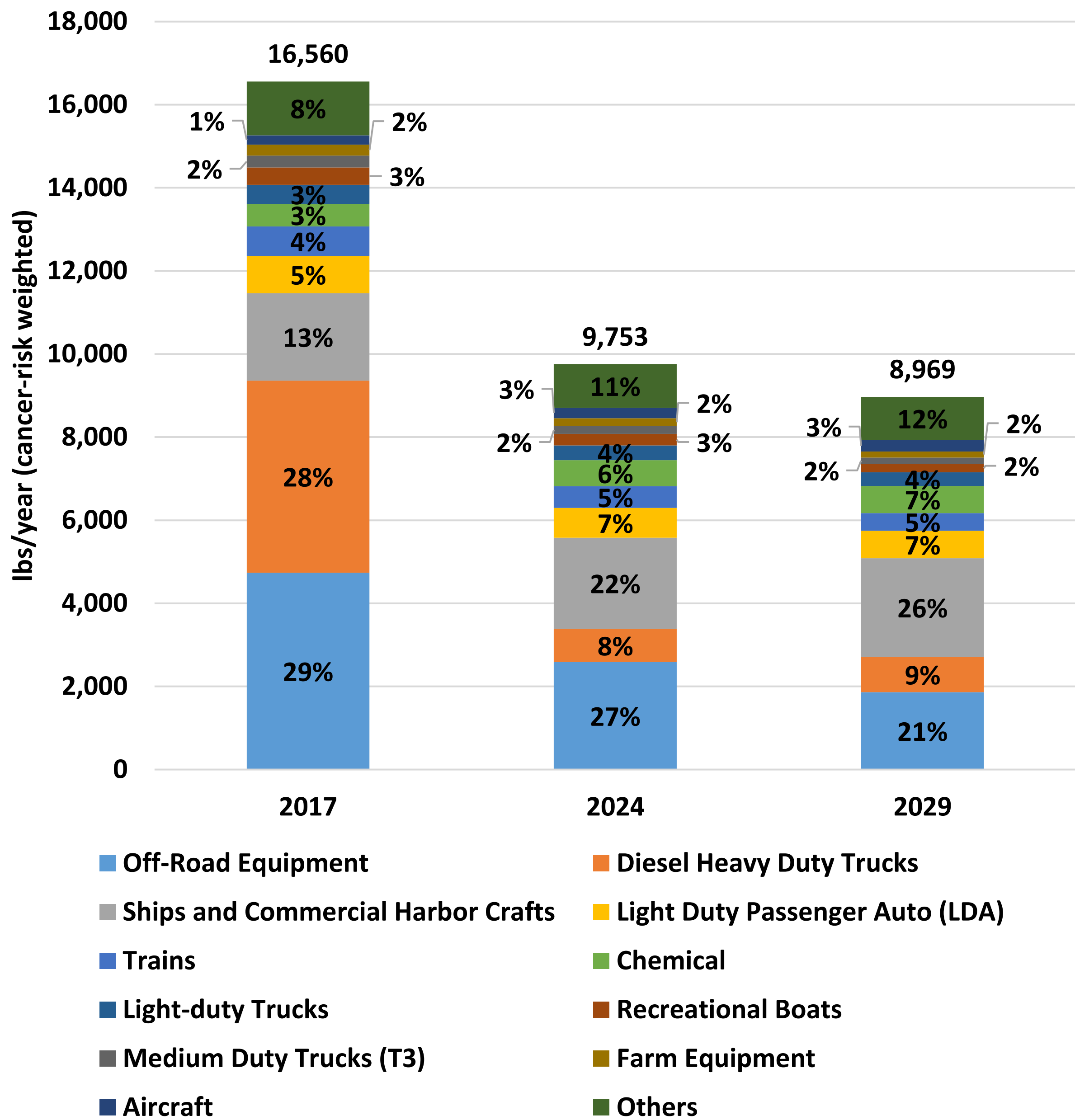

Figure 19. Toxic air contaminant emissions from all sources in the South Coast Air Basin, shown by major categories. Emissions are weighted based on their toxicity relative to DPM.

3.7. Uncertainties in Air Toxic Compounds Emissions

Emissions estimation contains inherent uncertainties, due to numerous assumptions and limited datasets, many of which are difficult to validate. Estimated emissions of toxic air contaminants have an even higher degree of uncertainty compared to estimates of criteria pollutants emissions. For the South Coast Air Basin, the emissions of CAPs have been evaluated closely for multiple decades due to the requirements set by the Clean Air Act. Because of the potential economic impacts of regulations, having an accurate inventory is critical for rule development purposes. TACs, while important to health risk assessment, have not historically had the same level of review as CAPs. Additional challenges for TACs are the vast number of TAC species, extremely low ambient concentrations for some species, the higher costs of measurements and complexity of source tests, and the variety of processes from which TACs are emitted.

The AB 617 guidance document recommends the use of reported emissions when available. Toxic emissions from point sources can also be estimated using speciation profiles using the same method as for area and mobile sources. Previous MATES studies relied on the speciation method. However, large discrepancies are sometimes observed between directly reported TACs and speciated toxic emissions based on PM and TOG emissions. The large discrepancies observed may be due to the uncertainties in assigning SCCs to sources, non-specific or outdated chemical speciation profiles, or indicate a need to improve measurement and reporting accuracy. Further evaluation is needed to resolve this discrepancy. The point source emissions included in the Appendix of each community's source attribution report are based on reported emissions, per CARB guidelines.

Mobile source air toxics inventories contain similar uncertainties. For example, urban buses were identified as a significant source of formaldehyde emissions in the current analysis, although they are not a significant source of criteria pollutants, such as NOx, VOC, and $PM_{2.5}$. This is likely due to the way the Compressed Natural Gas (CNG) fleet is represented in the speciation profile. The urban bus fleet in the South Coast Air Basin consists primarily of CNG vehicles. The EMFAC2017 web database indicates that CNG fueled buses account for 99.9% and 97.5% of the South Coast Air Basin total urban bus TOG and PM emissions, respectively. CNG engines emit a higher volume of TOG than diesel engines.

The current air toxics speciation methodology, which is based on a specific 14-digit EIC (Emission Inventory Code), does not accommodate a CNG bus specific speciation profile, but assigns diesel engine profiles for the CNG buses. Approximately 15% of TOG is allocated as formaldehyde in diesel exhaust. The same fraction was applied to TOG emission from urban buses to estimate formaldehyde. This likely overestimates formaldehyde emissions from urban buses, since previous studies by CARB (Yang and Allen, 2008; Yang, 2014) indicate that formaldehyde mass is approximately 10% of the CNG bus's TOG exhaust or even much less if a catalytic converter is used. While the emissions presented in the current report are the best currently available, further improvement is required to adjust the likely bias.

Among the species contributing to the overall toxicity is hexavalent chromium, which is emitted from industrial processes as well as mobile sources, specifically from exhaust and brake wear. Emission factors of hexavalent chromium from these sources are not readily available, and CARB speciation profiles do not include these sources. During previous MATES studies, an empirical adjustment was introduced to address hexavalent chromium from engine exhaust PM and brake wear. Modeling results confirmed the validity of the adjustment in MATES II (South Coast AQMD, 2000) and MATES III (South Coast AQMD, 2008). While further refinement is needed as the emission factors evolve with newer EMFAC models, detailed evaluation of the emissions from brake wear is warranted, as VMT is steadily increasing along with population growth in the South Coast Air Basin. Some speciation profiles for the exhaust of internal combustion engines are likely outdated and may need updates as well. Further adjustment will be explored to support the upcoming MATES V study and updates to CERPs in current and upcoming AB617 communities.

4. Updates and On-Going Improvements

South Coast AQMD continues to develop new resources and tools to improve the capabilities to better model and analyze the effects of air pollution in the region. South Coast AQMD strives to develop emission inventories that employ the most up-to-date information. Currently, South Coast AQMD is beginning the modeling phase for MATES V, which intends to estimate toxicity at a higher grid resolution than used in the previous studies.

There is a high degree of uncertainty in the VOC emissions inventory, especially fugitive emissions from stationary sources. Recently adopted Rule 1180 establishes requirements for refinery fenceline monitoring. The additional measurement data will help refine emissions estimates from large emitters. In addition, the South Coast AQMD is working to improve measurement techniques, using mobile platforms like the Fluxsense system, which will improve the quantification of VOC emissions.

South Coast AQMD continues to actively pursue the improvement of emission modeling tools. Biogenic emissions are one of the major sources with great levels of uncertainty. Urban biogenic VOCs contribute to ozone and secondary particle formation. South Coast AQMD has initiated a research project with University of California, Irvine, to improve the emissions inventory of biogenic emissions in the South Coast Air Basin.

Airports and ports are major facilities that contribute to the overall emissions in the South Coast Air Basin. There are ongoing efforts to better characterize the emissions of such operations. Following a control measure listed in the 2016 AQMP, the South Coast AQMD is currently working with the ports and commercial airports to develop emissions reductions strategies under Memoranda of Understandings that will also include updating of the emissions inventories for these facilities. This effort will improve the quantification of emissions for activities in the ports and commercial airports and will assist in refining the emission inventories of communities that are close to those operations, e.g. Wilmington, Carson, West Long Beach.

Aircraft emissions contribute significantly to the air pollution in the area. South Coast AQMD is switching to the Federal Aviation Agency's Aviation Environmental Design Tool (AEDT) model, from the Emissions and Dispersion Modeling System (EDMS) used in prior AQMPs, to further refine aircraft emissions by including three-dimensional allocation of aircraft take-off and landing emissions. The improvements in this sector will help refine emissions in areas near airports.

Ongoing work to develop the indirect source rules, for warehouses and distribution centers, railyards, and new and re-development projects, will help develop and refine local emission estimates at these facilities. South Coast AQMD and CARB are working to improve our understanding of off-road mobile sources and heavy-duty truck emissions related to goods movement. This will further improve the emission inventories of communities impacted by goods movement.

All new emission modeling efforts that are under development will help establish emission modeling capabilities that will be part of the 2022 AQMP. As in previous efforts, emission modeling tools are under continuous improvement, which will contribute to the development of emissions inventories in future years. Improvements in the emission estimates will benefit current and future efforts to develop emission inventories for AB 617 communities.

5. Summary

Previous efforts by South Coast AQMD, such as AQMPs and MATES, were utilized to identify major sources of toxicity and air pollution-related premature mortality in the South Coast Air Basin. In MATES IV (South Coast AQMD, 2015), emissions inventory and air toxic modeling were used to support the analysis of the potential sources that contribute to toxicity in the South Coast Air Basin. Results showed that DPM is by far the largest source of emissions that contributes to toxicity in many areas of the South Coast Air Basin. MATES IV (South Coast AQMD, 2015) included emissions and air quality modeling, and exposure analysis that used two of the techniques recommended by CARB to calculate air pollutant source attribution.

This report describes the methodologies to estimate CAP and TAC emissions from point, area, and on-road mobile and off-road mobile sources for the year 2017, and to project the emissions to two future milestone years: 2024 and 2029. Point source emissions were based on the South Coast AQMD's AER database. On-Road mobile source emissions were calculated from SCAG's travel activity and EMFAC2017 vehicle emission rates. Area and off-road mobile source emissions were estimated from statewide consumption and activity data and then allocated to community locations using a category-specific spatial allocation metrics. Future emissions were projected based on economic growth and controls required by current air quality regulations.

NOx and VOC emissions are expected to decrease in future years, but direct $PM_{2.5}$ emissions will stay similar to current level. This is due to the growth in paved road dusts and cooking, both of which are associated with economic and population growth in the South Coast Air Basin. Unlike $PM_{2.5}$, DPM is expected to decrease substantially in the future due to CARB's recent regulations on heavy duty trucks and other mobile sources. Nevertheless, DPM continues to be the predominant source of air toxic cancer risk in the South Coast Air Basin.

Except for point sources, the accuracy of emissions from on-road, off-road, and area sources rely on the resolution and accuracy of spatial surrogates. The emissions for the first year communities primarily relied on 4 km grid spacing except where finer gird information was available, such as the shape of roadways used in the SCAG's travel demand model. Finer resolution will help improve the emission estimates at the community level.

Source attribution for the first year communities relies on emission modeling tools developed in previous efforts, with recent refinements in point source emissions and improvements in surrogate information. Modeling tools are in constant development, which will help improve the emission modeling and source apportionment tools for AB 617 communities in the future.

6. References

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