Appendix B1b

Point, Quasi-Point, Nonpoint, and Marine/Air/Rail Inventory Development Overview

(Maryland)

Base Year 2017 Emissions Inventory

(Washington, DC-MD-VA 2015 Ozone NAAQS Nonattainment Area)

Maryland Department of the Environment

Larry Hogan
Governor

Boyd Rutherford
Lieutenant Governor

Ben Grumbles
Secretary

2017 SIP Emissions Inventory Methodologies

FOR THE WASHINGTON DC-MD-VA 2008 OZONE NAAQS NONATTAINMENT AREA

Prepared for:

U.S. Environmental Protection Agency

Prepared By:

Maryland Department of the Environment

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2017 Emissions Inventory Methodologies

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1.0 INTRODUCTION

The 2017 Emissions Inventory and Methodologies is being prepared for the purpose of describing the Scope of Work required to prepare an emission inventory of sulfur dioxide (SO2), nitrogen dioxide (NO2), ammonia (NH3), particulate matter (PM10 and PM2.5), and volatile organic compounds (VOC) emissions for the State of Maryland. The federal Clean Air Act (CAA), 42 U.S.C.A § 7401 et seq, as amended by the Clean Air Act Amendments of 1990, P.L. 101-549, (referred to hereafter as the Act) requires all areas of the nation to attain and maintain compliance with the federal ambient air quality standards. These federal standards are designed to protect the public health and welfare from these six criteria pollutants. These standards are referred to as the National Ambient Air Quality Standards (NAAQS). Areas that meet the NAAQS are referred to as “attainment areas”; those that do not are referred to as “nonattainment areas.” The document will provide an outline for content and organization review of the inventory. The goal is to provide guidance on the development of a reliable inventory, the quality of emissions data collected and provide for acceptable documentation and reporting of this information. The Maryland Department of the Environment Air and Radiation Administration (MDE-ARA), the Maryland Department of Transportation (MDOT), and the Metropolitan Washington Council of Government (MWCOG) will be involved in preparing various portions of the inventory by contributing information that is necessary for developing emissions estimates.

The final inventory document will include emissions from point sources, quasi-point sources, area sources, on-road mobile sources, non-road mobile sources, and biogenic emissions. MDE-ARA will use the MOVES NOROAD Model for small engine emissions. MDE-ARA will supply emissions for major point sources and area sources, and will accept EPA estimates for biogenic emissions. Mobile source emissions will be estimated using the MOVES Model.

The applications for emissions inventory data include use of the data in annual trends reports, State Implementation Plans (SIPs), compliance demonstrations, emissions trading, emissions fees programs, and in modeling activities designed to evaluate ambient air concentrations encountered by the general public. For the SIP program, the air emission inventory is a fundamental building block in developing an air quality control and maintenance strategy. Section 172, Part C, of the Clean Air Act (CAA) as amended in 1990, which addresses SIP requirements, states that “. . . plan provisions shall include a comprehensive, accurate, current inventory of actual emissions from all sources or the relevant pollutants or pollutants in such area . . .”. Regulatory agencies and industrial facilities rely on emission inventories on an ongoing basis as indicators of air quality changes and for setting permit requirements.

The end use of emission inventories requires that they be of the highest quality obtainable. They are the foundation of air quality decisions. Inventory quality is critical to defining realistic regulations and attainment strategies. Deficiencies and inconsistencies in existing compilation processes accentuate the need for developing and implementing more uniform and systematic approaches to collecting and reporting data. One of the primary goals of the document is to improve the quality of inventory data collection so that it is a reliable source of information for sound decision-making.

The intent of this report is to describe how the inventory was prepared and what information was considered in the inventory development.

This document is comprised of six sections, one section for each source category type.

1.1 Seasonal Adjustments

ARA has collected extensive data for the temporal allocation of emissions. Companies send us annual, quarterly, monthly, and daily usage, activity, and emission estimates. More specific information allows allocation of emissions to time of day.

In cases where the facilities did not provide peak ozone season emission estimates, the peak ozone season emissions were calculated by the following method and are included in the emissions summary tables, by county, at the end of this section:

1) Annual emissions in tons per year were converted into tons per day emissions by dividing annual emissions by operating days,
2) Tons per day emissions were then multiplied by a seasonality factor,
3) The seasonality factor was based on the quarterly percentage of operations estimated by the company adjusted for June, July, and August.
4) The ratio obtained in Step 3 was multiplied by the daily emissions calculated in Step 1 to generate the seasonally adjusted emissions.

TEMPORAL ADJUSTMENTS

Temporal adjustments are made because of seasonal differences in the rate of emissions or activity, or to apportion emissions to a particular season, day or hour. The best method for temporal adjustment is the one that produces the most accurate activity or adjustment factors for a source category reflecting the inventory time period and locality.

ARA accounts for temporal adjustment calculations by using the following methods:

- Seasonal Adjustments Factory (SAF) was applied to the calculated annual emission estimates within a period.

$$\text{SAF} = \frac{\text{Emissions per year}}{(\text{Operating days/week})\ (\text{Operating weeks/year})}$$

For example, if a VOC source category has one third more emissions during the 3-month ozone ratio: seasonal adjustment factor, the ratio of seasonal activity or emissions to average period emissions would equal SAF = 0.33/0.25 = 1.33.

- Heat Degree Days (HDD) or Average Temperature (**TEMP AVG**) Seasonal Adjustments Factory (SAF) was applied to the calculated annual emission estimates within a period.

HDD

$$\text{SAF} = \frac{\text{Emissions per year}}{(\mathbf{TEMP}_{AVG}\ \text{period/month})\ (\mathbf{TEMP}_{AVG}\text{/year})}$$

For example, if a VOC source category has one third more emissions during the 3-month ozone ratio that is June, July and August: HDD seasonal adjustment factor, the ratio of seasonal activity emissions to average period emission $\mathbf{TEMP}_{AVG}$ HDD SAF = 5339/15763 = 0.338701.

Nonroad:
For this source calculations were estimated using the NMIM model for nonroad emissions. The daily emissions function for the model was not working. Monthly emissions were generated and the summer months June, July, and August were averaged to give us an average summer day emission for each source represent in the model.

Ammonia Sources:
These source calculations were estimated using the Carnegie Mellon Ammonia (CMU) model for Nonpoint ammonia emissions. The sources represented in the model are constant all year and therefore the annual were divided by 365 to obtain average daily emissions.

1.2 Air Emissions Reporting Requirements (AERR)

MDE-ARA compiled a 2002 point source emission inventory in order to satisfy EPA reporting requirements under the Air Emissions Reporting Requirements. This will be the primary resource for developing refined estimates of $PM_{2.5}$ and NH_3 emissions.

2.0 Point Sources

2.1 INTRODUCTION

The Maryland Department of the Environment Air and Radiation Administration (ARA) is the lead agency responsible for compiling the point source emissions inventory, including identification of sources, documenting the method used to calculate emissions from each source, and presenting the findings. Emissions and emissions data are collected and calculated annually for facilities and businesses that fit the criteria to be a point source.

The Maryland stationary point source inventory is the result of efforts to characterize air emissions sources since the early 1970's. This section describes data collection, verification and emission estimation methods used to estimate point source emissions from stationary sources.

For the 2017 Periodic Emissions Inventory a point source located within a designated ozone nonattainment area is defined as a stationary commercial or industrial facility that operations and emits more than 10 tons per year of volatile organic compounds (VOC); or a 100 tons per year of carbon monoxide (CO), sulfur oxides (SO_x), particulate matter with an aerodynamic diameter less than 10 micrometers (PM_{10}), diameter less than 2.5 micrometers ($PM_{2.5}$), and total suspended particulates (TSP); or 25 tons per year of oxides of nitrogen (NO_x). These emissions criteria are more commonly refer to as “emissions thresholds” or simply, “thresholds.” Areas of the state classified as unclassifiable/attainment for ozone have the same thresholds except for oxides of nitrogen (NO_x), where the threshold is 100 tons per year NO_x.

2.1.1 COMPILING THE POINT SOURCE LIST

Maryland has a substantial database of both small and large air emission sources compiled over the last eighteen years. Since the thirteen central counties of Maryland and Baltimore City have been nonattainment for ozone since before 1982 and 80% of the state's population and major industrial sources lie within these counties, the database of over 10,700 sources (both above and below the point source thresholds) is reasonably complete. The list of point sources in this inventory was developed by applying the appropriate thresholds to the emission levels in the database to differentiate between point and area stationary sources. Sources with emission levels greater than the threshold or sources previously included in PEI submittals are by definition point sources while sources with emissions levels less than the thresholds are by definition area sources.

Several methods of source identification are used by ARA to ensure the point source inventory is as complete as possible. The primary data source is the Permitting Program, which oversees the registration requirements found in Title 26, Subtitle 11, Chapter 02, Code of Maryland Regulations (COMAR). The Compliance Program identifies other point sources though annual facility inspections and through investigations conducted in response to citizen complaints.

The primary means of new source identification is the steady influx of permit applications and equipment registrations. Many sources are required by COMAR 26.11.02, Permits, Approvals and Registration, to register with ARA. From 700 to 1,000 new sources are registered with the Department each year.

Most of these sources are not considered to be point sources as defined for inventory purposes, even though they require permits. As an example, emissions from some sources can be less than one ton per year. However, all sources that are registered with the Department are tracked until the Department receives notification that the equipment or emission source has ceased operations. An emissions source or its equipment is not permanently deleted from the registration database until the installation is demolished.

A secondary means of new source identification are the emission sources identified by Compliance Program staff during annual field inspections of major point sources. During these inspections, unregistered equipment is sometimes discovered. Statewide response to the Air Pollution Report and the Air Quality Complaint Hotline, has also led to the discovery of previously unidentified emissions sources. Sources discovered in this manner may be the result of the citizen complaints, or the result of further investigation of visual evidence such as buildings, storage yards, visible emissions, etc., sighted elsewhere during the response.

Maryland includes in its 2017 SIP submittal point sources that meet or are greater than threshold levels, and sources with emissions levels less than the thresholds are considered to be Area/Non-point sources.

ARA monitors and collects emissions thru its Compliance and Permitting Programs, which oversees the registration requirements found in Title 26, Subtitle 11, Chapter 02, Code of Maryland Regulations (COMAR), and its Compliance Program which identifies other point sources through annual facility inspections and through investigations conducted in response to citizen complaints.

Facility and business permit applications and equipment registrations are constantly tracked, updated, and monitored.

2.1.2 Emission Reporting Requirments for Major Sources

Facilities are required by Maryland air quality regulations COMAR 26.11.01.05-1 and 26.11.02.19D to certify the air emissions for the past calendar year. The certified emissions are used for inventory and planning purposes as well as to form a basis for billing of Permit-to-Operate fees.

The air pollutants to be certified fall into the categories of criteria air pollutant, toxic air pollutant or greenhouse gas air pollutant. Criteria pollutants are particulate matter (reported as PM10, PM2.5, and total particulate), sulfur oxides (SOx), nitrogen oxides (NOx), carbon monoxide (CO), lead (Pb), and volatile organic compounds (VOC). All forms of particulate matter must be broken down and reported as follows:

(1) Primary PM, PM10 and PM2.5: Particles that enter the atmosphere as a direct emission from a stack or an open source. It is comprised of two components: Filterable PM and Condensable PM. (these two PM

components are the components measured by a stack sampling train such as that specified by EPA Method 5 and have no upper particle size limit.)

(2) Filterable PM, PM10 and PM2.5: Particles that are directly emitted by a source as a solid or liquid at stack or release conditions and captured on the filter of a stack test train.

(3) Condensable PM, PM10 and PM2.5: Material that is in a vapor phase at stack conditions, but which condenses and/or reacts upon cooling and dilution in the ambient air to form solid or liquid PM immediately after discharge from the stack.

There are 192 toxic air pollutants. A copy of the air toxics list is available on the MDE website. Greenhouse gas air pollutants include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Fuel burning sources emit CO_2, CH_4, and N_2O. Only certain industrial sources emit HFCs, PFCs, and SF_6.

The emissions certification must be submitted in hard copy to the Air and Radiation Administration (ARA) offices annually by April 1st. Copies of the forms needed to complete the certification are located on the Maryland Department of the Environment website at https://mde.maryland.gov/programs/Air/AirQualityCompliance/Pages/index.aspx.

MDE's Compliance Program staff performs field inspections of major point sources. During these inspections, unregistered equipment is listed and registered equipment is check to see if they are working properly and operating according to state guidelines.

2.1.3 EMISSION CALCULATIONS and Verification

Major source facilities certify that the emission estimates that are submitted to the Department are accurate to the best of their knowledge. Typically technical staff use one of the following methodologies to calculate criteria pollutant emissions:

- EPA-supplied emission factors
- Material balances
- Emissions based on source test data
- Continuous emissions monitoring data
- Agency or company-generated emission factors

After receiving the emission certification reports for major sources the staff review the reports for completeness and correctness. MDE ARA staff review the reports to verify emission estimation calculations. Of particular importance are the estimation of emissions and the documentation of calculations. Accuracy and consistency will be checked. Any errors in calculation will be corrected before data is entered into the state data system.

After verifying the accuracy of the emission estimates and methodology, the results are then enter into MDE's Enterprise Environmental Management System (EEMS). The primary vehicle to integrate data collection is Tools for Environmental Management and Protection Organizations (TEMPO) developed by AMS, now called CGI. TEMPO is an Oracle-based relational database management system that uses Sybase Powerbuilder multi-tier client/server based modules. Along with TEMPO, the Department is incorporating Information Builder's WebFOCUS, fully integrated enterprise business intelligence and reporting platform.

When all discrepancies are resolved to the satisfaction of MDE, the final emissions estimates are then submitted as an update to MDE's EEMS-TEMPO state database system. All sources are checked to ensure data has been correctly reported. Plant level emissions in the emission certification reports will be compared to the reported level in the state system. Discrepancies will be corrected. The total facility estimate is used to determine whether the facility satisfies the criteria for classification of as a point source.

2.1.4 EPA Clean Air Market (CAMD) Reporting Requirements

The Clean Air Markets Division (CAMD) was developed by EPA to fulfill obligations under Part 75 of Volume 40 of the Code of Federal Regulations. The purpose was to establish continuous emission monitoring (CEM) and reporting requirements for electric generating units (EGUs) that burn fossil fuels and that serve a generator greater than 25 megawatts. Facilities that meet this requirement must submit hourly emissions data via the Emissions Collection and Monitoring Plan System (ECMPS).

ECMPS is a desktop tool that sources must use to submit monitoring plans, QA data, and emission data to EPA to comply with the Acid Rain Program, Cross-State Air Pollution Rule (CSAPR), and the Mercury and Air Toxics Standards (MATS).

For this select group of sources in Maryland, MDE ARA chose to collect emissions data from the CAMD Air Markets Program Data. MDE ARA selected this dataset over the MDE certified annual or daily reported emissions because the temporal profile of the data generated an ozone season daily emission estimate that was more precise.

2.1.5 MDE ARA Point Source Submittal

2.1.5.1 MDE ARA EEMS-TEMPO

Maryland's EEMS-TEMPO emissions database system records annual and peak ozone season daily emissions (when supplied).

In cases where the facilities did not provide peak ozone season emission estimates , the peak ozone season emissions were calculated by the following method and are included in the emissions summary tables, by county, at the end of this section:

1) Annual emissions in tons per year were converted into tons per day emissions by dividing annual emissions by operating days,
2) Tons per day emissions were then multiplied by a seasonality factor,
3) The seasonality factor was based on the quarterly percentage of operations estimated by the company adjusted for June, July, and August.
4) The ratio obtained in Step 3 was multiplied by the daily emissions calculated in Step 1 to generate the seasonally adjusted emissions.

2.1.5.2 EPA CAMD

For CAMD reporting sources MDE averaged the daily ozone season pollutant emissions (in tons).

3.0 QUASI-POINT SOURCES

3.1 INTRODUCTION

The Maryland Department of the Environment Air and Radiation has identified several facilities that due to size and/or function are considered point sources. These establishments contain a wide variety of air emission sources, including traditional point sources, on-road mobile sources, off-road mobile sources and area sources. For each particular establishment, the emissions from these sources are totaled under a single point source and summary documents include these "quasi-point" sources as point sources.

3.2 ANDREWS AIR FORCE BASE (JOINT BASE ANDREWS - JBA)

Description

"JBA, an active U.S. military installation located on 4,346 acres approximately 5 miles southeast of Washington, DC, is home to approximately 16,700 active duty, Guard, and Reserve personnel, civilian employees, and contractors. JBA is the home of the Air Force District of Washington's (AFDW) 11th Wing, the base's host. The Wing's mission is to provide installation security, services, and airfield management to support U.S. senior leaders; provide emergency reaction rotary-wing airpower for the National Capital Region; and for organizing, training, equipping, and deploying combat-ready forces for Air and Space Expeditionary Forces (AEFs). JBA hosts a wide variety of tenant organizations, including the 89th Airlift Wing, 459 Air Refueling Wing (Air Force Reserve Command), the 113 Wing and 201 Airlift Squadron of the District of Columbia Air National Guard, the Army and Air Force Exchange Service, the Civil Air Patrol, and a Naval Air Facility".

Pollutants

VOC, NOx, CO, PM, Toxics

Emission Source Categories

MDE staff reviewed emission estimates prepared for Maryland by JBA. These emission estimates included data for the following source categories:

- Mobile On-Road Source Emissions
- Mobile Nonroad Source Emissions
- Area Source Emissions
- Point Source Emissions

Emission Estimation Methodologies

Emission estimation methodologies varied by source category. A brief synopsis of the methodologies is presented below.

Mobile Onroad Source Emissions

JBA has an Onroad vehicle inventory made up of light and heavy duty vehicles. The vehicles are government own vehicles (GOV) and privately owned vehicles (POV). These vehicles use gasoline and diesel fuels. JBA has contractors like (e.g., DynCorp and AKIMA) working at the facility who track vehicles operating and fuel being used on complex. AKIMA maintains the On-Line Vehicle Interactive Management System (OLVIMS), which is a database that tracks GOV activity. Population statistics for 2017 were supplied by JBA to estimate POV emissions.

EMISSION FACTORS AND CALCULATIONS

On-road POV was calculated using estimated on base VMT and AMEC statistics.
On-road GOV emissions were calculated by multiplying estimated on base VMT by emission factors obtained from EPA's MOBILE 6.2 model.

Vehicle Description:

LDGV Light-Duty Gasoline Vehicles (Passenger Cars)
LDGT1 Light-Duty Gasoline Trucks 1 (0-6,000 lbs. GVWR, 0-3,750 lbs. LVW)
LDGT2 Light-Duty Gasoline Trucks 2 (0-6,000 lbs. GVWR, 3,751-5,750 lbs. LVW)
LDGT3 Light-Duty Gasoline Trucks 3 (6,001-8,500 lbs. GVWR, < 5,750 lbs. ALVW)
LDGT4 Light-Duty Gasoline Trucks 3 (6,001-8,500 lbs. GVWR, > 5,750 lbs. ALVW)
HDGV2b Heavy-Duty Gasoline Vehicles (8,501-10,000 lbs. GVWR)
HDGV3 Heavy-Duty Gasoline Vehicles (10,001-14,000 lbs. GVWR)
HDGV4 Heavy-Duty Gasoline Vehicles (14,001-16,000 lbs. GVWR)
HDGV5 Heavy-Duty Gasoline Vehicles (16,001-19,500 lbs. GVWR)
HDGV6 Heavy-Duty Gasoline Vehicles (19,501-26,000 lbs. GVWR)
HDGV7 Heavy-Duty Gasoline Vehicles (26,001-33,000 lbs. GVWR)
HDGV8a Heavy-Duty Gasoline Vehicles (33,001-60,000 lbs. GVWR)
HDGV8b Heavy-Duty Gasoline Vehicles (>60,000 lbs. GVWR)
HDGB Gasoline Buses (School, Transit and Urban)
LDDV Light-Duty Diesel Vehicles (Passenger Cars)
LDDT12 Light-Duty Diesel Trucks 1and 2 (0-6,000 lbs. GVWR)
LDDT34 Light-Duty Diesel Trucks 3 and 4 (6,001-8,500 lbs. GVWR)
HDDV2b Heavy-Duty Diesel Vehicles (8,501-10,000 lbs. GVWR)
HDDV3 Heavy-Duty Diesel Vehicles (10,001-14,000 lbs. GVWR)
HDDV4 Heavy-Duty Diesel Vehicles (14,001-16,000 lbs. GVWR)
HDDV5 Heavy-Duty Diesel Vehicles (16,001-19,500 lbs. GVWR)
HDDV6 Heavy-Duty Diesel Vehicles (19,501-26,000 lbs. GVWR)
HDDV7 Heavy-Duty Diesel Vehicles (26,001-33,000 lbs. GVWR)
HDDV8a Heavy-Duty Diesel Vehicles (33,001-60,000 lbs. GVWR)
HDDV8b Heavy-Duty Diesel Vehicles (>60,000 lbs. GVWR)
HDDBT Diesel Transit Buses, HDDBS Diesel School Buses, MC Motorcycles (Gasoline)

GOV was estimated using the formula:

$$\mathbf{E = VMT \times F \times C}$$

where:
E = annual emissions of particular pollutant from each vehicle category (lb/yr)
VMT = vehicle miles traveled on-base per year for each vehicle category (mi/yr)
F = average model year emission factor in the applicable vehicle category (g/mi)
C = pounds per gram conversion factor (2.205 x 10-3 lb/g)

Also, MOBILE6.2 was run using the parameters:
Vehicle classification
Fuel type, make/model
Vehicle registration numbers consistent with the OLVIMS database
Ethanol blended fuels (15 percent by volume gasoline, with the remainder being ethyl alcohol)
Minimum/maximum average temperature = 46°F / 67°F
Gasoline fuel vapor pressure = 10.0 psi

Diesel sulfur content = 20 ppm
All vehicle travel occurs on arterial roads at an average speed of 25 mph
Meteorological records for Prince George's County, MD
Average values of fuel vapor pressure and diesel sulfur content

GOV example calculation for NOx:
Vehicle category = LDGV
VMT = 219,546 (mi/yr)
F = 0.119 (g/mi)
C = 2.205×10-3 (lb/g)
ENOx = (219,546 mi/yr) × (0.119 g/mi) × (2.205×10-3 lb/g)
= 57.6 lb/yr
= 57.6 lb/yr/365 day/yr
= 0.157808 NOx lb/day divided by 2000 lb/ton
= **7.89E-05 NOx ton/day**

POV example calculation for NOx:
VMT for all POVs IN 2012 was 22,921,250 miles.
LDGV POVs is 46% × 22,921,250 = 10,543,775 mi/yr
MOBILE 6.2 emission factor for NOx is 0.463 g/mi.
Vehicle category = LDGV
V = 10,543,775 (mi/yr)
F = 0.463 (g/mi)
C = 2.205×10-3 (lb/g)
ENOx = (10,543,775 mi/yr) × (0.463 g/mi) × (2.205×10-3 lb/g)
= 10,764 lb/yr
= 10,764 lb/yr/365 day/yr
= 29.49 NOx lb/ day divided by 2000 lb/ton
= **1.47E-02 NOx ton/day**

Mobile Nonroad Source Emissions

Nonroad vehicles and equipment classifications:
Construction
Equipment
Industrial equipment
Commercial equipment
Agricultural equipment
Lawn and garden equipment
Recreational vehicles

Nonroad inventory include the equipment type, model year, engine horsepower, fuel type, engine cycles, and operating data.

Similar to onroad GOVs, nonroad vehicles considered government were tracked by AKIMA in conjunction with OLVIMS data and their fuel consumption.

EMISSION FACTORS AND CALCULATIONS

Nonroad emissions were calculated by multiplying estimated operating data by emission factors obtained from EPA's NONROAD 2008a (NONROAD) model for engines, equipment, and vehicles.

AMEC operating data was annual gallons of fuel or, operating hours. NONROAD model contains equipment with approximately 150 Source Classification Codes (SCCs) which identify their application, fuel type, engine type, and engine horsepower.

JBA had nonroad equipment that matched 26 SCCs listed.
Also, NONROAD model was run using the following parameters:

- Average minimum/maximum temperature = 46°F / 67°F
- Gasoline fuel vapor pressure = 10.0 psi
- Diesel sulfur content = 20 ppm

Emission factors were taken from the NONROAD model for each SCC. Note that model calculates emission factors by units of lb/hp-hr only. It was necessary to convert factors into units of lb/gal for operating data given in gal/yr in order to use the following equation:
(Example calculations come directly for JBA certification report -- 2012 Mobile Source Air Pollutant Emissions Inventory for Joint Base Andrews 20 November 2013)

$$Fg = \frac{Fh \times H}{BSFCavg}$$

where:
Fg = emission factor in lb/gal
Fh = NONROAD model emission factor in lb/hp-hr
H = Heating value of fuel (gasoline = 130,000 Btu/gal, diesel = 137,000 Btu/gal)
BSFCavg = average brake specific fuel consumption (typical value is 7,000 Btu/hp-hr)
The following equation was used for SCCs using annual operating hours:

$$Ep = T \times L \times H \times Fh$$

where:
Ep = annual emissions of criteria pollutant P (or carbon dioxide) for SCC (lb/yr)
T = total annual operating hours for all individual pieces of equipment in SCC (hr/yr)
L = fractional load factor corresponding to normal operation
H = average engine horsepower for SCC
Fh = average model year emission factor for SCC (lb/hp-hr)

Emission factors and load factors come from the NONROAD model, but only the emission factors differ according to SCC and year.

Example calculation for NOx:
Annual operating hours for 4-stroke commercial lawn and garden tractors (SCC = 2265004056) is shown below. In CY 2012,
The average engine rating is 10 hp
44 percent load
Total of 2,180 hours in CY 2012
Emission factor in 1999 for NOx is given as 0.00535 lb/hp-hr

Vehicle = 4-Stroke Commercial Lawn and Garden Tractors
SCC = 2265004056
Fuel = 4-Stroke Gasoline
T = 2,180 (hr/yr)
L = 0.44
H = 10 (hp)
F1999 = 0.00535 (lb/hp-hr)
ENOx = (2,180 hr/yr) × (0.44) × (10 hp) × (0.00535 lb/hp-hr) = 51 lb/yr
Divided by 2000 lb/ton and 365
ENOx = 6.99E-05 NOx tons/day

For operating data given as annual fuel consumption, NONROAD emission factors were used in the following equation to estimate annual criteria pollutant emissions for each SCC:
EP = C × Fg
where:
EP = annual emissions of criteria pollutant P (or carbon dioxide for SCC, lb/yr)
C = total annual fuel consumption for all individual pieces of equipment in SCC (gal/yr)
Fg = average model year emission factor for SCC (lb/gal)

Example calculation for NOx:
Diesel Vehicle Agricultural Tractors (SCC = 2270005015)
In CY 2012, the average model year for this SCC was 2006
Amount of diesel fuel = 2,633 gallons, and the NONROAD emission factor for NOx was 0.164 lb/gal.
Fg = 0.164 (lb/gal)
ENOx = (2,633 gal) × (0.164 lb/gal) = 432 lb/yr
ENOx = 5.92E-04 NOx tons/day HAP and TAP emissions were calculated using the speciated

Area Source Emissions

Aircraft landings and takeoffs or LTO emissions have been estimated under several source categories, but for this report are list here.

Activity

An activity level of 7 days a week with no seasonal adjustment factor was used.

Emission Factors

Aircraft emissions were calculated using the Emissions and Dispersion Modeling System (EDMS) version 5.1.4 model. EDMS contains make, model, engine type, and control equipment used for a large variety of aircraft. The EDMS also, contains emission factors for this aircraft which when you input LTO totals for a particular aircraft it will calculate the estimated emissions for it. Vehicular emission factors contained in EDMS are obtained from the EPA's MOVES2014a model. Construction emission factors were derived from EPA's NONROAD2008a Model.

Pollutants

VOC, NOx, CO, PM, Toxics

Emission Source Categories

MDE staff reviewed emission estimates prepared for JBA Airport by AMEC contractor. These emission estimates included data for the following source categories:

- Aircraft Emissions
  - Emissions from military aircraft LTOs
  - Emissions from commercial aircraft LTOs
  - Emissions from aircraft auxiliary power units

Emission Estimation Methodologies

Emission estimation methodologies varied by source category. A brief synopsis of the methodologies is presented below.

Emissions and Dispersion Modeling System (EDMS) Version 5.1.4

- **Aircraft**

FAA's EDMS computer program contains a database of aircraft engine emission factors based on engine make and model and four engine operation modes (taxi/idle, takeoff, climb out, and approach). EDMS also contains a database of emission factors for an aircraft's auxiliary power units (APUs). Time-in-mode data is also used as an input into the emission inventory. EDMS time-in-mode data include the time that aircraft spend in each of the four operating modes.

- **Ground Support Equipment**

FAA's EDMS computer program contains a database of the ground support equipment (GSE) used to service specific types of aircraft. Also included in the database are the emission factors for each piece of GSE, as well as the time that each piece of equipment spends servicing the aircraft.

- **Training Fires**

FAA's EDMS computer program contains a database of emission factors for five fuel types (JP-4, JP-5, JP-8, Tekflame and Propane). Training fire emissions are estimated by choosing the fuel type and specifying the amount of fuel consumed in the training exercise.

Point Source Adjustments

Collecting all emissions estimates under one facility effectively creates a single point source for all of the emissions. No other point sources were subtracted from the area source inventory to avoid double counting.

Adjustment for Controls

Controls were applied when applicable to a particular source category.

Spatial and Temporal Allocations

Spatial

Spatial allocation of the emission estimates to specific areas within JBA is not available.

Temporal

Data for temporal allocation is not available for this source.

4.0 AREAS SOURCES

4.1 EMISSION ESTIMATION METHOD BY CATEGORY

4.1.1 PETROLEUM DISTRIBUTION LOSSES

Evaporative emissions occur at all points in the gasoline distribution process. These operations, generally inventoried as area sources, are gasoline dispensing outlets and gasoline tank trucks in transit. Bulk terminals and gasoline bulk plants, which are intermediate distribution points between refineries and outlets, have been inventoried as point sources. Most gasoline dispensing outlets emit less than 10 tons of VOC per year and therefore have been inventoried using area source methods.

VOC emissions from gasoline dispensing outlets result from vapor losses during tank truck unloading into underground storage tanks, vehicle fueling (boat fueling at marinas), and underground storage tank breathing. Evaporative losses from each activity in this source category have been tabulated separately so that various emission reduction control measures could be easily evaluated.

Emissions from vehicle fueling, including spillage during fueling, were calculated with the MOVES model and the methodology is described in Section 5.0 Mobile Sources. Tank truck unloading, underground tank breathing, tank trucks in transit and aircraft refueling were calculated using emissions factors from AP-42 and EIIP.

4.1.1.1 Tank Truck Unloading

SCC: 25 01 060 053
25 01 060 051

Description:

Emissions from tank truck unloading are affected by whether the service station tank is equipped for submerged, splash or balance filling. Therefore calculations were based on the filling method used and gallons sold.

Pollutants

VOC and HAPs

Method and Data Sources:

The method used to calculate emissions (all VOC), is presented in EIIP[1], Chapter 11, Gasoline Marketing, which extracts the emission factors from AP-42, Volume I, Table 5.2-7.

Activity

The Maryland Comptroller of the Treasury, Gasoline Tax Division (see Appendices) provided annual gallons of gasoline and diesel fuel sold. This data includes taxable and non-taxed gasoline purchased by the U.S. Government. State and local government sales are included in the taxable sales data. The statewide total of gallons of fuel sold was allocated to the county level proportional to the number of registered vehicles within the county. Vehicle registration data was collected from the Maryland Department of Transportation, Motor Vehicle Administration that supplied the data to MDE's Mobile Sources Control Program. Diesel fuel powered vehicle totals were subtracted from the Maryland and county registration numbers.

Percentages of submerged, balanced submerged and splash-fill tanks were determined with the assistance of MDE Waste Management. MDE staff reported no splash filling at Maryland service stations in 2017. All underground storage tanks within the nonattainment areas of the State of Maryland are required to use vapor-balance submerged filling methods. Waste Management's underground tank inspection program and regulations concerning underground storage tanks have eliminated splash-fill tanks in the state. A SSCD study determined that the rule effectiveness factor for vapor balance controls was 91%.

An activity level of 7 days per week was used, based on observations by MDE staff of unloading at Maryland retail gas stations. A rule effectiveness of 91% was determined from a study of Stage I compliance performed in Regions III and IV by the MDE/ARA enforcement program in 1991. In the attainment counties outside of Regions III and IV, a default rule effectiveness of 80 % was used. This survey data was used to determine the penetration of each filling technology. The total fuel sales in the county were multiplied by the fraction using each filling technology. The AP-42 technology-specific emission factors were then used to estimate emissions from submerged filling and balanced submerged filling. The emissions from each filling technology were summed to estimate total emissions.

[1] Emission Inventory Improvement Program

Filling Method	Non-Attainment Area	Transport Region	Attainment Area
Submerged	9%	9%	20%
Balanced Submerged	91%	91%	80%
Splash	0%	0%	0%

Emission Factors

Emission factors are affected by true vapor pressure and temperature. Emissions from loading petroleum liquid can be estimated (with a probable error of ±30 percent) using the following expression[2]:

$$L_L = 12.46 * \frac{S * P * M}{T}$$

where:

L_L = loading loss, pounds per 1000 gallons (lb/10^3 gal) of liquid loaded (The loading loss is equivalent to an emission factor)

S = a saturation factor (see AP-42 Table 5.2-1)

P = true vapor pressure of liquid loaded, pounds per square inch absolute (psia)

M = molecular weight of vapors, pounds per pound-mole (lb/lb-mole)

T = temperature of bulk liquid loaded, °R (°F + 460)

Table 5.2-1 from AP-42 shows that the saturation factor (S) is a constant for a specific petroleum liquid, carrier and type of loading service

The true vapor pressure (P) can be estimated from the Reid vapor pressure using the following equation:

$$P = \exp\left\{\left[0.7553 - \left(\frac{413.0}{T + 459.6}\right)\right] S^{0.5} * \log_{10}(RVP) - \left[1.854 - \left(\frac{1042}{T + 459.6}\right)\right] S^{0.5} + \left[\left(\frac{2416}{T + 459.6}\right) - 2.013\right] \log_{10}(RVP) - \left(\frac{8742}{T + 459.6}\right) + 15.64\right\}$$

The molecular weight varies slightly with temperature and pressure, however for this analysis it is assumed to be constant.

Proportioning the loading factors yields

$$\frac{LL2}{LL1} = \frac{12.46 * S2 * P2 * M2 / T2}{12.46 * S1 * P1 * M1 / T1} = \frac{P2 * T1}{P1 * T2} \qquad LL2 = LL1 * \frac{P2 * T1}{P1 * T2}$$

The loading factor or emission factor is directly proportional to true vapor pressure and inversely proportional to temperature in degrees Rankin.

LL1 = 0.3 at RVP of 10 and 60 F; this yields LL1 =0.3; P =5.186; T=520 R

To calculate LL2 at RVP of 6.7 and 81.8 F or P = 5.094; T = 541.8 R

$$LL2 = LL1 * \frac{P2 * T1}{P1 * T2} = 0.3 * \frac{5.094 * 520}{5.186 * 541.8} = 0.2828$$

[2] AP42, Chapter 5.2: Transportation and Marketing of Petroleum Liquids

Initial emission factors of 0.3 lb $_{VOC}$ per 1000 gallons throughput for balanced submerged filling and 7.3 lb $_{VOC}$ per 1000 gallons throughput for submerged filling were used in all Maryland counties. These factors were then adjusted with county-specific monthly average temperature and true vapor pressure values using the above technique.

Filling Method	**Base Emission Factor** Lb. $_{VOC}$ per 1,000 gallon
Balanced Submerged	0.3
Submerged	7.3
Diesel Fuel Unloading	0.014

Point Source Adjustments

Emissions from Andrews Air Force Base were subtracted from Prince Georges County emission totals and put in the Quazi Point.

Adjustment for Controls

Controls for this source category are reflected in the emission factors.

Spatial and Temporal Allocations

Spatial

Spatial allocation source data was base on vehicle registration data that was provided through the Maryland Department of Transportation, Motor Vehicle Administration and source data supplied to MDE's Mobile Sources Control Program. Diesel fuel powered vehicle totals were subtracted from the Maryland and county registration numbers.

Temporal

Monthly temporal allocation activity data was provided through the Maryland Comptroller of the Treasury, Gasoline Tax Division (see Appendices) provided annual gallons of gasoline and diesel fuel sold. This data includes taxable and non-taxed gasoline purchased by the U.S. Government. State and local government sales are included in the taxable sales data. The statewide total of gallons of fuel sold was allocated to the county level proportional to the number of registered vehicles within the county. Also, a SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The equation for estimating emissions from tank truck unloading is:

$$E_{fj} = \frac{(G_i \text{ x } F_{i\,(fm)} \text{ x } EF_{fm}) + (G_i \text{ x } F_{i\,(fm)} \text{ x } EF_{fm})}{2000}$$ Where:

E_{fj} = Emissions of VOC in tons per day from tank truck unloading per county i

G_i = Gallons of gasoline sold in county i during 2014

$F_{i\,(fm)}$ = Fraction of gasoline dispensed per county i per filling method (balanced submerged or submerged) during 2014

EF_{fm} = Emission factor per filling method for tank truck unloading adjusted by RVP and temperature: (0.3 lb. VOC/1000 gallon throughput or 7.3 lb. VOC/1000 gallon throughput)

Tank Truck Unloading Sample Calculation (Howard County)

To calculate fuel usage for Howard County:

Filling Method	**Howard County Adjusted Emission Factor** Lb. $_{VOC}$ per 1,000 gallon
Balanced Submerged	0.3131
Submerged	7.6196
Diesel Fuel Unloading	0.014

Total fuel sold in Maryland in 2017[3] **=** 2,786,302,192 gallons

Allocate gallons of fuel sold to the county level by the 2017 county vehicle registration proportion:

$$\frac{\text{Howard County vehicle registration}^4}{\text{Total MD vehicle registration}} = \frac{262{,}702}{4{,}707{,}857} = 0.0558$$

G = 2,786,302,192 **x** 0. 0.0558 = 155,477,781 gallons sold in **Howard County**

EM = (G * Market % * EF adjusted / 1000) / 2000
EMbs = balanced submerged emissions
EMs = submerged emissions

EMbs = (155,477,781 * 91% * 0.3131/ 1000) / 2000 = **22.15 tons** $_{VOC}$ **per year**
EMs = (155,477,781 * 9% * 7.6196/ 1000) / 2000 = **53.31 tons** $_{VOC}$ **per year**

Tank Truck Unloading was found to have a
SAF = seasonal adjustment factor of 0.262525702
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted EMda = (EM / 365)*(SAF / POS)

EMbsda = (**22.15** / 365)*(0.262525702 / 0.25) = **0.06 VOC tons/day** balanced submerged
EMsda = (**53.31** / 365)*(0.262525702 / 0.25) = **0.15 VOC tons/day** submerged

[3] Annual sales of gasoline from Maryland Comptroller of the Treasury, Gasoline Tax Division
[4] State of Maryland Motor Vehicle Administration and MDE Mobile Sources Control Program

4.1.1.2 Auto Refueling

SCC: 25 01 060 100

Description

Emissions from Auto refueling are substantially less than those from Stage I because gasoline vapors that ordinarily might have escaped during vehicle fueling are re-circulated by each vehicle's on-board vapor recovery system. Emissions were calculated from estimated gallons sold per county.

Pollutants

VOC

Method and Data Sources

EPA recommends that the MOVES model be used to generate refueling emission factors for highway vehicle emission inventories (EPA, 2003). The model, designed to support the evaluation of air pollution from gasoline- and diesel-fueled vehicles, generates emission factors for tailpipe emissions and refueling activities. If you are running MOVES in rates mode, you will need to use the results from both the rate per distance output table and the rate per vehicle output table. The rates for emissions processes 18 and 19 by source type in the rate per distance table should be multiplied by the local VMT by source type. In addition, the rates for emission processes 18 and 19 by source type in the rate per vehicle need to be multiplied by the local vehicle population by source type. The sum of these two values is the total refueling emissions.

Activity

Input activity data such as VMT, vehicle registration, and gasoline sales are collected by MDE's Mobile section from the Maryland Department of Transportation and the Maryland State Comptroller's Office, Tax Motor Unit Division.

Emission Factors

ARA mobile sources staff ran the MOVES2014 model to estimate the refueling emissions using the grams per mile (g/mile) methodology described above. The emission estimates were converted from grams to tons.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

Controls for this source category include Onboard Refueling Vapor Recovery (ORVR) systems. The controls are reflected in the emission estimates produced by the (MOVES2014) model.

Spatial and Temporal Allocations

Spatial

The MOVES2014 model spatially allocates input files specify state county-level gasoline sales data to spatially allocate emission estimates.

Temporal

The MOVES2014 model allocates monthly activity data per state county-level and national level estimates.

Emissions Calculation

A sample equation for estimating emissions from auto refueling is:

$$E_{StII} = \frac{(G_i \times EF_{StII} \times MPG \times SAF)}{2000}$$

Where:

E_{StII} = emissions of VOC in tons per day from auto refueling

G_i = gallons of gasoline sold in county i during 2017

EF_{StII} = emission factor for auto refueling from the MOVES2014 model (grams/mile)

MPG = average fuel economy (miles/gallon)

SAF = seasonal adjustment factor to reflect summer weekday emissions

<u>Auto Refueling Sample Calculation</u>

Since all calculations are included in the MOVES2014 model output, a sample calculation is not available for this source category.

4.1.1.3 Underground Tank Breathing

SCC: 25 01 060 201

Description:

Underground tank breathing occurs when gasoline is drawn out of the tanks and into the pump lines. During this process air moves into the tank evaporating gasoline and emitting vapors.

Pollutants

VOC and HAPs

Method and Data Sources:

The method used to calculate emissions (all VOC), is presented in EIIP[5], Chapter 11, Gasoline Marketing, which extracts the emission factors from AP-42, Volume I, Table 5.2-7.

Activity

The Maryland Comptroller of the Treasury, Gasoline Tax Division provided annual gallons of gasoline and diesel fuel sold. This data includes taxable and non-taxed gasoline purchased by the U.S. Government. State and local government sales are included in the taxable sales data. The statewide total of gallons of fuel sold was allocated to the county level proportional to the number of registered vehicles within the county. Vehicle registration data was collected from the Maryland Department of Transportation, Motor Vehicle Administration that supplied the data to MDE's Mobile Sources Control Program. Diesel fuel powered vehicle totals were subtracted from the Maryland and county registration numbers.

Emission Factors

An emission factor of 1.0 lbs. VOC per 1000 gallons throughput was used. The emission factor was taken from EIIP, Chapter 11, Gasoline Marketing, which extracts the emission factors from AP-42, Volume I, Table 5.2-7. Factors were adjusted with county-specific monthly average temperature and true vapor pressure values.

MDE used the same sources for gasoline sales and car registration as in tank truck unloading.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

Controls for this source category are reflected in the emission factors.

[5] Emission Inventory Improvement Program

Spatial and Temporal Allocations

Spatial

Spatial allocation source data was base on vehicle registration data that was provided through the Maryland Department of Transportation, Motor Vehicle Administration and source data supplied to MDE's Mobile Sources Control Program. Diesel fuel powered vehicle totals were subtracted from the Maryland and county registration numbers.

Temporal

Monthly temporal allocation activity data was provided through the Maryland Comptroller of the Treasury, Gasoline Tax Division provided annual gallons of gasoline and diesel fuel sold. This data includes taxable and non-taxed gasoline purchased by the U.S. Government. State and local government sales are included in the taxable sales data. The statewide total of gallons of fuel sold was allocated to the county level proportional to the number of registered vehicles within the county. Also, a SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The equation used to estimate emissions from underground tank breathing is:

$$E_{utb} = \frac{(G_i \text{ x } EF_{utb})}{2000}$$ Where:

E_{utb} = emissions of VOC in tons per day from underground tank breathing and emptying

G_i = gallons of gasoline sold in county i during 2017

EF_{utb} = emission factor for underground tank breathing (1.0 lbs. $_{VOC}$/1000 gallon throughput)

Underground Tank Breathing Sample Calculation (Harford County)

To calculate fuel usage for Harford County:
Total fuel sold in Maryland in 2017[6] = **2,786,302** kgallons
Allocate gallons of fuel sold to the county level by the 2017 county vehicle registration proportion:

Harford County vehicle registration[7] = 227,702 = 0.0484

[6] Annual sales of gasoline from Maryland Comptroller of the Treasury, Gasoline Tax Division
[7] State of Maryland Motor Vehicle Administration and MDE Mobile Sources Control Program.

Total MD vehicle registration 4,707,857

Gcarr = **2,786,302 x** 0.0484 = **134,763** kgallons sold in **Harford County** in 2017.

EF_{utb} = **0.9267** lbs. $_{VOC}$/1000 gallon

$$E_{utb} = \frac{(\mathbf{134,763} \times 1000 \times 0.9267 / 1000)}{2000}$$

E_{utb} = 62.44 tons VOC **per year**

Underground Tank Breathing was found to have a
SAF = seasonal adjustment factor of 0.262525702
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted **E_{utbda}** = (E_{utb} / 365)*(SAF / POS)

E_{utbda} = (**62.44** / 365)*(0.262525702 / 0.25) = **0.18 VOC tons/day**

4.1.1.4 Gasoline Tank Trucks in Transit

SCC: 25 05 030 120

Description

Breathing losses from tank trucks during the transport of gasoline are caused by leaking delivery trucks, pressure in the tanks, and thermal effects on the vapor and on the liquid. A worst case situation arises if a poorly sealed tank has been loaded with gasoline and pure air becomes saturated. During the vaporization process, pressure increases and venting occurs. Emissions from this source category include the evaporation of petroleum vapor from:

- loaded tank trucks during transportation of gasoline from the bulk plant/terminal to the service station or other dispensing outlet, and
- from empty tank trucks returning from service stations to bulk plant/terminals

Pollutants

VOC

Method and Data Sources

The method used to calculate emissions (all VOC), is presented in EIIP[8], Chapter 11, Gasoline Marketing (Stage I & Stage II), and dated September 1997.

Activity

Emission Factors

EPA documents the emission factors in AP-42, Table 5.2-5 and EIIP states the emission factors within the above-referenced document in AP-42 Table 11.3-1. The AP-42 emission factors represent a typical range of values. EIIP averages the "typical range values" within AP-42 and arrives at average emission factor values of 0.055 and 0.005 lbs. VOC per 1000-gallon gasoline, respectively for emissions from empty tank trucks and emissions from full tank trucks.

Emission Source	**EIIP Table 11-3.1 Lb/1000 gallon "Average"**	**AP-42 Table 5-2.5 Lb/1000 gallon "Typical Range"**
Gasoline Tank Trucks in Transit		
Empty Tank Trucks	**0.055**	**0 - 0.11**
Full Tank Trucks	**0.005**	**0 - 0.01**

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

[8] Emission Inventory Improvement Program

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

MDE used the same sources for gasoline sales and car registration as in tank truck unloading. Emission factors came from EIIP, Volume I, and Table 5.2-5, of 0.06 pounds VOC per 1000 gallons throughput (combines 0.005 lb $_{VOC}$ /1000 gallon full tank truck delivery, and 0.055 lb $_{VOC}$ /1000 gallon empty tank return). MDE also used a bulk facility throughput adjustment factor of 1.09 and calculated throughput by a ratio of county retail sales and state retail sales times state fuel sales.

Emission Factors:

Full tank truck delivery	0.005 lbs. $_{VOC}$ per 1000 gallons
Empty tank truck return	0.055 lbs. $_{VOC}$ per 1000 gallons
Combined (full & empty)	0.060 lbs. $_{VOC}$ per 1000 gallons

Bulk Facility Throughput Adjustment Factor: 1.09

Equation:

$$E_{tt} = \frac{(G_i \times 1.09 \times EF_{tt})}{2000}$$ Where:

E_{tt} = emissions of VOC in tons per day from tank trucks in transit

G_i = thousand gallons of fuel sold in county i

EF_{tt} = Combined (full & empty) tank trucks in transit emission factor

2017 Gasoline Tank Trucks in Transit Sample Calculation (Harford County)

To calculate fuel usage for Harford County:
Total on-road and non-road fuel sold in Harford County **=** **134,763** kgallons

G = **134,763** kgallons sold in Harford County

$$E_{tt} = \frac{(\mathbf{134,763} \times 1.09 \times 0.06)}{2000}$$

E_{tt} = **4.41** tons $_{VOC}$ per year emitted from tank trucks in transit in **Harford County**.

Underground Tank Breathing was found to have a
SAF = seasonal adjustment factor of 0.262525702
POS = peak ozone period of 0.25
Days of the Period 312
Daily adjusted $E_{tt\mathbf{da}}$ = (E_{tt} / 312)*(SAF / POS)

$E_{tt\mathbf{da}}$ = (**4.41** / 312)*(0.262525702 / 0.25) = **0.0148 VOC tons/day**

4.1.1.5 Aviation Gasoline Distribution Stage 1 and Stage 2

SCC: 25 01 080 050
25 01 080 100

Description

In Stage I aviation gasoline (also called "AvGas") used in small reciprocating piston-engines is shipped to airports for use in civil aviation. AvGas is first placed into bulk terminals, and then into tanker trucks. These filling processes will cause the displacement of vapors into the atmosphere during the transfer of gasoline from tank trucks to storage tanks, and vice versa.

Stage II is the transfer of fuel from the tanker trucks into general aviation aircraft; during this process vapors are also displaced into the atmosphere.

Pollutants

VOC, Pb (Lead), and HAPs

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No adjustments for controls.

Spatial and Temporal Allocations

Spatial
County-level AvGas fuel distributions reported through Energy Information Administration **-**EIA was spatial allocated for this sources.

Temporal
Annual county-level emissions from PAD-level AvGas consumption from EIA, Petroleum Supply Annual 2017 reports were temporally allocated for this sources. SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Method and Data Sources

MDE staff used the methodology developed from the PECHAN/ERTAC Study, 2007, base on terminals using AvGas fuel activity assumptions data.

Activity

MDE used selected data from the Department of Energy's State Energy Data System obtain fuel consumption data. MDE used airport survey data and the Maryland Aviation Administration's 2016 Operations Count for Public-Use Airports to obtain operational counts. A few airports, such as Andrews Air Force Base, provided their own operations count.

Fuel Type	Fuel Consumption (1,000 Gallons)
Commercial Jet	64,974
Aviation Gasoline	1,428
Military Jet	649.74

Emission Factors

Emission factors for AvGas distribution from came from the (TRC Environmental Corporation's ***Estimation of Alkylated Lead Emissions, Final Report***, U.S EPA, Office of Air Quality Planning and Standards. RTP,NC 1993.

The emissions factors are separated by emissions source such as

EFtf = Aviation Gasoline from Tank Fill

EFst = Aviation Gasoline from Storage Tank

EFc = Aviation Gasoline from Composite

EFbl = Aviation Gasoline from Breathing Losses

Factors Not Used:

EFv = Aviation Gasoline from Valves (There are NO AvGas Facilities/Tank Farms in MD)

EFp = Aviation Gasoline from Pumps (There are NO AvGas Facilities/Tank Farms in MD)

EF Type	VOC Emission Factors	Units
Tank Fill	0.009021383	LB/GALLON AvGas
Storage Tank	0.003605215	LB/GALLON AvGas
Composite	0.010306575	LB/GALLON AvGas
Breathing Losses	0.001694117	LB/GALLON AvGas
Valves Not Used	0.573201882	LB/VALVE*DAY
Pumps Not Used	5.952481079	LB/SEAL*DAY
EFsum (Sum of Factors Used)	0.024627290	LB/GALLON AvGas
Tanker to Truck Transfer Stage II	0.0136	LB/GALLON AvGas

Emission Estimate Equation: County Level

EM = EFsum **x** Fraction of LTOs **x** Amount of Aviation Gasoline

EM_i = EFsum **x** (CA_i / SA_i) **x** F_i

Where:

F_i = County aircraft fuel use
CA_i = County aircraft activity (LTO)
SA_i = State aircraft activity (LTO)
$EFsum_i$ = **Sum of Factors Used**
EM_i = specific county (i) emissions from aircraft refueling in tons VOC per year

2017 Sample Calculation for Stage I AvGas Distribution (**Harford County**)

$F_{\_Harford}$ = 1,428,000 gallons

Fraction of LTOs = $\frac{CA_{\_Harford}}{SA} = \frac{17,964}{331,051} = 0.054264$

$EFsum_{\_Harford\ Stage\ I}$ = 0.0246272899 lb/gal. AvGas

$EM_{\_Harford\ Stage\ I}$ = (0.0246272899 **x** 0.054264 **x** 1,428,000)/2000 = **0.9542 tons** VOC **/ year**

Stage I AvGas Distribution was found to have a
SAF = seasonal adjustment factor of 0.26
POS = peak ozone period of 0.25
Days of the Period 300
Daily adjusted $EM_{\_Harford\ Stage\ I\ daily}$ = ($EM_{\_Harford\ Stage\ I}$ / 300)*(SAF / POS)

$EM_{\_Harford\ Stage\ I\ daily}$ = (**0.9542** / 300)*(0.26 / 0.25) = **3.31E-03 VOC tons/day**

2017 Sample Calculation for Stage II AvGas Distribution (**Harford County**)

$F_{\_Harford}$ = 1,428,000 gallons

Fraction of LTOs = $\frac{CA_{\_Harford}}{SA} = \frac{17,964}{331,051} = 0.054264$

$EFsum_{\_Harford\ Stage\ II}$ = **0.0136** lb/gal AvGas

$EM_{\_Harford\ Stage\ II}$ = (0.0136 **x** 0.054264 **x** 1,428,000)/2000 = **0.5269** tons VOC /year

Stage I AvGas Distribution was found to have a
SAF = seasonal adjustment factor of 0.26
POS = peak ozone period of 0.25
Days of the Period 300
Daily adjusted $EM_{\_Harford\ Stage\ II\ daily}$ = ($EM_{\_Harford\ Stage\ II}$ / 300)*(SAF / POS)
$EM_{\_Harford\ Stage\ II\ daily}$ = (**0.5269** / 300)*(0.26 / 0.25) = 1**.83E-03 VOC tons/day**

4.1.1.6 Petroleum Vessel Unloading Losses

SCC:

2505020030	**crude oil**
2505020090	**distillate oil**
2505020120	**Gasoline**
2505020150	**Jet naphtha**
2505020060	**residual oil**
2505020180	**kerosene**

Description

Petroleum liquids are transported via ships and barges, and on-land transportation. The procedures discussed below relate to marine transport of petroleum liquids. This category does not include emissions from fuel consumed by vessels while in transit or in port. Evaporative VOC emissions from ocean going ships and barges carrying petroleum liquids result from loading losses, ballasting losses and transit losses. Petroleum liquids are classified into groups which are represented by crude oil, gasoline, jet naphtha, distillate oil/kerosene, or residual oil. Loading and ballasting losses do not occur with pipeline transport of petroleum products (AP-42, Section 5.2).

Loading losses occur as organic vapors in "empty" cargo tanks are displaced to the atmosphere by the liquid being loaded into the tanks. These vapors are a composite of vapors formed in three ways:

- Vapors which are formed in the "empty" tank by evaporation of residual product from previous loads;
- Vapors transferred to the tank from a vapor balance system that was used when the previous load was being unloaded; and
- Vapors generated in the tank as the new product is being loaded.

Loading losses are usually the largest source of evaporative emissions from petroleum vessels (EPA, 1996).

Ballasting losses are associated with the unloading of petroleum liquids at marine terminals and refinery loading docks. It is common practice to load several cargo tank compartments with sea water after the cargo has been unloaded. This water, called "ballast," improves the stability of the empty tanker during the subsequent voyage. Ballasting emissions occur as vapor-laden air in the empty cargo tank is displaced to the atmosphere by ballast water being pumped into the tank.

Transit losses are similar to breathing losses associated with petroleum storage. Transit loss is the expulsion of vapor from a vessel compartment through vapor contraction and expansion, which are the result of changes in temperature and barometric pressure. This loss may be accompanied by slight changes in the level of the liquid in the tank due to liquid expansion or contraction due to the temperature change. Some ships are equipped with controls for these losses.

Pollutants

VOC

Method and Data Sources

Activity

The method used to calculate emissions (all VOC) is presented in EIIP[9], Chapter 12, Marine Vessel Loading, Ballasting and Transit, dated May 1998.

A significant part of the emissions from this source are from the Eastern Shore of Maryland because petroleum products are delivered to this area by barge rather than by pipeline as in the rest of the state. To compile emissions MDE used guidance in EIIP, Chapter 12, Marine Vessel Loading, Ballasting and Transit and emissions factors from EIIP Table 12.4-5, Waterborne Commerce of the United States, Waterways and Harbors Atlantic Coast, Part 1, 2016 data, and AP-42, Table 7.1-2 liquid densities. Waterborne Commerce supplied tonnage and type of petroleum products delivered to the various ports in Maryland for the year 2016. Tonnages of petroleum delivered were converted into Kgals (1000 gallons) and then used to calculate emissions.

Factors

UNCONTROLLED VOC EMISSION FACTORS FOR PETROLEUM CARRYING MARINE VESSELS (EPA, 1996)				
Petroleum Liquid	**Ship/Ocean Vessel Loading (Lbs. VOC per 1,000 gallons Transferred)**	**Barge Loading (Lbs. VOC per 1,000 gallons Transferred)**	**Ballasting (Lbs. VOC per 1,000 gallons Transferred)**	**Transit (Lbs. VOC per 1,000 gallons Transferred)**
Crude Oil	0.61	1	1.1	1.3
Gasoline	1.8	3.4	0.8	2.7
Jet Naphtha / Other	0.5	1.2	NA	0.7
Distillate Oil / Kerosene	0.005	0.012	NA	0.005
Residual Oil	4×10^{-5}	9×10^{-5}	NA	3×10^{-5}

[9] Emission Inventory Improvement Program

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Data obtained from sources such as the *Waterborne Commerce of the United States* are typically provided in terms other than 1,000 gallons (Mgal) as is required in EIIP Equation 12.4-1 and must be converted. Equation 12.4-3 can be used to convert units from 1,000 ton (Mtons) to Mgal. Where:

$PP_V = (PP_M / d) \times (2{,}000 \text{ lb/ton}) \times (\text{Mgal}/1{,}000 \text{ gallons}) \times (1{,}000 \text{ tons/Mtons})$

PP_V = Amount of petroleum liquid (Mgal)
PP_M = Amount of petroleum liquid (Mtons)
d = Density of petroleum liquid; see Table 7.1-2 in AP-42 (lb/gallon)

	Density[10] (lb/gal)
Distillate Oil	7.10
Residual Oil	7.90
Gasoline	5.60
Kerosene	7.00
Crude Oil	7.10
Jet Naphtha	6.40

If controls exist, then control efficiency can be calculated:

$PP_C = PP_U \times (1 - CE/100)$

Where:

PP_C = Controlled emissions (tons)
PP_U = Uncontrolled emissions (tons)
CE = Control efficiency (%)

[10] AP-42, Table 7.1-2

Equation:

$$PV_P = \frac{[(SOEF_P \times PP_{S,P}) + (BREF_P \times PP_{B,P}) + (BLEF_{P,U} \times 0.20 \times PP_{BL,P}) + (TREF_P \times PP_{T,P})]}{2000}$$

Where:

PV_P : Total VOC emissions from petroleum vessel loading, ballasting, and transit for each of the petroleum liquids (p) transported: crude oil, gasoline, kerosene, distillate oil, and residual oil (tons)

$SOEF_P$: Ship/ocean vessel loading emission factor (pounds VOC per 1,000 gallons transferred)

$PP_{S,P}$: Amount of petroleum liquid (p) loaded into ships and ocean vessels in the inventory region (1,000 gallons)

$BREF_P$: Barge vessel loading emission factor (pounds VOC per 1,000 gallons transferred)

$PP_{B,P}$: Amount of petroleum liquid (p) loaded into barges in the inventory region (1,000 gallons)

$BLEF_{P,U}$: Ballasting emission factor (pounds VOC per 1,000 gallons water ballasted)

$PP_{BL,P}$: Amount of petroleum liquid (p) unloaded from vessels that are ballasted (1,000 gallons)

$TREF_P$: Vessel transit emission factor (pounds VOC per week per 1,000 gallons transferred)

$PP_{T,P}$: Amount of petroleum liquid (p) transported by marine vessels in the inventory region (1,000 gallons)

2016 Petroleum Vessel Unloading Losses Sample Calculation (Gasoline – Baltimore City

Gallons (in Thousands) of Petroleum Shipped in Baltimore Harbor						
	Crude Oil	**Distillate Oil**	**Gasoline**	**Jet Naphtha**	**Residual Oil**	**Kerosene**
Baltimore City	**1,127**	**74,366**	**467,857**	**4,063**	**300,000**	**200,000**

Tonnage of distillate oil shipped in Baltimore Harbor (from Waterborne Commerce of the U.S., 2016) were converted in thousands of gallons (Kgals) and then used to calculate emissions.

Vessel Loading Emissions

For vessel loading operations, 90 percent of the total throughput was loaded at terminals with a control system of 95 percent efficiency. According to the local port authorities, transit time in the inventory area is two days (2/7 of a week). Emissions for each emission point are calculated using Equation 12.4-1 and the emission factors from EIIP Table 12.4-5. In this example, emissions for each emission point are calculated separately and then totaled. Note that CE is applied to vessel loading emissions, and transit emissions are apportioned to two days per week by multiplying emissions by 2/7.

Baltimore City:
Vessel Loading gas = 0.00 Kgal
Barge Loading gas = 0.00 Kgal
Ballasting gas = 0.00 Kgal
Transit gas = 467,857 Kgal
Baltimore gas Total = (0.00 + 0.00 + 0.00 + 328,571) = **467,857** Kgal

Vessel Loading (gasoline) emissions are calculated:
PV_{GAS} = [(1.8 lbs $_{VOC}$/Kgal) x (0.00 Kgal/yr) x {0.10 + [0.9 (1 – 95/100)]} ÷ 2,000 lb/ton
PV_{GAS} = 0.00 tons/year
Barge Loading emissions are calculated:
PV_{GAS} = [(3.4 lbs $_{VOC}$/Kgal) x (0.00 Kgal/yr)] ÷ 2,000 lb/ton
PV_{GAS} = **0.00** tons/year

Ballasting emissions are calculated:
PV_{GAS} = [(0.8 lbs $_{VOC}$/Kgal) x (0.00 Kgal/yr) x (0.20)] ÷ 2,000 lbs/ton
PV_{GAS} = **0.00** tons/year

Note that the calculation for ballasting emissions in the equation includes a correction term of 0.20. This correction term reflects the practice of loading a ship or barge at some fraction of *capacity* when *ballasting*.

Transit emissions are calculated:
According to the Maryland Port Authorities transit time is 6 hours out of 24 or 25% during a week (7 days).

PV_{GAS} = (2.7 lbs $_{VOC}$/Kgal) x (**467,857** Kgal/yr) x (0.25/7wk) ÷ 2,000 lbs/ton
PV_{GAS} = **22.56 voc** tons/year

$EM_{\_BCitytotal}$ **Vessel Loading** total VOC emissions are calculated as follows:
$EM_{\_BCitytotal}$ = **0.00** tons/year + **0.00** tons/year + **0.00** tons/year + **22.56** tons/year
$EM_{\_BCitytotal}$ **= 22.56 tons/yr** (gasoline)

Petroleum Vessel Unloading was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 312
Daily adjusted $EM_{\_BCitytotal\mathbf{da}}$ = ($EM_{\_BCitytotal}$ / 312)*(SAF / POS)

$EM_{\_BCitytotal\mathbf{da}}$ = **(22.56** / 312)*(0.25 / 0.25) = **5.08E-02 VOC tons/day**

4.1.1.7 Portable Fuel Containers

SCC: 25 01 011 011 (Residential – Permeation)
25 01 011 012 (Residential – Diurnal)
25 01 011 013 (Residential – Transport)
25 01 012 011 (Commercial – Permeation)
25 01 012 012 (Commercial – Diurnal)
25 01 012 013 (Commercial – Transport)

Description

Portable fuel containers (PFCs) store and transport fuel from gasoline service stations to residential homes and businesses. Emissions from PFC use include:

- ***Permeation Emissions***, which are produced after fuel has been stored long enough in a can for fuel molecules to infiltrate and saturate the can material.
- ***Diurnal Emissions***, which result when stored fuel vapors escape to the outside of a gas can through any possible openings while the gas can is subjected to daily cycle of increasing and decreasing ambient temperatures. Diurnal emissions are dependent on the closed- or open-storage condition of a gas can.
- ***Transport Emissions*** arise when fuel escapes (e.g., spills, etc.) from gas cans that are in transit.

Both residential and commercial PFCs are included. The SCCs for PFCs are also new and are shown above.

Pollutants

VOC

Method Data
Sources and

The method used to calculate emissions (all VOC), is adopted from a CARB[11] survey and methodology adopted by OTC[12]. Portable fuel container emissions are calculated by accounting for emissions from five different components related to gas container use: permeation, diurnal, transport-spillage, refueling spillage and refueling vapor displacement emissions. The permeation, diurnal emissions (associated with storage) and transport-spillage (associated with filling the can) emissions are included in the area source inventory. The equipment refueling spillage and refueling vapor displacement emissions are calculated from the non-road model and are included in the non-road inventory.

Portable fuel container emissions are calculated by accounting for emissions from five different components related to gas container use: permeation, diurnal, transport-spillage, refueling

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[11] ARB's Mailout MSC 99-25, "Public Meeting to Consider Approval of CA's Portable Gasoline-Container Emissions Inventory, " (ARB, 199b)

[12] Control Measure Development Support Analysis of Ozone Transport Commission Model Rules, E.H. Pechan & Associates, Inc. 5528-B Hempstead Way, Springfield, VA 22151, March 31, 2001.

spillage and refueling vapor displacement emissions. The permeation, diurnal emissions (associated with storage) and transport-spillage (associated with filling the can) emissions are included in the area source inventory. The equipment refueling spillage and refueling vapor displacement emissions are calculated from the non-road model and are included in the non-road inventory

Activity

The following input data is required to calculate emissions for this source category.

1. Rather than assuming that the numbers of PFCs per household and per business were consistent across the entire State, MDE used EPA's non-road emissions model to estimate nonroad consumption of gasoline by county by source category classification (SCC) code. Each SCC code has a unique usage (commercial versus residential), a unique ratio of the percent of fuel dispensed from PFCs. The previous draft version of this report (EPA420-D-06-003) was based on estimates from the draft NONROAD2004 model (versus from fuel pumps), and a unique spillage rate (grams per gallon).
2. Number of commercial businesses[13] 2002 expected to have at least one gas can by county, NAICS 11, 23, 31,311, 441, 447, 45299, 484, 488, 493, 53131, 5321, 532291, 5323, 5324, 54132, 54162, 54169, 56173, 71391, 71393, 7212, 811, and 81293.
3. MDE was able to estimate by county by (SCC) code the total quantity of gasoline supplied from PFCs.

Emission Factors

Separate emission factors were developed for permeation, diurnal, transport and spillage emissions for PFC (both for commercial and residential PFCs). These emission factors were derived from CARB's survey data (CARB, 1999).

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

Maryland's COMAR 26.11.13.07 rule regulates control adjustments of VOC emissions from portable fuel containers (PFC's) that requires performance standards for PFCs and/or spouts that will reduce emissions do to storage, transport, and refueling activities. (2017 control efficiency of 55% and a control factor of 83.3%). COMAR weblink: http://www.dsd.state.md.us/comar/title_search/Title_List.aspx

Spatial and Temporal Allocations

[13] Total 2017 employment and business establishments by 6 digit NAICS code and by county, County Business Patterns

Spatial
For the residential PFC SCCs, emissions were allocated to the local area level based on a housing surrogate. Commercial PFC emissions were allocated to the local area level based on commercial and industrial business location.

Temporal
Temporal allocation in part due to the number of days in a month with greater than or equal to 0.1 inch of precipitation, but > 0.01 inches a day as part of the emission estimations and seasonal adjustments.

Emissions Calculation

The equation used to estimate emissions from portable fuel containers is:

Equation:

The residential-gas-can population is calculated as follows:

$$Pop_R = (N)*(A)*(Count_R) \quad \text{(Eq. 1)}$$

where:

Pop_R	=	Statewide Residential-Gas-Can Population
N	=	Number of Occupied-Housing Units in OTC State
A	=	Percentage of Households with Gas Cans (46%)
$Count_R$	=	Average Number of Residential-Gas Cans per Household

Statewide residential-gas-can-permeation emissions are computed as follows:

$$HC_{PR} = \Sigma\ (Pop_R)*(S)*(EF_P)*(B_R)*(Size_R)*(Level)*CF \quad \text{(Eq. 2)}$$

where:

HC_{PR}	=	Permeation Emissions in tons per day (tpd)
Pop_R	=	Statewide Residential-Gas-Can Population
EF_P	=	Appropriate Permeation-Emission Factor (g/gal-day)
S	=	Percentage of Gas Cans Stored with Fuel (70%)
B_R	=	Percentage of Cans Stored in Closed Condition with respect to Material (Plastic 53%; Metal 13%)
$Size_R$	=	Weighted Average Capacity of Residential-Gas Cans (2.34 gal.)
Level	=	Weighted Average Amount of Stored Fuel (49%)
CF	=	**0.002204623 lbs/g conversion factor**

Diurnal emissions from both open- and closed-system-residential-gas cans are calculated as follows:

$$HC_{DR} = (Pop_R)*(S)*(EF_D)*(B_R)*(Size_R)*(Level) \quad \text{(Eq. 3)}$$

where: HC_{DR} = Diurnal Emissions (tpd) for Residential-Gas Cans with respect to Storage Condition (Open or Closed) and Material (Plastic or Metal)

Pop_R = Statewide Residential-Gas-Can Population

S = Percentage of Gas-Can Population Stored with Fuel (70%)

EF_D = Appropriate Diurnal-Emission Factor with respect to Storage Condition and Material (g/gal-day or g/day)

B_R = Percentage of Gas-Can Population with respect to Storage Condition and Material

$Size_R$ = Weighted Average Capacity of Residential-Gas Cans (2.34 gal.)

Level = Weighted Average Amount of Stored Fuel (49%)

CF = 907,184.5844 g/ton

Residential-transport-spillage emissions are determined as:

$$HC_{TR} = (Pop_R)*(S)*(Refill_R)*(EF_T)*(B_R) \quad \text{(Eq. 4)}$$

where: HC_{TR} = Residential-Gas-Can-Transport-Spillage Emissions (tpd)

Pop_R = Statewide Residential-Gas-Can Population

S = Percentage of Gas Cans Stored with Fuel (70%)

$Refill_R$ = Average Number of Residential-Gas-Cans-Pump-Refills per Day per Can (refill/day from survey)

EF_T = Transport-Emission Factor with respect to Storage Condition (g/refill)

B_R = Percentage of Gas Cans with respect to Storage Condition and Material

CF = **0.002204623 lbs/g conversion factor**

The commercial-gas-can population is calculated as follows:

$$Pop_C = (N_C)*(Count_C) \quad \text{(Eq. 5)}$$

where: Pop_C = Statewide Commercial-Gas-Can Population

N_C = Number of Occupied Businesses in State

$Count_C$ = Average Number of Gas Cans per Business

Statewide commercial-gas-can-permeation emissions are computed as follows:

$$HC_{PC} = \Sigma\ (Pop_C)*(S)*(EF_P)*(B_C)*(Size_C)*(Level) \quad \text{(Eq. 6)}$$

where: HC_{PC} = Permeation Emissions (tpd)

Pop_C = Statewide Commercial-Gas-Can Population

EF_P = Appropriate Permeation-Emission Factor (g/gal-day)

S = Percentage of Gas Cans Stored with Fuel (70% for Residential Survey)

B_C = Percentage of Applicable Gas Cans Stored in Closed Condition

$Size_C$ = Weighted Average Capacity of Commercial-Gas Cans (3.43 gal)

Level = Weighted Average Amount of Stored Fuel (49% from Residential Survey)
CF = **0.002204623 lbs/g conversion factor**

The amount of diurnal emissions from both open- and closed-system commercial-gas cans is calculated as follows:

$$HC_{DC} = (Pop_C)*(S)*(EF_D)*(B_C)*(Size_C)*(Level) \quad \text{(Eq. 7)}$$

where:
HC_{DC} = Diurnal Emissions (tpd) for Commercial-Gas Cans with respect to Storage Condition (Open or Closed) and Material (Plastic or Metal)
Pop_C = Statewide Commercial-Gas-Can Population
EF_D = Appropriate Diurnal-Emission Factor with respect to Storage Condition and Material (g/gal-day or g/day)
S = Percentage of Gas Cans Stored with Fuel (70% from Residential Survey)
B_C = Percentage of Gas Cans with respect to Storage Condition and Material
$Size_C$ = Weighted Average Capacity of Commercial-Gas Cans (3.43 gal.)
Level = Weighted Average Amount of Stored Fuel (49% from Residential Survey)
CF = **0.002204623 lbs/g conversion factor**

The non-lawn-and-garden-equipment commercial-gas-can refills at the pump are derived as follows:

$$REFILL_C = \left[\frac{\left(\sum Fuel\right)}{(SIZE_C)*(POP_{NON})*(S)} \right] \quad \text{(Eq. 8)}$$

where:
$Refill_C$ = Average Number of Non-Lawn-and-Garden Equipment Commercial-Gas-Cans Pump Refills per Day per Can (refill/day)
Fuel = Non-Lawn-and-Garden Equipment Fuel Consumption (gal/day) for 2000
$Size_C$ = Weighted Average Capacity of Commercial-Gas Cans (3.43 gal/can-refill)
POP_{NON} = Statewide Commercial-Gas-Can Population with respect to Non-Lawn-and-Garden Businesses
S = Percentage of Gas Cans Stored with Fuel (70% from Residential Survey)
CF = **0.002204623 lbs/g conversion factor**

The commercial-transport-spillage emissions are determined as:

$HC_{TC} = (Pop_C)*(S)*(B_C)*(Refill_C)*(EF_{TC})$ (Eq. 9)

where:

HC_{TC} = Commercial-Gas-Can-Transport-Spillage Emissions (tpd)
Pop_C = Statewide Commercial-Gas-Can Population
S = Percentage of Gas Cans Stored with Fuel (70% from Residential Survey)
B_C = Percentage of Gas Cans with respect to Storage Condition and Material
$Refill_C$ = Average Number of Gas-Cans Pump Refills per Day per Can
EF_{TC} = Transport-Spillage Emission Factor (g/refill) with respect to Storage Condition
CF = **0.002204623 lbs/g conversion factor**

The total area source portable fuel container emissions are summed as follows:

$E_{PFC-A} = HC_{PR}+HC_{DR}+HC_{TR}+HCPC+HC_{DC}+HC_{TC}$

$E_{PFC-SD} = E_{PFC-A} * SAF_{/}/ADDF$

Where:

E_{PFC-A} = (tons/yr) for an annual emission of pollutant by county
E_{PFC-SD} = (tons/day) for a typical summer day emission of pollutant
AADF = Annual activity day factor (SAF * 52 weeks/year)
SAF = Seasonal adjustment factor

4.1.2 STATIONARY SOURCE SOLVENT APPLICATION

4.1.2.1 Dry Cleaners

SCC: 24 20 000 000

Description

Dry-Cleaning facilities utilize solvents in their cleaning process which causes the emission of VOCs into the air.

Pollutants

VOC

Method and Data Source

Emissions from the dry-cleaning process were estimated by taking county employment and adjusted employment numbers from dry-cleaning and multiplying them by a given per capita emission factor for VOCs.

Activity

The County Business Patterns reports employment data for the counties of Maryland. Employment data is listed by the North American Industrial Classification Standard (NAICS) code(s) (81231, 81232, and 81233) that are used to determine county-level employment. Employment data collected was allocated to each county using *County Business Patterns* employment data for 2016 for the counties of Maryland. County Business Patterns internet addresses (http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl). Midpoint adjustments were determined for counties which had employment given a letter range.

Emission Factor

Emission factor from the Pechan/ERTAC Study, 2007, base on employment activity data. VOC = 467 lbs per person.

Point Source Adjustments

None

Adjustments for Controls

None

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

Emissions are calculated for each county using emission factors and activity as:

$$E_{xy} = EMP_x \times EF_y$$

where:

E_{xy} = annual emissions for county x and pollutant y
EMP_x = employment data associated with county x
EF_y = emission factor for pollutant y

<u>2017 Sample Calculation Dry-Cleaning Emissions (Howard County)</u>

$E_{Howardvoc}$ = EMP_{Howard} × EFvoc
$E_{Howardvoc}$ = 381 person × 467 lbs voc/person (in calculation in is 381.31 persons)
$E_{Howardvoc}$ = 178,071.77 lbs. voc
$E_{Howardvoc}$ = 89.04 tons voc per year

Dry-Cleaning was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 312
Daily adjusted $E_{Howardvoc\mathbf{da}}$ = ($E_{Howardvoc}$ / 312)*(SAF / POS)

$E_{Howardvoc\mathbf{da}}$ = (89.04 / 312*(0.25 / 0.25) = **2.85E-01 VOC tons/day**

4.1.2.2 Industrial and Institutional Cleaning

SCC: 24 15 300 000

Description

Industrial and Institutional Cleaning (Cold Cleaning Degreasing) is seen primarily at auto repair stations or manufacturing facilities, where solvents at room temperature (or slightly warmed) are used to clean parts via immersion or rinsing.

Industrial and Institutional Cleaning are usually individually small emission sources and because they are widely scattered and frequently used, they are most easily treated as area sources. If they are collocated at a major source, they may be included in the point source inventory and those emissions will need to be subtracted from the area source estimate.

There are two basic types of cleaning machines: batch and in-line cleaning machines (also called continuous cleaning machines). Both of these equipment types are designed to use solvent to clean parts. The solvent is either used to clean in its non-vapor liquid form (at a temperature below the boiling point, referred to as cold cleaning), or heated to a temperature above its boiling point (referred to as vapor cleaning). Other solvent cleaning operations involve the use of solvent in wipe-cleaning and equipment cleanup. Emissions from solvent cleaning machines can also be considered to be point sources; therefore, the estimation process for the source category must take this into account to prevent double counting of emissions. Additionally, emissions from solvent cleanup may be included as a part of an industry- or process-specific emission estimate.

Pollutants

VOC and HAP (Trichloroethylene – 79016)

Method and Data Source

MDE staff used the methodology developed from the PECHAN/ERTAC Study, 2007, base on emplacement activity data and method documented in EIIP[14], Chapter 6, Solvent Cleaning, dated September 1997 to emission estimation for this source category.

Activity

The County Business Patterns reports employment data for the counties of Maryland. Employment data is listed by the North American Industrial Classification Standard (NAICS) code(s) that are used to determine county-level employment. Employment data collected was allocated to each county using *County Business Patterns* employment data for 2016 for the counties of Maryland. County Business Patterns internet addresses (https://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t).

An activity level of 6 days a week with no seasonal adjustment factor was used as recommended in the EIIP document. Solvent storage and recycling centers are included in

[14] Emission Inventory Improvement Program

the point source inventory. A 2002 reduction factor (Phase II Attainment Plan for the Baltimore Nonattainment Area and Cecil County) of 53.60% was applied to the calculated emissions. This factor combines reductions from technology rules and good housekeeping practices and the application of rule effectiveness as shown below:

Reduction factor = (control efficiency) x (rule effectiveness) x (rule penetration)
Reduction factor = 0.67 x 0.80 x 1.00
Reduction factor = 0.5360

Emission Factor
Table 6.5-2 of the EIIP document lists a total emission factor of 87 lbs. VOC per employee per year for solvent cleaning operations. The emission factor for the HAPs Trichloroethylene – 79016 was developed from the Pechan/ERTAC Study, 2007. Pechan/ERTAC Study, 2007 determine HAP Trichloroethylene emission factor base on a percent weight factor of total solvent VOC which is 0.00686. This percent weight factor of total solvent VOC was multiply by the total emission factor of 87 lbs. VOC per employee per year and divided by 100 that resulted in Trichloroethylene emission factor of 0.59685 lbs. $_{\textbf{Trichloroethylene}}$ /yr/employee.

Factors

E_{cc} = 87 lbs $_{VOC}$ per employee per year for cold cleaning degreasers
CE_{cc} = 67%
RE_{cc} = 80%
RP_{cc} = 100%

Note:
Conveyor degreasing operations considered point sources that are listed in the MDE/ARA registration files. Point source emissions were then subtracted from the area source inventory by taking the reported emissions and back calculating to get the number of employees, which was then subtracted from the county business total employment before final estimation.

Point Source Adjustments

Solvent cleaning emissions from facilities identified as point sources were subtracted from the area source inventory to avoid double counting.

Adjustment for Controls

Maryland has adopted a cold and vapor degreasing regulation (COMAR 26.11.19.09). The regulation mandates that all cold degreasing material must have a vapor pressure less than or equal to 1 mm Hg at 20 degrees centigrade after May 15, 1996. The regulation also requires that good operating practices be implemented to minimize VOC losses. MDE estimates a 67 percent control efficiency for this control.

Spatial and Temporal Allocations

Spatial

CBP employment data was spatial allocation for this source.

Temporal

See section 2.2.1.1

Emissions Calculation

The equation used to estimate emissions from cold cleaning/degreasing is:

Equation:

$$E_{CC} = \left\{ \frac{EMPL_j * EF_{cc}}{2000} * \left[1 - (CE_{CC} * RE_{CC} * RP_{CC})\right] \right\} - E_{PtSourceCC}$$

Where:

E_{cc} = Emissions of VOC in tons/day from cold cleaners
$EMPL_j$ = 2016 employment of county j
EF_{cc} = VOC emissions factor for cold cleaning degreasing
CE_{cc} = Control efficiency for cold cleaning degreasing
RE_{cc} = Rule Effectiveness for cold cleaning degreasing
RP_{cc} = Rule Penetration for cold cleaning degreasing
$E_{PtSourceCC}$ = Point Source Emissions from cold cleaning degreasing

<u>2017 Sample Calculation for Cold Cleaning Degreasing Products Industrial and Institutional **(Baltimore City)**</u>

Reported Point Source Emissions = 5.3786 tons VOC
Point Source Employment = (5.3786 *2000 tons/lb./ 87 lbs. $_{VOC/employee}$) = 123.65 employees
$EMPL_{Baltmore}$ = (13,521 [15] – 123.65) = 13,397.28 employees
EF_{cc} = 87 lbs. $_{VOC}$ /employee/year
$E_{ccBaltimore}$ = (13,397.28 employee x 87 lbs. $_{VOC}$ /employee/year) / (tons/2000 lbs.)
$E_{ccBaltimore}$ = 582.78 tons $_{VOC}$ /year

To adjust for controls
$E_{ccBaltControlled}$ = 582.78 tons $_{VOC}$ /year **x** [1 – (0.67 x 0.80 x 1.00)] **= 270.41 tons** $_{\mathbf{VOC}}$ / year

Cold Cleaning Degreasing was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 312
Daily adjusted $E_{ccBaltControlled\mathbf{da}}$ = ($E_{ccBaltControlled}$ / 312)*(SAF / POS)
$E_{ccBaltControlled\mathbf{da}}$ = (**270.41** / 312)*(0.25 / 0.25) = **8.67E-01 VOC tons/day**

[15] *County Business Patterns* 2016 employment data for Maryland by Counties

3.3.2.3 Surface Coating

Surface coating includes paints, enamels, varnishes, lacquers and other product finishes. Some of those coatings contain a solvent-based liquid carrier; others use a water-based liquid carrier but still contain a small portion of solvents. Solvents are also used to clean up painting equipment. The primary types of surface coating applications are architectural coatings, automobile refinishing and traffic paints.

4.1.2.3 Architectural Surface Coating

SCC: 24 01 002 000 (Solvent-based)
SCC: 24 01 003 000 (Water-based)
SCC: 24 01 001 000 (Solvent & Water)

Description

Architectural surface coating is an area source that occurs from homeowners and contractors painting homes, buildings and signs.

Pollutants

VOC

Method and Data Sources

MDE staff used an alternative per capita emission estimation method documented in EIIP[1], Chapter 3 Architectural Surface Coating, dated November 1995. The document provides an outline for developing a per capita usage factor, and for using that usage factor with an emission factor to calculate VOC emissions.

Activity

Determine the per capita usage factor by dividing the national total architectural surface coating quantities[2] for solvent- and water-based coatings by the U.S. population[3] for that year.

Per Capita Usage Factor Development

The table below shows a portion of Table 2 from the U.S. Bureau of Census MA325F(10)-1 - Paint and Allied Products 2010. This section of the table summarizes the market information available on architectural coatings for the year of 2010. In the table, types of paints are identified as being either solvent- or water-based paints, except for the two types listed as Architectural Lacquers and Architectural Coatings N.S.K. These latter

[1] Emission Inventory Improvement Program
[2] Total national coating usage is compiled by the Bureau of the Census, Report MA325F—Paint and Allied Products, available on the Census Bureau Bulletin Board, (301)457-2310.
[3] Population data from the U.S. Bureau of the Census, Population Estimates Branch (see Appendices).

types of paints can be assumed to be entirely solvent-based coatings. The calculation to obtain the number of gallons of solvent based paints totals the gallons for Exterior Solvent Type, Interior Solvent Type, Architectural Lacquers and Architectural Coatings N.S.K:

Solvent-Based Paints = 113,964 thousand gallons of paints

The calculation to obtain the number of gallons of water based paints totals the gallons for Exterior Water Type and Interior Water Type:

Water-Based Paints = 510,560 thousand gallons of paints

The per capita usage factor is calculated by dividing the total usage of solvent based paints by the U.S. population, and the total usage of water based paint by the U.S. population.

$$\text{Per Capita Solvent Based Usage Factor} = \frac{\text{Gallons of Solvent Based Paints}}{\text{U. S. Population}} = \frac{113{,}964{,}000}{325{,}719{,}178} = 0.34988$$

$$\text{Per Capita Water Based Usage Factor} = \frac{\text{Gallons of Water Based Paints}}{\text{U. S. Population}} = \frac{510{,}560{,}000}{325{,}719{,}178} = 1.56748$$

Table 2. Quantity and Value of Shipments of Paint and Allied Products: 2010 and 2009

Product code	Product description	Year	Quantity
3255101	Architectural coatings	2010	643,900
		2009	634,874
3255101111	Exterior, solvent thinned paints and tinted bases, including barn and roof paints	2010	33,847
		2009	33,571
3255101115	Exterior, solvent thinned enamels and tinted bases, including exterior-interior floor enamels	2010	17,367
		2009	14,755
3255101119	Exterior, solvent thinned undercoaters and primers	2010	6,816
		2009	6,448

3255101121	Exterior, solvent thinned clear finishes and sealers	2010	4,028
		2009	4,054
3255101125	Exterior solvent thinned stains, including shingle and shake	2010	13,618
		2009	12,096
3255101129	Exterior, other solvent thinned coatings, including bituminous paints	2010	1,578
		2009	1,671
3255101131	Exterior, water thinned paints and tinted bases, including barn and roof paints	2010	92,625
		2009	93,665
3255101135	Exterior, water thinned exterior-interior deck and floor enamels	2010	10,583
		2009	10,727
3255101139	Exterior, water thinned undercoaters and primers	2010	10,587
		2009	10,725
3255101141	Exterior, water thinned stains and sealers	2010	21,501
		2009	20,678
3255101145	Exterior, other exterior water thinned coatings	2010	9,035
		2009	8,980
3255101211	Interior, flat solvent thinned wall paint and tinting bases, including mill white paints	2010	1,155
		2009	1,288
3255101215	Interior, gloss and quick drying enamels and other gloss solvent thinned paints and enamels	2010	3,983
		2009	3,389
3255101219	Interior, semigloss, eggshell, satin solvent thinned paints and tinting bases	2010	9,870
		2009	9,691
3255101221	Interior, solvent thinned undercoaters and primers	2010	**21,702**
		2009	(D)
3255101225	Interior, solvent thinned clear finishes and sealers	2010	(S)
		2009	(S)

3255101229	Interior, solvent thinned stains	2010	1,309
		2009	1,216
3255101231	Interior, other solvent thinned coatings	2010	(D)
		2009	(D)
3255101235	Interior, flat water thinned paints and tinting bases	2010	144,394
		2009	142,894
3255101239	Interior, semigloss, eggshell, satin, and other water thinned paints and tinting bases	2010	183,428
		2009	176,562
3255101241	Interior, water thinned undercoaters and primers	2010	38,407
		2009	42,781
3255101245	Interior, other interior water thinned coatings, stains, and sealers	2010	5,119
		2009	5,250
3255101249	Architectural lacquers	2010	4,086
		2009	4,126
3255104	Product finishes for original equipment manufacturers (OEM), excluding marine coatings	2010	329,931
		2009	285,070
3255104111	Automobile, light truck, van, and sport utility vehicle finishes	2010	43,172
		2009	31,580
3255104121	Automobile parts finishes	2010	2,792
		2009	1,929
3255104131	Heavy duty truck, bus, and recreational vehicle finishes	2010	5,757
		2009	5,352
3255104141	Other transportation equipment finishes, including aircraft and railroad	2010	5,369
		2009	4,187
3255104211	Appliance, heating equipment, and air-conditioner finishes	2010	3,990
		2009	4,266
3255104215	Wood furniture, cabinet, and fixture finishes	2010	34,578

		2009	32,500
3255104219	Wood and composition board flat stock finishes	2010	7,135
		2009	6,274
3255104221	Metal building product finishes (including coatings for aluminum extrusions and siding)	2010	36,455
		2009	35,303
3255104225	Container and closure finishes	2010	40,164
		2009	35,647
3255104229	Machinery and equipment finishes, including road building equipment and farm implement	2010	10,151
		2009	9,462
3255104231	Non-wood furniture and fixture finishes, including business equipment finishes	2010	22,155
		2009	20,710
3255104235	Paper, paper board, film, and foil finishes, excluding pigment binders	2010	(S)
		2009	10,854
3255104239	Electrical insulating coatings	2010	1,015
		2009	866
3255104241	Thermoset general decorative, appliance powder coatings **1/**	2010	8,951
		2009	6,933
3255104245	Thermoset general decorative, automotive powder coatings **1/**	2010	3,765
		2009	2,437
3255104249	Thermoset general decorative, architectural powder coatings (such as aluminum extrusions) 1/	2010	1,096
		2009	959
3255104251	Thermoset general decorative, lawn and garden powder coatings **1/**	2010	999
		2009	890
3255104255	Thermoset general decorative, general metal finishing powder coatings **1/**	2010	19,806
		2009	16,225
3255104259	Thermoset functional powder coatings (for pipe, rebar,	2010	(D)

	electrical insulation, etc.) **1/**	2009	(D)
3255104261	Thermoplastic powder coatings (all) **1/**	2010 2009	(D) (D)
3255104263	Other powder coatings	2010 2009	(D) (D)
3255104265	Other industrial product finishes	2010 2009	23,378 20,774
3255107	Special purpose coatings, including all marine coatings	2010 2009	168,326 158,575
3255107111	Industrial new construction and maintenance paints, interior	2010 2009	35,570 34,704
3255107115	Industrial new construction and maintenance paints, exterior	2010 2009	16,571 13,886
3255107121	Traffic marking paints (all types; shelf goods and highway department)	2010 2009	37,335 35,047
3255107131	Automotive, other transportation and machinery refinish paints and enamels, including primers	2010 2009	55,899 52,504
3255107141	Marine paints, ship and off-shore facilities and shelf goods for both new construction and marine refinish and maintenance. Excludes spar varnish	2010 2009	10,924 11,498
3255107151	Marine paints for yacht and pleasure craft, new construction, refinish and maintenance	2010 2009	(D) (D)
3255107161	Aerosol - paint concentrates produced for packaging in aerosol containers	2010 2009	(D) (D)
325510B	Miscellaneous allied paint products	2010 2009	145,119 134,263
325510B111	Paint and varnish removers	2010	(D)

		2009	5,075
325510B121	Thinners for lacquers and other solvent based paint products	2010	(D)
		2009	30,249
325510B131	Pigment dispersions	2010	(D)
		2009	25,877
325510B141	Other miscellaneous allied paint products, including brush cleaners, ink vehicles, putty and glazing compounds, etc.	2010	83,708
		2009	73,062

Emission Factor

Use the emission factors for architectural surface coatings (EPA, 1993A), that are shown in Table 5-2 of the EIIP document and reproduced below:

Coating Type	**VOC Content Lbs / gallon**
Water-based	0.74
Solvent-based	3.87
Total	4.61

This activity occurs 7 days a week and is usually more common in the summer months as indicated by a seasonal adjustment factor of 1.3 (see Table 5.8-1 in Procedures). It should be noted that 99% of solvents in these coatings are VOC.

Point Source Adjustments

Because the application of architectural surface coating is defined as an area source, there is no need to subtract point source emissions from the total, and all emissions estimated for this source are area source emissions.

Adjustment for Controls

EPA surface coating regulation reduction combined with Phase I and II of the OTC AIM Rule resulted in a reduction 32.4%.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The equation used to estimate emissions from architectural surface coatings is:

Equation to calculate solvent-based emissions is:

$$EM_{ASC-SB} = \frac{POP_i \mathbf{x} UF_{ASC-SB} \mathbf{x} EF_{SB} \mathbf{x} [(1-(CE_{ASC} \text{ x } RE_{ASC} \text{ x } RP_{ASC})]}{2000}$$

Where:

EM_{ASC-SB} = VOC emissions in tons per day from solvent-based architectural surface coatings
POP_i = 2016 population of county i
UF_{ASC-SB} = Usage factor for solvent-based architectural surface coatings
EF_{SB} = VOC emission factor for solvent-based architectural surface coatings
CE_{ASC} = Control efficiency[4] for architectural surface coatings
RE_{ASC} = Rule effectiveness[5] for architectural surface coatings
RP_{ASC} = Rule penetration for architectural surface coatings

Equation to calculate water-based emissions is:

$$EM_{ASC-WB} = \frac{POP_i \mathbf{x} UF_{ASC-WB} \mathbf{x} EF_{WB} \mathbf{x} [(1-(CE_{ASC} \text{ x } RE_{ASC} \text{ x } RP_{ASC})]}{2000}$$

Where:

EM_{ASC-WB} = VOC emissions in tons per day from water-based architectural surface coatings
POP_i = 2016 population of county i
UF_{ASC-WB} = Usage factor for water-based architectural surface coatings
EF_{WB} = VOC emission factor for water-based architectural surface coatings
CE_{ASC} = Control efficiency for architectural surface coatings
RE_{ASC} = Rule effectiveness for architectural surface coatings
RP_{ASC} = Rule penetration for architectural surface coatings

[4] An overall 32.4% reduction in emissions is due to regulation
[5] EPA's AIM regulation and the OTC Rules were applied to architectural surface coatings

2017 Example Calculation Architectural Surface Coating (Carroll County)

Solvent-Based
$POP_{Carroll}$ = 167656 persons
UF_{ASC-SB} = 0.34988 gal/capita
EF_{SB} = 3.87 lbs. $_{VOC}$/gal/year
CE_{ASC} = 32.4%
RE_{ASC} = 100%
RP_{ASC} = 100%

EM_{ASC-SB} = ((167656 x 0.34988 x 3.87) x [1 – (0.324 x 1.00 x 1.00)]) / 2000
EM_{ASC-SB} = 76.73 tons $_{VOC}$ per year Carroll County

Architectural Surface Coating Solvent-Based was found to have a
SAF = seasonal adjustment factor of 0.33
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted **$EM_{ASC-SBda}$** = (**EM_{ASC-SB}** / 365)*(SAF / POS)

$EM_{ASC-SBda}$ = (**76.73** / 365*(0.33 / 0.25) = **2.77E-01 VOC tons/day**

Water-Based
$POP_{Carroll}$ = 167656 persons
UF_{ASC-WB} = 1.56748 gal/capita
EF_{WB} = 0.74 lbs. $_{VOC}$/gal/year
CE_{ASC} = 32.4%
RE_{ASC} = 100%
RP_{ASC} = 100%

EM_{ASC-WB} = ((167656 x 1.56748 x 0.74) x [1 – (0.324 x 1.00 x 1.00)]) / 2000
EM_{ASC-WB} = 65.73 tons $_{VOC}$ per year Carroll County

Architectural Surface Coating Solvent-Based was found to have a
SAF = seasonal adjustment factor of 0.33
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted **$EM_{ASC-WBda}$** = (**EM_{ASC-WB}** / 365)*(SAF / POS)

$EM_{ASC-WBda}$ = (**65.73** / 365*(0.33 / 0.25) = 2**.38E-01 VOC tons/day**

4.1.2.4 Auto Refinishing

SCC: 24 01 005 000

Description

Automobile refinishing is the repainting of worn or damaged automobiles, light trucks and other vehicles. Coating of new cars is not included in this category but falls under industrial coating. In automobile refinishing, lacquers and enamels are usually applied with hand-operated spray guns. Because the vehicles contain heat-sensitive plastics and rubber, the coatings are dried or cured in low-temperature ovens or at ambient conditions. MDE adopted a regulation based upon federal guidance that requires the use of reformulated coatings and equipment with greater transfer efficiency in the application of coatings.

Pollutants

VOC

Method and Data Sources

MDE staff used an alternative per employee emission estimation methodology documented in EIIP[6], Chapter 13, Auto Body Refinishing, dated January 2000. The document provides an outline for developing a per employee emission factor using a national VOC emission estimate and national employment data.

Activity
MDE calculated an emission factor of 669.008 lbs. VOC per employee per year using an estimate of 151.9 million pounds of solvents sold nationally in 2007 and dividing it by 2007 County Business Patterns employment number of 227,085 for NAICS 811121: Automotive Body, Paint, Interior and Glass Repair. The amount of solvent sold was provided by the EPA in conjunction with The Freedonia Group and ERTAC.

Maryland has an auto body regulation which allowed MDE to take an 8% reduction in emissions. The autobody refinishing category does not include new car coating.

Emission Factor:
669.008 lbs of VOC per employee per year

[6] Emission Inventory Improvement Program

Point Source Adjustments

Autobody refinishing emissions from facilities identified as point sources were subtracted from the area source inventory to avoid double counting.

Adjustment for Controls

Maryland's auto body regulation allowed MDE to apply an 8% control.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The equation used to estimate emissions from automobile refinishing is:

$$E_{AR} = \frac{(EMP_J - Emp_{Point\ AR}) \times EF_{AR} \times [1 - (RE \times RP \times CE)]}{2000}$$

Where:

E_{AR} = VOC emissions in tons per year from auto refinishing
EMP_J = Number of employees in county j for NAICS 811121 (auto refinishing) from County Business Patterns
EF_{AR} = VOC emission factor for auto refinishing
$Emp_{Point\ AR}$ = Employment back calculated from point source emissions

<u>2017 Example Calculation Auto Refinishing (Baltimore City)</u>

$$E_{AR} = \frac{(372 - 0) \times 669.008 \times [1 - (1.0 \times 1.0 \times .08)]}{2000}$$

E_{AR} = 114.48 Tons $_{VOC}$ / year
Auto Refinishing was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 260
Daily adjusted $\mathbf{E_{ARda}}$ = ($\mathbf{E_{AR}}$ / 260)*(SAF / POS)

$\mathbf{E_{ARda}}$ = (**114.48** / 260*(0.25 / 0.25) = **4.40E-01 VOC tons/day**

4.1.2.5 Traffic Markings

SCC: 24 01 008 000 - Traffic paints

Description

Traffic paints are used to mark pavement, the majority of which is used to create dividing lines for traffic lanes. These markings are applied by state or local highway maintenance crews or by contractors. VOC emissions result from the evaporation of organic solvents during and shortly after the application of the marking paint. All traffic paint emissions are included in the area source inventory.

Pollutants

VOC

Method and Data Sources

MDE surveyed city, county, and state agencies for gallons of paint used and the VOC content of the paint used.

Activity

The Maryland State Highway Administration (SHA) keeps data on gallons of traffic marking paint used by district and not by individual counties. For emissions from SHA line painting, each county's proportion of the total district's lane miles was multiplied by total gallons painted in a district to get an estimated amount of gallons used for each county. In a few counties, SHA does all the line painting. Also, data was collected from the Maryland Aviation Administration (MAA) and the Mass Transit Administration (MTA).

MDE was able to gather information on gallons of traffic paint used during the ozone season and during a year. The Material Safety Data Sheets and Environmental Data Sheets were collected for each paint and solvent used by each local jurisdiction and State agency doing the striping. It was necessary to collect data on yellow and white paint separately because the amount of VOCs per gallon is different for each type of paint.

The emission totals are slightly lower than in previous inventories because many jurisdictions have switched to latex (water-borne) paints for traffic marking, and those areas already using latex paints have switched to using a latex paint that is lower in VOC content than what was previously used. The widespread use of latex paints means that there are no longer any emissions from the solvents used to clean painting equipment when oil based paints are used. Several counties have been using thermoplastic and glass beads to help in traffic marking which also give off VOCs. A ratio of 14.1 and 13.5 pounds per gallon of white and yellow thermoplastic respectively were equated and added to the amount of paint used. A ratio of 17.5 gallons of white paint was used for every 148.75

pounds of beads used. VOC content for thermoplastic and beads came from Material Safety Data Sheets and ratios were estimated with the help of paint suppliers and contractors.

The following information was collected from all public agencies using traffic marking paint in Maryland:

Gallons of yellow traffic paint and solvent used in 2017
Gallons of white traffic paint and solvent used in 2017

The MSDS and Environmental Data Sheets per type of paint provided the following information:

- Percent volatile by weight
- Percent water by weight
- Percent volatile organic compounds by weight
- Total VOC (lbs./gal)
- VOC/gallon less water

Emission Factor

Traffic Paints	VOC Emission Factor (lbs. VOC/gallons)
Yellow Paint	0.36 to 0.78
White Paint	0.11 to 0.78

The VOC pound per gallon of paint was obtain from the Material Safety Data Sheet (MSDS) for each color and brand of paint used. The appropriate factor was used for each calculation and the table above shows the range for each color.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

MDE applied controls obtained from EPA AIM Rule & OTC Phase II AIM Rule for this source category, which combined produced a 9.7% reduction.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

Traffic Paint Sample Calculation (Harford County)

(1) Calculate VOC emissions from yellow and white traffic paints for year 2017

a. State Highway Administration (SHA) and Local Government (LG) Traffic Paint Use

Total yellow gallons used in 2017 = 6,715 gallons LG
Total VOC per gallon of yellow paint used[22] = 0.56 lbs. $_{VOC}$ /gallon
Total white gallons used 2017 = 1,189 gallons LG
Total VOC per gallon of white paint used[23] = 0.57 lbs. $_{VOC}$ /gallon

Total yellow gallons used in 2017 = 12,884 gallons SHA
Total VOC per gallon of yellow paint used[24] = 0.57 lbs. $_{VOC}$ /gallon
Total white gallons used 2017 = 17,079 gallons SHA
Total VOC per gallon of white paint used[25] = 0.57 lbs. $_{VOC}$ /gallon

$$E_{\text{Yellow Paint}} = \frac{((6{,}715 \times 0.56) + (12{,}884 \times 0.57))}{(2{,}000 \text{ lbs./ton})}$$

$$\mathbf{E_{\text{Yellow Paint}} = 5.55 \text{ tons / year}}$$

$$E_{\text{White Paint}} = \frac{((1{,}189 \times 0.57) + (17{,}079 \times 0.57))}{(2{,}000 \text{ lbs./ton})}$$

$$\mathbf{E_{\text{White Paint}} = 5.21 \text{ tons / year}}$$

b. Maryland Aviation Administration (MAA) Traffic Paint Use

[22] MSDS from Caroline County's Department of Public Works, Division of Highways
[23] MSDS from Caroline County's Department of Public Works, Division of Highways
[24] MSDS from Caroline County's Department of Public Works, Division of Highways
[25] MSDS from Caroline County's Department of Public Works, Division of Highways

The MAA did not apply any paint in Harford County.

c. Maryland Transportation Administration (MTA) Traffic Paint Use

Total yellow gallons used in 2017 = 92 gallons MTA
Total VOC per gallon of yellow paint used[26] = 0.57 lbs. $_{VOC}$ /gallon
Total white gallons used 2017 = 167 gallons MTA
Total VOC per gallon of white paint used[27] = 0.57 lbs. $_{VOC}$ /gallon

$$E_{\text{Yellow Paint}} = \frac{(92 \times 0.57)}{(2{,}000 \text{ lbs./ton})}$$

$E_{\text{Yellow Paint}}$ = 0.03 tons / year

$$E_{\text{White Paint}} = \frac{(167 \times 0.57)}{(2{,}000 \text{ lbs./ton})}$$

$E_{\text{White Paint}}$ = 0.05 tons / year

$$E_{\text{Paint Total}} = E_{\text{SHA Paint Total}} + E_{\text{Local Paint Total}} + E_{\text{MAA Paint Total}} + E_{\text{MTA Paint Total}} + E_{\text{Paint Solvent}}$$

$$E_{\text{Paint Total}} = (\mathbf{5.55} + \mathbf{5.21} + 0.0 + \mathbf{0.08} + 0.0) \times (1-0.097)$$

$E_{\text{Paint Total}}$ = 9.78 tons / year VOC emissions for Harford County.

Traffic Paint was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 260
Daily adjusted $\mathbf{E_{ARda}} = (\mathbf{E_{AR}} / 260)*(SAF / POS)$

$\mathbf{E_{ARda}} = (\mathbf{9.78} / 260*(0.25 / 0.25) =$ **3.76E-02 VOC tons/day**

[26] MSDS from Caroline County's Department of Public Works, Division of Highways
[27] MSDS from Caroline County's Department of Public Works, Division of Highways

4.1.2.6 Industrial Surface Coating

SCC: 24 01 015 000 (Finish Wood Product Manufacturing)
24 01 020 000 (Wood Furniture and Fixtures)
24 01 025 000 (Metal Furniture and Fixtures)
24 01 030 000 (Paper, Film, and Foil)
24 01 040 000 (Metal Cans)
24 01 060 000 (Household Appliances Manufacturing)
24 01 065 000 (Electronic and Other Electrical)
24 01070 000 (Motor Vehicles)
24 01 075 000 (Aircraft)
24 01 080 000 (Marine)
24 01 085 000 (Railroads)
24 01 090 000 (Miscellaneous Manufacturing)
24 01 100 000 (Industrial Maintenance Coatings)
24 01 200 000(Other Coatings)

Description

Industrial surface coatings are applied during the manufacture of a wide variety of products, including furniture, cans, automobiles, other transportation equipment, machinery, appliances, metal coil, flat wood, wire and other miscellaneous products. In addition, coatings are used in maintenance operations at industrial facilities but these are considered paint sources.

Pollutants

VOC and HAPs

Method and Data Sources

MDE used the methods and procedures documented in EIIP[28], Chapter 8 Industrial Surface Coatings, dated September 1997. Applicable point source emissions (those within the same NAICS) are taken from the MDE/ARA registration files have been subtracted from the emissions calculated on a per capita and per employee basis that are presented below.

Activity

The choice between using per capita factors or per employee factors for categories where made based on the quality of data. County Business Patterns internet address: http://censtats.census.gov/ lists employee data by North American Industry Classification System (NAICS). Many values are based on actual data. However, some county NAICS list a range for the number of employees through a letter code. In this case the arithmetic average number of employees per letter code per county was adjusted so that the state total employment in a NAICS matched the sum of the number of employees reported per county. For those categories where all or most of the employment data was listed as a range, the per capita factor was assumed to be more reliable and was used to calculate emissions. The U.S. Census Bureau reports population statistics for the counties of

[28] Emission Inventory Improvement Program

Maryland. Population statistics for 2017 for the counties of Maryland were collected from the U.S. Census Bureau Internet address (http://www.census.gov).

Because the emission factors were developed based on NAICS employment data and 2013 was the last year employment data was available per NAICS, MDE used the 2013 County Business Patterns as the source for employment figures.

Emission Factor

Per employee factors were used for the industry surrogate employment NAICS because they are generally more reliable (see Procedures, Table 4-10.1), and a comparison with per capita emissions in one county showed that for these SICs, the per capita factors led to a large overestimation of emissions. Per capita factors were used for the industry surrogate population NAICS because they prove to be more reliable for emission calculations than the per employee factor.

Industry	SCC	NAICS	Surrogate
Finish Wood Product Manufacturing	2401015000	321	Employment
Wood Furniture and Fixtures	2401020000	337110, 337121, 337122, 337127, 337129, 337211,337212, 337215, 339111	Employment
Metal Furniture and Fixtures	2401025000	337124, 337127, 337214, 337215, 339111	Employment
Paper, Film, and Foil	2401030000	322222	Employment
Metal Cans	2401040000	33243	Employment
Household Appliances Manufacturing	2401060000	3352	Employment
Electronic and Other Electrical	2401065000	331319, 31422, 331491, 35921, 335929	Employment
Motor Vehicles	2401070000	3361, 3362, 3363	Employment
Aircraft	2401075000	3364	Employment
Marine	2401080000	3366, 488390	Employment
Railroads	2401085000	3365	Employment
Miscellaneous Manufacturing	2401090000	339, 3369	Employment
Industrial Maintenance Coatings	2401100000	NA[a]	Population
Other Coatings	2401200000	NA[a]	Population

Furthermore, NAICS used were the best correspond to SIC for each source category so that emission factors that were generated from EIIP SIC data could be used. EPA provided the correlation between NAICS and SIC

Industrial Maintenance Coatings (NAICS) and **Other Coatings (NAICS)**, emission factors are listed in a document prepared by Dennis Beauregard at EPA and named "Freedonia EFs 06-16-09.xls". The file has been modified by E.H Pechan and Associates, Inc. to correct for an error in NAICS code 441 for Cleaning Products: Industrial and Institutional (2415000000). The Freedonia emissions factor calculation file can be obtain from EPA for further detail on how each of the factors below were estimated.

Industry	Per Employment VOC Emission Factor (lbs. $_{VOC}$/employee/year)	Per Capita VOC Emission Factor (lbs. $_{VOC}$/person/year)
Finish Wood Product Manufacturing	43	NA
Wood Furniture and Fixtures	244	NA
Metal Furniture and Fixtures	772	NA
Paper, Film, and Foil	735	NA
Metal Cans	2,326	NA
Household Appliances Manufacturing	254	NA
Electronic and Other Electrical	24.7	NA
Motor Vehicles	164	NA
Aircraft	15	NA
Marine	198	NA
Railroads	222	NA
Miscellaneous Manufacturing	136	NA
Industrial Maintenance Coatings	NA	0.8
Other Coatings	NA	0.8

Point Source Adjustments

Applicable point source emissions (those within the same NAICS) taken from the MDE/ARA registration files have been subtracted from the calculated emissions, and their emissions are separated from the totals presented below.

Adjustment for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

<u>Equation:</u>

$$E_{FW} = \frac{EMPL_i \mathbf{x} EF_{FW}}{2000}$$

Where:

E_{FW} = VOC emissions in tons per year from finish wood product manufacturing.

$EMPL_i$ = employees in county i employed in NAICS 321.

EF_{FW}[29] = VOC emission factor for finished wood which is 43 lbs. $_{VOC}$ per employee per year

<u>2017 Example Calculation Industrial Surface Coating – Finish Wood Product Manufacturing (Baltimore City)</u>

Number of employees in NAICS 321 in Baltimore City (2016 County Business Patterns):

$EMPL_{BC}$ = **44.8**

Emission factor for finish wood product manufacturing (lbs. VOC/employee/year):

EF_{FW} = **43**

$$E_{FW\ (Baltimore\ City)} = \frac{(45\ \mathbf{x}\ 43)}{2000}$$

$E_{FW\ (Baltimore\ City)}$ = 0.96 tons $_{VOC}$ per year

Traffic Paint was found to have a

SAF = seasonal adjustment factor of 0.25

POS = peak ozone period of 0.25

Days of the Period 260

Daily adjusted **E_{ARda}** = (**$E_{FW\ (Baltimore\ City)}$** / 260)*(SAF / POS)

E_{ARda} = (**0.96** / 260*(0.25 / 0.25) = **3.70E-03 VOC tons/day**

[29] Table 8.5-1, EIIP Chapter 8 Industrial Surface Coatings

4.1.2.7 Industrial Adhesives

SCC: 2440000000

Description

Industrial adhesives are the application of a liquid or powder substance, such as solvent type paints, varnishes, and lacquers to a surface for decorative or protective purposes. The substances can be applied by brushing, rolling, spraying, dipping or flow coating. VOCs are released into the air as the substance dries. Powder coatings are applied to a hot surface and then melted; VOCs are released as the powder melts and dries.

Pollutants

VOC and HAPs

Method and Data Sources

MDE staff used EPA's "Solvent Mass Balance" methodology for estimating emissions from nonpoint solvents, which uses the total solvent production and sales for a particular source category to estimate overall emissions then subtracting out emissions due to point sources, waste management, and recycling.

Activity

Per capita activity data was used and downloaded from the US Census Bureau (internet address: http://www.census.gov) July 1, 2017 population statistic estimates for the counties of Maryland[30].

Emission Factor

MDE used the emission factor of 1.10 lbs/capita/year developed by Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Adhesives and Sealants, California Air Resources Board document for adhesives and sealants (CARB RACT/BARCT for Adhesives/ Sealants, Dec 1998)[31].

CARB RACT/BARCT estimated emission factor calculation for adhesives/sealants is as following:

VOC = 45 tons/day estimated in 1994 * 365 days/year * 2000 lbs/ton / 29,760,021 capita where 45 tons/day is the estimated state-wide emissions for industrial adhesives in California, 2000 lbs/ton is a conversion factor, and 29,760,021 capita is the 1990 population of California.

VOC Emf = 1.10 lbs/capita/year of industrial adhesives

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[30] 2017 estimated population from U.S. Bureau of the Census, Population Estimation Branch (see Appendices).

[31] Emission factors were developed by CARB RACT/BARCT for Adhesives/ Sealants, Dec 1998.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

Maryland has adopted an industrial adhesive and coatings regulation (COMAR 26.11.19.15). The regulation is similar to the one proposed by the Ozone Transport Commission (OTC) and achieves VOC reductions through two basic components: sale and manufacture restrictions that limit the VOC content of specified adhesives, sealants and primers sold in the state; and use restrictions that apply primarily to commercial/industrial applications.

A reasonably available control technology determination (CARB RACT/BARCT for Adhesives/ Sealants, Dec 1998) prepared by the California Air Resources Board (CARB) in 1998 forms the basis of this model rule. In the years 1998-2001, the provisions of the CARB determination were adopted in regulatory form in various air pollution control districts in California including the Bay Area, Ventura County, Sacramento Metropolitan and San Joaquin Valley.

CARB and OTC estimate a 64.4 percent reduction in emissions from the source category regulation that was fully implemented in Maryland in 2009.

Spatial and Temporal Allocations

Spatial
Data for spatial allocation is not available for this source.

Temporal
SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

Equation:

$$E_{OC} = \frac{POP_i \mathbf{x} EF_{OC}}{2000} \times [1 - (CE \times RE \times RP)]$$

where:
E_{OC}[32] = VOC emissions in tons per year from industrial adhesives.
POP_i = 2017 population of county i
EF_{OC}[33] = VOC emission factor for industrial adhesives.
CE = Control Efficiency
RE = Rule Effectiveness
RP = Rule Penetration

[32] 2017 estimated population from U.S. Bureau of the Census, Population Estimation Branch (see Appendices).
[33] Emission Inventory Imporvement Program Vol III, Ch. 6, September 1997.

To adjust for control efficiency OTC-PECHAN Control Measure Report:
2017 base year where:
CE = 0.644, RE = RP = 1.

[1 – (CE x RE x RP)] = [1 – (0.644 x 1 x 1)] = 0.356

2017 Per Capital Sample Calculation for Industrial Adhesives in Harford County:

2017 U.S. Census Bureau Population Estimate for Harford County:
POP_i = 251,032
Emission factor for industrial adhesives (lbs. VOC/person/year):
EF_{OC} = 1.10

5 days per week activity level, no seasonal adjustment factor

Equation:

$$E_{OC} = \frac{POP_i \times EF_{OC}}{2000} \times [1 - (CE \times RE \times RP)]$$

$$\mathbf{E_{OCHarford} = \frac{251{,}032 \times 1.10 \times [1 - (0.644 \times 1.0 \times 1.0)]}{2000} = 49.15\ tons_{VOC}\ per\ year.}$$

Industrial Adhesives was found to have a
SAF = seasonal adjustment factor of 0.28
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted $\mathbf{E_{OCHarfordda}}$ = ($\mathbf{E_{OCHarford}}$ / 365)*(SAF / POS)

$\mathbf{E_{OCHarfordda}}$ = (**49.15** / 365)*(0.28 / 0.25) = 1**.51E-01 VOC tons/day**

4.1.2.8 Graphic Arts

SCC: 24 25 000 000 (Screen & Plateless)
24 25 010 000 (Offset Lithography)
24 25 020 000 (Letterpress)
24 25 030 000 (Rotogravure)
24 25 040 000 (Flexography)

Description

Graphic arts include operations that are involved in the printing of newspapers, magazines, books and other printed materials. There are six basic operations used in graphic arts: lithography, gravure, letterpress, flexography, screen printing and metal decorating (plateless). In our calculations screen and plateless printing were paired together and make up a combined 6% market share of all printing. Lithography accounts for nearly half of all graphic arts operations.

Pollutants

VOC

Method and Data Sources

MDE staff used an alternative per capita emission estimation method documented in EIIP[4], Chapter 7 Graphic Arts, dated November 1996. The EIIP methodology recommended an emission factor of 1.3 lbs. $_{VOC}$ per capita per year emission factor (EPA, 1991) for graphic arts sources emitting less than 100 tons VOC per year. Yearly activity was used with no seasonal adjustment factor as recommended in Table 5.8-1 in Procedures. All point source graphic arts facilities (NAICS 11531) in the ARA registration files for 2017 emissions where subtracted from the area source inventory.

Activity

The estimated percentage of market share, reported in Table 7.2-3 of the EIIP document and reproduced below, was used to allocate the total graphic arts emissions to specific printing types. Maryland has different regulations regarding specific types of printing operations and thus to calculate controlled emissions the estimated percentage that each type of printing operation contributes to the total had to be determined.

Type of Printing (MS_{type} **)**	**Estimated Percentage of Product Market Share**
Rotogravure	18
Flexography	18
Offset Lithography	47
Letterpress	8
Screen	3
Plateless	3

[4] Emission Inventory Improvement Program

Emission Factor
1.3 lbs. $_{VOC}$ per capita per year

Point Source Adjustments

Graphic arts emissions from facilities identified as point sources were subtracted from the area source inventory to avoid double counting.

Adjustment for Controls

Control efficiency is based on Maryland regulations for each type of printing process and has been developed within technical support documents for the graphic arts printing regulations. Rule penetration has been defined as the estimated percentage that each type of printing operation. Rule effectiveness has been assigned the EPA default value of 80 per cent.

Control	Lithographic	Rotogravure	Letterpress	Flexographic	Screen
Rule Effectiveness (RE)	0.800	0.800	0.800	0.800	0.800
Rule Penetration (RP)	1.000	1.000	1.000	1.000	1.000
Control Efficiency (CE)	0.750	0.630	0.000	0.540	0.350
Reduction factor (RE x RP x CE)	0.600	0.504	0.000	0.432	0.280

Spatial and Temporal Allocations

Spatial
Data for spatial allocation is not available for this source.

Temporal
SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The equation used to estimate emissions from graphic arts is:

Equation:

$$E_{GA} = \frac{MS_{type} \mathbf{x} POP_i \mathbf{x} EF_{GA}}{2000} \times (1 - RF_{GA})$$

Where:

E_{GA} = VOC emissions in tons per year from graphic arts
MS_{type} = Market share percent of the type of printing
POP_i = 2017 population of county i
EF_{GA} = VOC emission factor for graphic arts (1.3[34] lbs. $_{VOC}$ per person per year)
RF_{GA} = Reduction Factor for Printing
RF_L = Reduction Factor for Lithographic Printing
RF_{LP} = Reduction Factor for Letterpress Printing
RF_R = Reduction Factor for Rotogravure Printing
RF_F = Reduction Factor for Flexographic Printing
RF_S = Reduction Factor for Screen & Plateless Printing

2017 Example Calculation Graphic Arts (Anne Arundel County)

$$E_{GAL} = \frac{0.47 \times 568{,}346 \times 1.3}{2000} \times (1 - 0.600)$$

$$E_{GALP} = \frac{0.08 \times 568{,}346 \times 1.3}{2000} \times (1 - 0.0)$$

$$E_{GAR} = \frac{0.18 \times 568{,}346 \times 1.3}{2000} \times (1 - 0.504)$$

$$E_{GAF} = \frac{0.18 \times 568{,}346 \times 1.3}{2000} \times (1 - 0.432)$$

$$E_{GAS} = \frac{0.06 \times 568{,}346 \times 1.3}{2000} \times (1 - 0.280)$$

$$E_{GAsum} = (E_{GAL} + E_{GALP} + E_{GAR} + E_{GAF} + E_{GAS})$$

$$E_{GAsum} = (69.45 + 29.55 + 32.98 + 37.77 + 15.96)$$

E_{GAsum} = 185.72 tons $_{VOC}$ **per person year (Totals may be slightly different due to rounding)**

Graphic Arts was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 260
Daily adjusted $E_{GAsum\mathbf{da}}$ = (E_{GAsum} / 260)*(SAF / POS)

$E_{GAsum\mathbf{da}}$ = (**185.72** / 260)*(0.25 / 0.25) = **7.14E-01 VOC tons/day**

[34] Emission factor from EIIP Chapter 7 Graphic Arts

4.1.2.9 Asphalt Paving and Roofing

SCC: 24 61 022 000 Emulsified
24 61 020 000 Misc. Application (Road Oil)
24 61 021 000 Cutback
24 61 023 000 Roofing

Description

The two types of asphalt paving used for road paving and repair are cutback asphalt and emulsified asphalt. Cutback asphalt is a liquefied road surface prepared by blending (or "cutting back") asphalt cement with different petroleum distillates or (road oils). The second type, emulsified asphalt, is also a liquefied road surface, but is prepared with a water/soap mixture instead of petroleum distillates. Cutback asphalt emits more VOCs, and its use has been limited in Maryland to the non-ozone period of April 15 to October 15. Asphalt like tar is also used for roofing similar to rubberizing.

Pollutants

VOC

Method and Data Sources

MDE calculated emissions for this category by using a combination of factors from the Sacramento Metropolitan Air Quality Management District (SMAQMD) 1991 Survey, the California Air Resources Board, and EPA's AP-42. It estimated that 80% of all asphalt used in Maryland is for paving, and the remaining 20% is for roofing.

Activity

Total barrels of asphalt used in Maryland was obtained from the Energy Information Administration (EIA) and separated to county level. Maryland used 2,280,000 barrels of asphalt in 2016. Also, 2017 population statistics for the counties of Maryland were collected from the Census Bureau Internet address (http://www.census.gov).

Emission Factors:

Asphalt Related Material	VOC Emission Factors	EF Units
Emulsified	17.9	lbs/ton
Road Oils	70.4	lbs/ton
Cutback	268.3	lbs/ton
Asphalt Roofing	6.2	lbs/ton

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

State of Maryland Department of Environment regulations (COMAR 26.11.11.02B), prohibit use of cutback asphalt paving from April 15 to October 15 so ozone precursor emissions from cutback asphalt application were not calculated. Cutback asphalt is made by blending asphalt cement with petroleum distillates that evaporate when the road surface is "cured" after application. Cutback was given a control efficiency of 100 %, rule effectiveness of 80%, and rule penetration of 100%. All other asphalts had no controls applied. Emulsified asphalt is asphalt cement mixed with a blend of water and an emulsifier, usually soap.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

Emission estimates were calculated by converting total barrels used to tons of asphalt, multiplying it by appropriate emission factor, and then proportioning them by population to the county level. There is 350 lbs of asphalt in each barrel. Out of all asphalt used in the state, approximately 80% is used for paving and 20% is used for roofing. Paving asphalt usage is further separated below:

Paving Asphalt Percent	
Paving Hot-mix:	**92%**
Paving Emulsified:	**5%**
Paving Road Oils:	**2%**
Paving Cutback	**1%**
Roofing of state total	**20%**

Tons of Paving Asphalt	
Hot-mix:	**293,664**
Emulsified:	**15,960**
Road Oils:	**6,384**
Cutback	**3,192**
Roofing	**79,864**

Hot-mix emissions were calculated by facilities and reported with point source inventory.

The equation used to estimate emissions from asphalt paving is:

$$E_A = \frac{CLA_{Type} \mathbf{x} EF_{Type}}{2000} \times (1 - (RE \mathbf{x} RP \mathbf{x} CE))$$

Where:

E_A = VOC emissions tons

CLA_{Type} = Estimated amount of asphalt type used (tons)

EF_{Type} = emission factor for type of asphalt in lbs $_{VOC}$ per ton of asphalt per yr

RE = Rule Effectiveness

RP = Rule Penetration

CE = Control efficiency

2017 Road Oils Asphalt Sample Calculations: Anne Arundel County

Total Maryland Population for 2017 was 6,016,447 people.
Anne Arundel County population for 2017 was 568,346 people.

Usage ratio for Anne Arundel County is USEa = (568,346 / 6,016,447) = 0.0945
Total barrels of asphalt used in Maryland in
2017 were 2,280,000 and minus 20% for roofing leaves 1,824,000 barrels. 2% is road oils, which is 36,480 barrels.

$$CLA_{AA} = \frac{(36{,}480 \text{ barrel x } 350 \text{ lbs per barrel})}{2000} \times 0.0945 = 603.29 \text{ tons road used}$$

$$E_{AARoadOils} = \frac{603.29 \times 70.4}{2000} \times (1 - (1 \mathbf{x} 1 \mathbf{x} 0))$$

$E_{AARoadOils}$ = **21.24** tons $_{VOC}$ Anne Arundel County per year

(Similar calculation can be done for each asphalt type for each county)

Road Oils Asphalt was found to have a
SAF = seasonal adjustment factor of 0.39
POS = peak ozone period of 0.25
Days of the Period 312
Daily adjusted $E_{AARoadOils\mathbf{da}}$ = ($E_{AARoadOils}$ / 312)*(SAF / POS)

$E_{AARoadOilsda}$ = (21.24 / 312)*(0.39 / 0.25) = **1.06E-01 VOC tons/day**

4.1.2.10 Synthetic Organic Chemical Storage Tanks

This category is fully represented in the point source inventory.

4.1.2.11 Pesticide Application

SCC: 24 61 800 001 Surface Application
24 61 800 002 Soil Application

Description

Pesticides are substances or mixtures used to control plant and animal life for the purposes of: agricultural production, public health from pest-borne disease, reducing property damage due to pests, and improving the aesthetic quality of outdoor and indoor surroundings. Agriculture, homeowners, industry, and government agencies use pesticides. The largest usage of pesticides by weight is in agriculture. Agricultural pesticides control weeds, insects, mites, fungi, nematodes, and other threats to the yield, quality, or safety of food production. There are several methods used to apply pesticides. For our calculations we used surface or soil application.

Emissions arise from pesticide use because of the volatile nature of many ingredients, solvents, or other additives used in the formulations. Many pesticide formulations use solvents as carriers for more active organic or inorganic ingredients. In pesticide formulations, the organic or inorganic solute is the "active ingredient" (AI), while the solvent carrier is the "inert carrier." Thus, the terms "active" and "inert" in pesticide formulations refer to toxicological action, and are not indicators of photochemical activity. Both the active and inert ingredients in these formulations evaporate and contribute to VOC emissions.

Pollutants

VOC and HAPs

Method and
Data Source:

Pesticide usage data used to calculate pesticide emissions came from a 2014 survey conducted by the Pesticide Regulation Section of the Maryland Department of Agriculture and the U.S. Department of Agriculture. Also, the Maryland and National Agricultural Statistics services in cooperation with the Departments of Agriculture compiled information for the document, Maryland Pesticide Statistics for 2014, which reported pesticide usage in pounds used in a year by active ingredient for each Maryland County.

EPA post new guidance for calculating pesticide emissions on its FTP site under the document, "**Agricultural Pesticide Application**". The site also included files containing new estimated emission factors for several different pesticides and a weighted average emission factor (EF_{avg}) value of 0.4 pounds of VOC per pound of active ingredient (default factor). Since Maryland had over 200 pesticides reported and about 50 of the pesticides listed in the Maryland Pesticide

Statistics were not found in any of EPA's files or any of the other country wide databases, an estimation of emissions were split into those calculated from EPA factors and the rest were defaulted from the EF_{avg} value.

The emissions were calculated by multiplying the amount of active ingredient by its emission factor. The total amounts of emissions were estimated, but the amount used in each county was not given, therefore reported harvest acres were used to divide emissions into each county. Pesticide use was not reported for a particular pesticide-by-crop, but the Maryland Department of Agriculture's, "Harvested Acres 2015-2017 MD Annual Bulletin" reported the types of crops and the amount of each harvest in each county. In Maryland pesticides for soybean and corn are normally applied to soil and wheat and barley are applied to the surface. A percentage based on the portion of each crop type was also used to further divide emissions by county and by soil or surface application and reported by SCC. Pesticides used to estimate emissions are shown below. 2009 statistics had to be used for hay and alfalfa.

Pesticides Used in Maryland 2015 to 2017

County	Pesticide MD Report	EPA Emission Factor lb./lb.	Active Ingredient lbs	VOC lbs	VOC tons
ALLEGANY	Glyphosate	0.158572216	7,867	1,247	**0.62**
ALLEGANY	2;4-D	0.827317385	1,228	1,016	**0.51**
ALLEGANY	Picloram; K salt	0.398396794	1,130	450	**0.23**
ALLEGANY	Disod. Octa. tetra.	0.4	931	372	**0.19**
ALLEGANY	Beta-cyfluthrin	1.735956923	327	568	**0.28**
ALLEGANY	Aminopyralid potassium salt	0.160221675	221	35	**0.02**
ALLEGANY	Imidacloprid	0.30515662	194	59	**0.03**
ALLEGANY	Bifenthrin	1.565896363	133	208	**0.10**
ALLEGANY	Lambda-cyhalothrin	0.400383954	86	34	**0.02**
ALLEGANY	Pyriproxyfen	1.386748166	76	105	**0.05**
ANNE ARUNDEL	Fipronil	6.462993609	190,450	1,230,877	**615.44**
ANNE ARUNDEL	Glyphosate	0.158572216	13,974	2,216	**1.11**
ANNE ARUNDEL	2;4-D	0.827317385	8,733	7,225	**3.61**
ANNE ARUNDEL	Imidacloprid	0.30515662	7,184	2,192	**1.10**
ANNE ARUNDEL	Pyriproxyfen	1.386748166	6,753	9,365	**4.68**
ANNE ARUNDEL	Beta-cyfluthrin	1.735956923	5,989	10,397	**5.20**

ANNE ARUNDEL	Boric acid	0.4	2,712	1,085	**0.54**
ANNE ARUNDEL	MCPA; dimethyl. salt	0.470093248	2,299	1,081	**0.54**
ANNE ARUNDEL	Atrazine	0.148401799	2,202	327	**0.16**
ANNE ARUNDEL	Pendimethalin	0.558789524	2,154	1,204	**0.60**
BALTIMORE	Glyphosate	0.158572216	53,133	8,425	**4.21**
BALTIMORE	2;4-D	0.827317385	27,306	22,591	**11.30**
BALTIMORE	Imidacloprid	0.30515662	21,530	6,570	**3.29**
BALTIMORE	Cyfluthrin	1.735956923	20,029	34,769	**17.38**
BALTIMORE	Chlorothalonil	0.1129023	18,499	2,089	**1.04**
BALTIMORE	S-Metolachlor	0.197923197	16,635	3,292	**1.65**
BALTIMORE	Atrazine	0.148401799	16,279	2,416	**1.21**
BALTIMORE	Prodiamine	0.125840336	13,753	1,731	**0.87**
BALTIMORE	Paraquat Dichloride	0.310577425	10,044	3,119	**1.56**
BALTIMORE	Mineral oil	0.4	7,668	3,067	**1.53**
CALVERT	Imidacloprid	0.30515662	24,388	7,442	**3.72**
CALVERT	Glyphosate	0.158572216	5,062	803	**0.40**
CALVERT	Atrazine	0.148401799	2,708	402	**0.20**
CALVERT	Mineral oil	0.4	2,421	968	**0.48**
CALVERT	Paraquat Dichloride	0.310577425	2,142	665	**0.33**
CALVERT	Thifensulfuron	0.049333333	620	31	**0.02**
CALVERT	2;4-D	0.827317385	450	372	**0.19**
CALVERT	Fipronil	6.462993609	146	944	**0.47**
CALVERT	Bifenthrin	1.565896363	83	130	**0.06**
CALVERT	Beta-cyfluthrin	1.735956923	81	141	**0.07**
CAROLINE	Glyphosate	0.158572216	26,494	4,201	**2.10**
CAROLINE	Atrazine	0.148401799	12,960	1,923	**0.96**
CAROLINE	S-Metolachlor	0.197923197	9,009	1,783	**0.89**
CAROLINE	Simazine	0.08875528	4,354	386	**0.19**
CAROLINE	2;4-D	0.827317385	3,370	2,788	**1.39**
CAROLINE	Mineral oil	0.4	2,195	878	**0.44**
CAROLINE	Chlorothalonil	0.1129023	1,659	187	**0.09**
CAROLINE	Paraquat Dichloride	0.310577425	1,308	406	**0.20**
CAROLINE	Mesotrione	0.236083333	1,019	241	**0.12**
CAROLINE	Captan	0.144094541	909	131	**0.07**
CARROLL	Pendimethalin	0.558789524	112,428	62,824	**31.41**
CARROLL	Glyphosate	0.158572216	61,284	9,718	**4.86**
CARROLL	Atrazine	0.148401799	50,298	7,464	**3.73**

CARROLL	S-Metolachlor	0.197923197	38,036	7,528	**3.76**
CARROLL	Paraquat Dichloride	0.310577425	31,556	9,801	**4.90**
CARROLL	2;4-D	0.827317385	25,817	21,359	**10.68**
CARROLL	Simazine	0.08875528	18,716	1,661	**0.83**
CARROLL	Thifensulfuron	0.049333333	13,591	670	**0.34**
CARROLL	Fipronil	6.462993609	10,390	67,151	**33.58**
CARROLL	Tribenuron-methyl	0.030454341	6,772	206	**0.10**
CECIL	Chlorothalonil	0.1129023	13,144	1,484	**0.74**
CECIL	Glyphosate	0.158572216	11,589	1,838	**0.92**
CECIL	Mineral oil	0.4	9,571	3,828	**1.91**
CECIL	Atrazine	0.148401799	5,264	781	**0.39**
CECIL	2;4-D	0.827317385	3,915	3,239	**1.62**
CECIL	Captan	0.144094541	2,773	400	**0.20**
CECIL	Pendimethalin	0.558789524	2,055	1,148	**0.57**
CECIL	S-Metolachlor	0.197923197	1,824	361	**0.18**
CECIL	Imidacloprid	0.30515662	569	174	**0.09**
CECIL	Thiophanate-methyl	0.117956516	529	62	**0.03**
CHARLES	Glyphosate	0.158572216	6,005	952	**0.48**
CHARLES	Imidacloprid	0.30515662	5,570	1,700	**0.85**
CHARLES	2;4-D	0.827317385	2,231	1,846	**0.92**
CHARLES	Acetochlor	0.400383954	1,390	557	**0.28**
CHARLES	Atrazine	0.148401799	973	144	**0.07**
CHARLES	Pyriproxyfen	1.386748166	846	1,173	**0.59**
CHARLES	Bifenthrin	1.565896363	421	659	**0.33**
CHARLES	Beta-cyfluthrin	1.735956923	221	384	**0.19**
CHARLES	MCPP-P; DMA Salt	0.4	179	72	**0.04**
CHARLES	Cypermethrin	1.521227778	177	269	**0.13**
DORCHESTER	Glyphosate	0.158572216	26,735	4,239	**2.12**
DORCHESTER	Atrazine	0.148401799	16,170	2,400	**1.20**
DORCHESTER	S-Metolachlor	0.197923197	4,187	829	**0.41**
DORCHESTER	Permethrin	3.34487239	1,239	4,144	**2.07**
DORCHESTER	Difenoconazole	1.120455469	470	527	**0.26**
DORCHESTER	Beta-cyfluthrin	1.735956923	461	800	**0.40**
DORCHESTER	Imidacloprid	0.30515662	369	113	**0.06**
DORCHESTER	Bifenthrin	1.565896363	252	395	**0.20**
DORCHESTER	Indoxacarb	0.452534916	158	72	**0.04**
DORCHESTER	Lambda-cyhalothrin	0.400383954	139	56	**0.03**
FREDERICK	Simazine	0.08875528	159,303	14,139	**7.07**
FREDERICK	Glyphosate	0.158572216	54,620	8,661	**4.33**
FREDERICK	Chlorothalonil	0.1129023	46,910	5,296	**2.65**

FREDERICK	Atrazine	0.148401799	18,211	2,703	**1.35**
FREDERICK	2;4-D	0.827317385	12,974	10,734	**5.37**
FREDERICK	Bifenthrin	1.565896363	8,970	14,046	**7.02**
FREDERICK	S-Metolachlor	0.197923197	8,368	1,656	**0.83**
FREDERICK	Dithiopyr	0.955493833	5,859	5,598	**2.80**
FREDERICK	Paraquat Dichloride	0.310577425	5,753	1,787	**0.89**
FREDERICK	Mono-potassium salt	0.4	4,726	1,890	**0.95**
GARRETT	Glyphosate	0.158572216	9,451	1,499	**0.75**
GARRETT	S-Metolachlor	0.197923197	6,789	1,344	**0.67**
GARRETT	Imidacloprid	0.30515662	6,346	1,937	**0.97**
GARRETT	Atrazine	0.148401799	3,801	564	**0.28**
GARRETT	Metolachlor	0.197923197	2,094	414	**0.21**
GARRETT	Mesotrione	0.236083333	469	111	**0.06**
GARRETT	Pendimethalin	0.558789524	368	206	**0.10**
GARRETT	2;4-D	0.827317385	258	213	**0.11**
GARRETT	2;4-DB	0.066501976	195	13	**0.01**
GARRETT	Dicamba; dimet. salt	0.084360404	164	14	**0.01**
HARFORD	2;4-D	0.827317385	19,447	16,089	**8.04**
HARFORD	Glyphosate	0.158572216	15,384	2,439	**1.22**
HARFORD	Atrazine	0.148401799	14,589	2,165	**1.08**
HARFORD	Paraquat Dichloride	0.310577425	8,337	2,589	**1.29**
HARFORD	S-Metolachlor	0.197923197	6,836	1,353	**0.68**
HARFORD	Thifensulfuron	0.049333333	5,557	274	**0.14**
HARFORD	Simazine	0.08875528	3,593	319	**0.16**
HARFORD	Chlorothalonil	0.1129023	3,116	352	**0.18**
HARFORD	Prodiamine	0.125840336	2,948	371	**0.19**
HARFORD	Tribenuron-methyl	0.030454341	2,770	84	**0.04**
HOWARD	Glyphosate	0.158572216	23,936	3,796	**1.90**
HOWARD	S-Metolachlor	0.197923197	10,833	2,144	**1.07**
HOWARD	Atrazine	0.148401799	10,590	1,572	**0.79**
HOWARD	2;4-D	0.827317385	9,605	7,946	**3.97**
HOWARD	Fipronil	6.462993609	9,480	61,269	**30.63**
HOWARD	Propiconazole	1.052037715	5,839	6,143	**3.07**
HOWARD	Paraquat Dichloride	0.310577425	3,604	1,119	**0.56**
HOWARD	Imidacloprid	0.30515662	3,148	961	**0.48**
HOWARD	Thifensulfuron	0.049333333	2,922	144	**0.07**
HOWARD	Chlorothalonil	0.1129023	2,779	314	**0.16**
KENT	Glyphosate	0.158572216	31,754	5,035	**2.52**
KENT	Atrazine	0.148401799	7,606	1,129	**0.56**
KENT	S-Metolachlor	0.197923197	4,262	844	**0.42**

KENT	2;4-D	0.827317385	3,356	2,776	**1.39**
KENT	Simazine	0.08875528	3,130	278	**0.14**
KENT	Mono-potassium salt	0.4	476	190	**0.10**
KENT	Imidacloprid	0.30515662	270	82	**0.04**
KENT	Thifensulfuron	0.049333333	257	13	**0.01**
KENT	Bifenthrin	1.565896363	232	363	**0.18**
KENT	Difenoconazole	1.120455469	184	206	**0.10**
MONTGOMERY	Glyphosate	0.158572216	28,791	4,565	**2.28**
MONTGOMERY	Atrazine	0.148401799	18,717	2,778	**1.39**
MONTGOMERY	Chlorothalonil	0.1129023	12,508	1,412	**0.71**
MONTGOMERY	S-Metolachlor	0.197923197	9,161	1,813	**0.91**
MONTGOMERY	Fosetyl-al	0.04897535	6,070	297	**0.15**
MONTGOMERY	Paraquat Dichloride	0.310577425	5,764	1,790	**0.90**
MONTGOMERY	Mineral oil	0.4	5,657	2,263	**1.13**
MONTGOMERY	Dithiopyr	0.955493833	5,584	5,335	**2.67**
MONTGOMERY	Iprodione	0.202777271	5,520	1,119	**0.56**
MONTGOMERY	2;4-D	0.827317385	5,109	4,227	**2.11**
PRINCE GEORGE'S	Imidacloprid	0.30515662	17,076	5,211	**2.61**
PRINCE GEORGE'S	Glyphosate	0.158572216	8,121	1,288	**0.64**
PRINCE GEORGE'S	Beta-cyfluthrin	1.735956923	6,695	11,622	**5.81**
PRINCE GEORGE'S	Piperonyl butoxide	4.504163141	6,257	28,183	**14.09**
PRINCE GEORGE'S	Silicon dioxide	0.4	3,243	1,297	**0.65**
PRINCE GEORGE'S	Fipronil	6.462993609	2,487	16,073	**8.04**
PRINCE GEORGE'S	Pyriproxyfen	1.386748166	1,933	2,681	**1.34**
PRINCE GEORGE'S	Mineral oil	0.4	1,851	740	**0.37**
PRINCE GEORGE'S	Atrazine	0.148401799	1,756	261	**0.13**
PRINCE GEORGE'S	Boric acid	0.4	1,510	604	**0.30**
QUEEN ANNE'S	Glyphosate	0.158572216	45,283	7,181	**3.59**
QUEEN ANNE'S	Atrazine	0.148401799	7,739	1,148	**0.57**
QUEEN ANNE'S	2;4-D	0.827317385	5,762	4,767	**2.38**
QUEEN ANNE'S	S-Metolachlor	0.197923197	2,963	586	**0.29**

QUEEN ANNE'S	Mono-potassium salt	0.4	692	277	**0.14**
QUEEN ANNE'S	Simazine	0.08875528	418	37	**0.02**
QUEEN ANNE'S	Pendimethalin	0.558789524	400	224	**0.11**
QUEEN ANNE'S	Captan	0.144094541	349	50	**0.03**
QUEEN ANNE'S	Imidacloprid	0.30515662	283	86	**0.04**
QUEEN ANNE'S	Pyriproxyfen	1.386748166	235	326	**0.16**
ST. MARY'S	Imidacloprid	0.30515662	55,344	16,889	**8.44**
ST. MARY'S	Glyphosate	0.158572216	12,970	2,057	**1.03**
ST. MARY'S	Atrazine	0.148401799	6,864	1,019	**0.51**
ST. MARY'S	S-Metolachlor	0.197923197	5,476	1,084	**0.54**
ST. MARY'S	Paraquat Dichloride	0.310577425	2,661	826	**0.41**
ST. MARY'S	Chlorothalonil	0.1129023	2,199	248	**0.12**
ST. MARY'S	Pendimethalin	0.558789524	1,483	829	**0.41**
ST. MARY'S	Simazine	0.08875528	1,466	130	**0.07**
ST. MARY'S	Thifensulfuron	0.049333333	1,057	52	**0.03**
ST. MARY'S	2;4-D	0.827317385	788	652	**0.33**
SOMERSET	Glyphosate	0.158572216	10,040	1,592	**0.80**
SOMERSET	2;4-D	0.827317385	1,019	843	**0.42**
SOMERSET	Indoxacarb	0.452534916	2	1	**0.00**
TALBOT	Glyphosate	0.158572216	62,403	9,895	**4.95**
TALBOT	Clethodim	1.839959947	19,366	35,633	**17.82**
TALBOT	2;4-D	0.827317385	7,185	5,944	**2.97**
TALBOT	Atrazine	0.148401799	5,783	858	**0.43**
TALBOT	Metolachlor	0.197923197	2,900	574	**0.29**
TALBOT	Paraquat Dichloride	0.310577425	2,693	836	**0.42**
TALBOT	MCPP-P; DMA Salt	0.4	1,528	611	**0.31**
TALBOT	Copper triethanolamine complex	0.4	1,401	560	**0.28**
TALBOT	Copper ethanolamine	0.4	1,097	439	**0.22**
TALBOT	Diquat dibromide	1.456185648	379	552	**0.28**
WASHINGTON	Atrazine	0.148401799	32,002	4,749	**2.37**
WASHINGTON	Clopyralid mono salt	0.050478293	25,444	1,284	**0.64**
WASHINGTON	2;4-D	0.827317385	24,223	20,040	**10.02**
WASHINGTON	Glyphosate	0.158572216	23,756	3,767	**1.88**
WASHINGTON	Paraquat Dichloride	0.310577425	11,850	3,680	**1.84**
WASHINGTON	Thifensulfuron	0.049333333	8,692	429	**0.21**
WASHINGTON	Mineral oil	0.4	7,550	3,020	**1.51**

WASHINGTON	Mancozeb	0.04714311	4,851	229	**0.11**
WASHINGTON	Tribenuron-methyl	0.030454341	4,329	132	**0.07**
WASHINGTON	Disod. Octa. tetra.	0.4	4,198	1,679	**0.84**
WICOMICO	Glyphosate	0.158572216	13,634	2,162	**1.08**
WICOMICO	2;4-D	0.827317385	2,763	2,286	**1.14**
WICOMICO	S-Metolachlor	0.197923197	2,521	499	**0.25**
WICOMICO	Atrazine	0.148401799	1,445	214	**0.11**
WICOMICO	Deltamethrin	3.948853616	687	2,713	**1.36**
WICOMICO	Beta-cyfluthrin	1.735956923	396	687	**0.34**
WICOMICO	Lambda-cyhalothrin	0.400383954	162	65	**0.03**
WICOMICO	Indoxacarb	0.452534916	152	69	**0.03**
WICOMICO	Boric acid	0.4	141	56	**0.03**
WICOMICO	Difenoconazole	1.120455469	136	152	**0.08**
WORCESTER	Glyphosate	0.158572216	82,612	13,100	**6.55**
WORCESTER	Atrazine	0.148401799	19,221	2,852	**1.43**
WORCESTER	Paraquat Dichloride	0.310577425	14,771	4,588	**2.29**
WORCESTER	S-Metolachlor	0.197923197	10,356	2,050	**1.02**
WORCESTER	Deltamethrin	3.948853616	2,055	8,115	**4.06**
WORCESTER	Dicamba; dimet. salt	0.084360404	1,524	129	**0.06**
WORCESTER	2;4-D	0.827317385	1,483	1,227	**0.61**
WORCESTER	Beta-cyfluthrin	1.735956923	920	1,597	**0.80**
WORCESTER	Imidacloprid	0.30515662	707	216	**0.11**
WORCESTER	Lambda-cyhalothrin	0.400383954	618	247	**0.12**

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Harvested Acres by County and Percent of Total Harvested

County	Harvested Acres Crop Pesticides surface	Harvested Acres Crop Pesticides soil	Harvested Acres Total	Percent (%) surface	Percent (%) soil
ALLEGHANY	8,375	2,116	10,491	0.80	0.20
ANNE ARUNDEL	3,500	4,400	7,900	0.44	0.56
BALTIMORE	7,500	41,100	48,600	0.15	0.85
CALVERT	3,000	3,498	6,498	0.46	0.54
CAROLINE	25,700	87,855	113,555	0.23	0.77
CARROLL	42,271	73,914	116,185	0.36	0.64
CECIL	27,213	42,386	69,599	0.39	0.61
CHARLES	5,500	0	5,500	1.00	0.00
DORCHESTER	39,509	72,100	111,609	0.35	0.65
FREDERICK	62,004	97,358	159,362	0.39	0.61
GARRETT	24,188	4,300	28,488	0.85	0.15
HARFORD	13,683	41,494	55,177	0.25	0.75
HOWARD	8,581	5,529	14,109	0.61	0.39
KENT	26,063	87,433	113,495	0.23	0.77
MONTGOMERY	10,000	10,575	20,575	0.49	0.51
PRINCE GEORGES	3,300	13,050	16,350	0.20	0.80
QUENN ANNES	14,600	105,600	120,200	0.12	0.88
ST. MARY'S	6,013	32,650	38,663	0.16	0.84
SOMERSET	9,100	31,700	40,800	0.22	0.78
TALBOT	18,000	71,700	89,700	0.20	0.80
WASHINGTON	26,672	20,643	47,315	0.56	0.44
WICOMICO	14,003	46,000	60,003	0.23	0.77
WORCESTER	17,952	69,600	87,552	0.21	0.79
BALTIMORE CITY	0	0	0	0.00	0.00

Emissions Calculation

Equations:

$$E_{pest} = \frac{(AI \times EF_{pest})}{2000}$$

where:
AI = Active Ingredient (lb. / yr.)
EF_{pest} = Emission Factor for particular pesticide (lb. VOC / lb. AI)

Sample Calculations:
Pesticide – Fipronil with 190,450 pounds of active ingredient used in Maryland.

EPA's EF for Fipronil is 6.46 (lb. VOC / lb. AI)

$E_{Fipronil} = \frac{(190,450 \times 6.46)}{2000} =$ **615.44** tons of Voc year

After calculating VOCs for each pesticide a portion was distributed across counties that harvested crops using the table above containing percentages for total harvested acres. Then VOCs were summed in each county. The types of crops were summed in each county by application a percentage was derived and assigned the appropriate SCC code for soil or surface.

Total VOCs from Soil applied pesticides for Harford County were estimated to be:
$E_{HarfordSoil}$ = 9.79 tons per year
Pesticides-Soil for Harford County was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 312
Daily adjusted $E_{HarfordSoil\mathbf{da}} = (E_{HarfordSoil} / 312)*(SAF / POS)$
$E_{HarfordSoil\mathbf{da}} = (9.79 / 312)*(0.25 / 0.25) =$ **3.14E-02 VOC tons/day**

4.1.2.12 Commercial/Consumer Solvent Use

SCC: 24 60 100 000 (Personal Care)
24 60 200 000 (Household)
24 60 400 000 (Automotive Aftermarket)
24 60 500 000 (Coatings and Related)
24 60 600 000 (Adhesives and Sealants)
24 60 800 000 (FIFRA - Regulated)
24 60 900 000 (Miscellaneous Products)

Description

Certain commercial/consumer uses of products containing volatile organics cannot easily be identified by questionnaires, surveys or other inventory procedures yielding locale-specific emission estimates. This category includes the following sources: household products, toiletries, aerosol products, rubbing compounds, windshield washing fluid, polishes, waxes, non-industrial adhesives, space deodorants, moth control agents and laundry detergents.

Pollutants

VOC and HAPs

Method and Data Sources

The recommended emission factor that combines emissions from all these sources is 7.84 pounds VOC per person per year, from EIIP Volume III, Area Sources, Preferred and Alternate Methods (July, 1997). This emission factor excludes non-reactive VOC and takes into account more recent volatility levels based on product reformulation, than does AP-42, Fifth Edition. MDE used an activity level of 7 days a week and no seasonal adjustment factor as suggested in Table 5.8-1 in Procedures.

Activity
The U.S. Census Bureau reports and collects population statistics for the counties of Maryland. U.S. Census Bureau Internet address: (http://www.census.gov).

Emission Factors:

Commercial and Consumer Products (All) 7.84 lbs. $_{VOC}$/person/year

Original EPA Per Capita VOC Emission Factors [35, 36]		
Industry	**SCC**	**1996 Per Capita VOC Emission Factor (lbs. $_{VOC}$/person/year)**
Personal Care Products	2460100000	2.32
Household Products	2460200000	0.79
Automotive Aftermarket Products	2460400000	1.36
Coatings and Related Products	2460500000	0.95
Adhesives and Sealants	2460600000	0.57
FIFRA - Regulated Products	2460800000	178
Miscellaneous Products	2460900000	0.07
Total (All Commercial & Consumer Products) =		7.84

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

Federal regulations provide a 20 percent reduction in emissions from a 3.9 lbs. $_{VOC}$/person subset of the total commercial and consumer products category.

Commercial and consumer products are regulated by three separate category measures. The three control measures are; the original Federal regulations, effective, OTC Phase I controls, effective, and OTC Phase II controls effective. Each of the control measures are discussed briefly below:

[35] Source: Adapted from EPA, 1995
[36] Emission factors are based on usage and population data for 1990.

Control Set 1: Federal regulations provide a 20 percent reduction in emissions from 3.9 lbs. VOC/person subset of the total commercial and consumer products category. This results in following controls per commercial and consumer solvent subcategory:

Per Capita VOC Emission Factors After Federal Rule

Product Category	SCC	Emission Factor (lbs. VOC/person/year)c
Personal Care Products	24601000000	2.08
Household Products	24602000000	0.63
Automotive Aftermarket Products	24604000000	1.13
Adhesives and Sealants	24606000000	0.51
FIFRA-Regulated Products	24608000000	1.68
Coatings and Related Products	24605000000	0.95
Miscellaneous Products	24609000000	0.07
Total (All Commercial & Consumer Products) =		**7.06**

Control Set 2: OTC Phase I rule was based on the five CARB consumer products rules and further emission reductions of 14.20 % beyond federal regulation provided in control set one above. This results in the following controls per commercial and consumer solvent subcategory:

Per Capita VOC Emission Factors After OCT Phase 1

Product Category	SCC	Emission Factor (lbs. VOC/person/year)c
Personal Care Products	24601000000	1.79
Household Products	24602000000	0.54
Automotive Aftermarket Products	24604000000	0.98
Adhesives and Sealants	24606000000	0.43
FIFRA-Regulated Products	24608000000	1.44
Coatings and Related Products	24605000000	0.82
Miscellaneous Products	24609000000	0.07
Total (All Commercial & Consumer Products) =		**6.06**

Control Set 3: OTC Phase II rule was based on the five CARB consumer products rules and further emission reductions of 2.0 % beyond federal regulation provided in control set one above. This results in the following controls per commercial and consumer solvent subcategory:

Per Capita VOC Emission Factors After OCT Phase 2

Product Category	**SCC**	**Emission Factor (lbs. VOC/person/year)c**
Personal Care Products	24601000000	1.7529695
Household Products	24602000000	0.5268063
Automotive Aftermarket Products	24604000000	0.9571004
Adhesives and Sealants	24606000000	0.4269687
FIFRA-Regulated Products	24608000000	1.4084942
Coatings and Related Products	24605000000	0.8047066
Miscellaneous Products	24609000000	0.0581146
Total (All Commercial & Consumer Products)	=	**5.9351604**

Control Set 4: OTC Phase III rule was based on the five CARB consumer products rules and further emission reductions of 3.1% beyond federal regulation provided in control set one above. This results in the following controls per commercial and consumer solvent subcategory:

Per Capita VOC Emission Factors After OCT Phase 2

Product Category	**SCC**	**Emission Factor (lbs. VOC/person/year)c**
Personal Care Products	24601000000	1.6986275
Household Products	24602000000	0.5104753
Automotive Aftermarket Products	24604000000	0.9274303
Adhesives and Sealants	24606000000	0.4137326
FIFRA-Regulated Products	24608000000	1.3648309
Coatings and Related Products	24605000000	0.7797607
Miscellaneous Products	24609000000	0.0563131
Total (All Commercial & Consumer Products)	=	**5.7511704**

Control Set 5: OTC Phase IV rule was based on the five CARB consumer products rules and further emission reductions of 10.3 % beyond federal regulation provided in control set one above. This results in the following controls per commercial and consumer solvent subcategory:

Per Capita VOC Emission Factors After OCT Phase 2

Product Category	**SCC**	**Emission Factor (lbs. VOC/person/year)c**
Personal Care Products	24601000000	1.5236689
Household Products	24602000000	0.4578964
Automotive Aftermarket Products	24604000000	0.8319050
Adhesives and Sealants	24606000000	0.3711182
FIFRA-Regulated Products	24608000000	1.2242533
Coatings and Related Products	24605000000	0.6994453
Miscellaneous Products	24609000000	0.0505128
Total (All Commercial & Consumer Products) =		**5.1587998**

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The per capita equation used to estimate emissions from commercial and consumer solvents is:

$$E_{CC} = \frac{[\, POP_i \mathbf{x}\, EF_{CC}\,] - [\,(POP_i \mathbf{x}\, CS_{CC}) \text{ x } CE_{CC}\,]}{2000}$$

Where:

E_{CC} = VOC emissions in tons per day from commercial and consumer solvents
POP_i = 2017 population of county i
EF_{CC} = VOC emission factor for commercial and consumer solvents (7.84 lbs. $_{VOC}$/person)
CS_{CC} = Controlled subset of commercial and consumer solvents (3.9 lbs. $_{VOC}$/person)
CE_{CC} = Control efficiency for controlled subset of commercial and consumer solvents (20%)

2017 Sample Calculation Personal Care Products Consumer Solvent Use (Anne Arundel County)
VOC Emission Factors after OCT Phase 2

$$E_{PersonalCare} = \frac{[(568{,}346^{37}) \times (1.5236689)]}{2000}$$

$E_{PersonalCare}$ = **432.99 tons** VOC **per year for Anne Arundel County**

Personal Care Products for Anne Arundel County was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted $E_{PersonalCare\mathbf{da}}$ = ($E_{PersonalCare}$ / 365)*(SAF / POS)

$E_{PersonalCare\mathbf{da}}$ = (**432.99** / 365)*(0.25 / 0.25) = **1.19E+00 VOC tons/day**

4.1.2.12.1 Barge, Tank, Tank Truck, Rail Car and Drum Cleaning

SCC: 24 61 160 000

The EPA explained to MDE staff that the agency has not developed an emission factor for this category. The EPA also stated that most barge, tank truck, rail car and drum cleaning is done by steam cleaning and the residue goes to industrial and public waste disposal treatment plants. It is impossible to separate this category's portion of the treatment plant emissions. EPA considers the emissions from this category to be insignificant. Emissions from this category are calculated for the appropriate facilities in the point source inventory.

[37] 2017 Population data from U.S. Bureau of Census, Population Estimates Branch

4.1.3 BIOPROCESS EMISSIONS SOURCES

4.1.3.1 Bakeries

SCC: 23 02 050 000

Description

Bakeries emit VOC, primarily ethanol formed by yeast fermentation of bread or dough, during the baking process. Ethanol is emitted through a vent, along with combustion product gases. Large commercial bakeries are inventoried as point sources. In-store and neighborhood bakeries have lower emissions, and thus are considered area sources.

Pollutants

VOC

Method and Data Sources

MDE staff followed methodology described in an EIIP Area Source Category Method Abstract – Bakeries, dated June 1999. An emission factor of 220 tons $_{VOC}$ per was used. Applicable point source emissions (those within the same NAICS) taken from the MDE/ARA registration files have been subtracted from the emissions calculated by employee.

Activity

Employee numbers were taken from County Business Patterns 2016 - Maryland, NAICS 311812, Bakery Products and 311811, Retail Bakeries (see Appendices). Some county employment data is represented by a letter code indicating a range for the number of employees for that NAICS. In this case the arithmetic average number of employees per letter code per county was adjusted so that the state total employment in a NAICS matched the sum of the number of employees reported per county.

Emission Factor

An emission factor of 220 tons $_{VOC}$ per employee was utilized.

Point Source Adjustments

Bakery emissions from facilities identified as point sources (NAICS 311812 and 311811) were subtracted from the area source inventory to avoid double counting.

Adjustment for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The equation used to estimate emissions from bakeries is:

Equation:

$E_{BAK} = EF_{BAK}$ **x** EMPj

Where:

E_{BAK} = VOC emissions from small bakeries in tons per year
EF_{BAK} = per employee emission factor for bakeries
EMPj = number of employees at small (less than 20 employees), bakeries in county j

Point Source Adjustments

$E_{BAK\text{-}ADJ} = EF_{BAK}$ **x** $EMPj_{Pt. Sources}$

Where:

$E_{BAK\text{-}ADJ}$ = Point source adjusted bakery emissions
EF_{BAK} = per employee emission factor for bakeries
$EMPj_{Pt. SourcesAd}$[38] = Point Source Adjustment was done by subtracting employment for Baltimore City related sources before calculating emissions.

2017 Sample Calculation for Bakery VOC Emissions (Baltimore City):

Employees in NAICS 311811 and 311812 in Baltimore City:
$EMP_{Pt.BCity}$ = 786.54 emp

Employees in Baltimore City Bakeries:
EMP_{BCity} = 1,021 emp

$EMP_{BC\ Pt.\ SourcesAd}$ = 1,021 - 786.54 = 234.45 emp

$E_{BAK} = EF_{BAK}$ **x** $EMPj_{Pt.\ SourcesAd}$

[38] Point Source Reduction from MDE ARA registration files

E_{BAK} = 220 **x** 234.45 lbs. $_{VOC}$ per year

E_{BAK} = 51,579 lbs. $_{VOC}$ per year

E_{BAK} = 25.79 tons $_{VOC}$ per year

Bakeries for Baltimore City was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 260
Daily adjusted E_{BAKda} = (**E_{BAK}** / 260)*(SAF / POS)

E_{BAKda} = (**25.79** / 260)*(0.25 / 0.25) = **9.92E-02 VOC tons/day**

4.1.3.2 Breweries

SCC: 23 02 070 001

Description

During the fermentation process, breweries emit ethanol and other VOCs. Although large-scale commercial breweries have been inventoried as point sources, there are microbreweries and brewpubs that emit lower levels of VOCs and therefore must be inventoried as area sources. These smaller breweries emit most of their VOCs from the fermentation room, not the brew kettle as is the case with the large breweries.

Pollutants

VOC

Method and Data Sources

MDE/ARA staff surveyed small brewpubs and microbreweries in Maryland.

Activity
The survey questionnaire asked the brewing facilities to provide MDE/ARA with the amount of barrels brewed per month for the calendar year 2017. For those facilities that reported only annual production amounts, an average monthly value was used.

Emission Factor
Emissions from the small breweries were calculated using an emission factor cited in a February 5, 1992 Technical Memorandum prepared by Radian Corporation for EPA. This emission factor is 56.743 lbs. $_{VOC}$ per 1000 barrels produced. One barrel equals 31 gallons. Note: Emf conversion is: 56.743 lb VOC/1000 barrels = 0.05674 lb/barrel = 0.0018303 lb/gal.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The equation used to estimate emissions from bakeries is:

$$E_{BREW} = \frac{EF_{BREW}\ \mathbf{x}\ BPj}{2000}$$

Where:

E_{BREW} = VOC emissions from small bakeries in tons per year
EF_{BREW} = emission factor for small breweries
BPj = 2017 beer production in barrels

2017 Sample Calculation for Small Brewery VOC Emissions (Howard County):

Number barrels produced by microbreweries in Howard County = 15,108 barrels

$$E_{BREW} = \frac{0.05674\ \mathbf{x}\ 15{,}108}{2000}$$

E_{BREW} = 0.43 tons $_{VOC}$ per year

Breweries for Howard County was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 260
Daily adjusted E_{BREWda} = (**E_{BREW}** / 260)*(SAF / POS)

E_{BREWda} = (**0.43** / 260)*(0.25 / 0.25) = **1.65E-03 VOC tons/day**

4.1.3.3 Wineries

SCC: 23 02 070 005

Description

Ethanol emissions from wineries occur during the fermentation process. The emissions vary, depending upon the type of wine (red vs. white), the fermentation temperature and the sugar content of the grapes used.

Pollutants

VOC

Method and Data Sources

MDE used the methods and procedures documented in AP-42[39], Chapter 12, Beverages, Section 2, Wines and Brandies dated September 1995. AP42 Chapter 9.12.2

Activity
The U.S. Department of the Treasury's Alcohol and Tobacco Tax and Trade Bureau, State of Maryland Comptroller's Office, and direct survey of most of Maryland's wineries revealed that approximately 514,969 gallons of wine was produced in 2017. The survey suggests that 249,635.53 gallons of white and 265,332.95 gallons of red wine were actually produced.

Emission Factor
Table 9.12.2-1 of AP-42 shows that ethanol emissions are 1.8 lbs. $_{VOC}$ per 1000 gallons of white wine fermented and 4.6 lbs. $_{VOC}$ per 1000 gallons of red wine fermented.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial
Data for spatial allocation is not available for this source.

[39] AP42, Chapter 9.12.2: Food and Agricultural Industries, Beverages, Wines and Brandies

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation State Total

Emission Factors:	**red =**	**0.0046**	**lb voc per gal**
	white =	**0.0018**	**lb voc per gal**

White wine EMtotal = (249,635.53 gal x **0.0018 lb voc per gal) / 2000**
White wine EMtotal = 0.225 tons voc **per year**

Red wine EMtotal = (265,332.95 gal x **0.0046 lb voc per gal) / 2000**
Red wine EMtotal = 0.610 tons voc **per year**

Using the above figures, the production of wine by all Maryland wineries in 2017 resulted in the production **of 0.835 tons** voc **per year**

Daily calculation can be made for each county (see example below)
Anne Arundel County Winery VOC total was:
$EM_{Anne\ Arundel}$ = 1.96E-02 tons voc **per year**

Wineries for Anne Arundel County was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 260
Daily adjusted $\mathbf{EM}_{Anne\ Arundel\,\mathbf{da}}$ = ($\mathbf{EM}_{Anne\ Arundel}$ / 260)*(SAF / POS)

$\mathbf{EM}_{Anne\ Arundel\,\mathbf{da}}$ = (**1.96E-02** / 260)*(0.25 / 0.25) = **7.54E-05 VOC tons/day**

4.1.3.4 Distilleries

Description

Ethanol emissions are the largest component of the VOCs emitted from distilleries. Distilleries produce both grain alcohol for industrial and fuel purposes, and distilled spirits such as whiskey and brandy for consumption purposes. The emissions points in the distilled spirits manufacturing process are likely to be the same as in breweries and wineries, with the aging process as an additional source of emissions. During the aging process, ethanol and water seep through the wooden barrels used to age whiskey and evaporate into the air. Aging and barrel emptying are the major sources of VOC emissions from whiskey production.

Pollutants

VOC

Method and
Data Sources

MDE staff indicated that no distilleries below the 10 ton per year point source cutoff operated in the inventory area during 2017. Fugitive VOC emissions from the aging process at large distillery operations can be substantial and will be included in the point source inventory.

4.1.4 CATASTROPHIC/ACCIDENTAL RELEASES

4.1.4.1 Oil Spills

SCC: 28 30 000 000

Description

Oil spills involve oil tanker accidents, tanker truck accidents, and spills and blowouts from oil rigs or pipelines in coastal and inland areas. Because a wide range of fuel types may be spilled, the nature and quantity of emissions can vary. Emissions are also influenced by the clean-up procedure and by dispersion and weathering processes.

Oil spill evaporation produces local VOC emissions. If spills catch fire, additional SO_2, CO, CO_2, PM, NOx and VOC emissions may result. Other potentially toxic chemical compounds may also be released as a result of chemical cleanup

Pollutants

VOC

Method and
Data Sources

Activity

Data on oil spills in Maryland were obtained from MDE's Oil Control’s Emergency Response Program. They provided MDE/ARA staff a yearly report of all oil spills that occurred in Maryland during 2017. Spills around Maryland totaled to about 67,985 gallons.

Emission Factor
MDE staff used an emission factor recommended to the Metropolitan Washington Council of Governments by E.H. Pechan and Associates, Inc., the contractor used by MWCOG to prepare their 1990 base year inventory. This emission factor was based on a California Air Resources Board (CARB), study of air emissions from large oil spills. Using this information, an average emission factor was calculated to be 0.0000925 tons VOC per gallon of oil spilled.

Point Source Adjustments

No point source adjustments were made.

Adjustment for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial
Data for spatial allocation is not available for this source.

Temporal
SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The equation used to estimate emissions from oil spills:

$$E_{\text{Oil Spills}} = EF_{\text{Oil Spills}} \times GOSi$$

Where:
$E_{\text{Oil Spills}}$ = VOC emissions from oil spills in tons $_{\text{VOC}}$ per year
$EF_{\text{Oil Spills}}$ = tons of pollutant per gallon of oil spilled
GOSi = gallons of oil spilled in county i

2017 Sample Calculation for Oil Spill VOC Emissions (Baltimore County):

Annual Emissions:
Number gallons oil spilled Baltimore County 2017: **6,351** gallons

$E_{Oil\ Spills} = (0.0000925)\ \mathbf{x}\ (6{,}351)$

$\mathbf{E_{Oil\ Spills} = 5.87E\text{-}01\ tons_{VOC}\ per\ year}$

Oil Spills for Baltimore County was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 312
Daily adjusted $E_{Oil\ Spills\mathbf{da}} = (E_{Oil\ Spills} / 312)*(SAF / POS)$

$E_{Oil\ Spills\mathbf{da}}$ = (**5.87E-01** / 312)*(0.25 / 0.25) = **1.88E-03 VOC tons/day**

4.1.4.2 Leaking Underground Storage Tanks / Soil Remediation

SCC: 26 60 000 000

Description

Many underground storage tanks (USTs) are over 15 years old and are constructed of steel, which may rust over time. The underground piping connected to these tanks also has the potential to leak. Leaking USTs (leaking underground storage tank sites or LUST sites) are of concern because they may result in the contamination of drinking water, subsurface soils, and ground and surface water, and may emit toxic and/or explosive vapors. The contaminated soil and water may also emit VOC.

Pollutants

VOC

Method and Data Sources

Activity

Emission calculation methods were taken from EIIP, AREA SOURCE CATEGORY METHOD ABSTRACT - REMEDIATION OF LEAKING UNDERGROUND STORAGE TANKS, 2001. The numbers of LUST sites by county were obtained from MDE's Oil Control Program. No seasonal variation was assumed. Each remediation event takes an average of 30 days; during this period emissions are released.

Emission Factor

An emissions factor of 28 lbs of VOC per day per site was used.

Point Source Adjustments

No point source adjustments were made.

Adjustment for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

$$E_{LUST} = \frac{LS1_j \mathbf{x} EF \mathbf{x} 30 \text{ day}}{2000 \text{ lb./ton}}$$

where:

E_{LUST} = VOC emissions in tons per year from leaking underground storage tanks

$LS1_j$ = number of remediation site(s) in county j

EF = emissions factor

<u>2017 Sample Calculation for Leaking Underground Storage Tanks (Anne Arundel County)</u>

No seasonal variation assumed

$$E_{LUST\text{-}AA} = \frac{53 \mathbf{x} 28_{VOC} \text{ lbs./day } \mathbf{x} 30 \text{ day}}{2000 \text{ lb./ton}}$$

$E_{LUST\text{-}AA}$ = 22.66 tons $_{VOC}$ per year

Leaking Underground Storage Tanks for Anne Arundel was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted $E_{LUST\text{-}AA\mathbf{da}}$ = ($E_{LUST\text{-}AA}$ / 365)*(SAF / POS)

$E_{LUST\text{-}AA\mathbf{da}}$ = (**22.66** / 365)*(0.25 / 0.25) = **6.10E-02 VOC tons/day**

4.1.5 SOLID WASTE DISPOSAL, TREATMENT, AND RECOVERY

4.1.5.1 On-site Incineration

SCC: 2601020000

Description

On-site incineration is the confined burning of waste on a small scale by institutions such as hospitals, nursing homes, veterinary offices, funeral homes and laboratories. Large-scale incineration is included in the point source inventory.

Pollutants

VOC, NOx, SOx, CO, $PM_{10,}$ $PM_{2.5,}$ and HAPS,

Method and Data Sources

In Maryland incinerators are regulated under COMAR 26.11.08. Maryland began regulating incinerators for control of particulates in the 1970's. In AQCRs III and IV single chamber incinerators, the type that would be used for on-site residential incineration, were banned. All such incinerators were rendered inoperative under the direction of the Maryland Department of the Environment (MDE). Over 1700 small incinerators were eliminated under this requirement.

In the other Maryland counties included in the Washington, D.C. nonattainment area, incineration of trash in on-site incinerators is prohibited except in areas where public trash collection is not provided.

COMAR 26.11.08.09 now requires all incinerators to obtain a permit to operate and any person who owns or operates an incinerator must obtain certification from MDE and renew the certification annually.

MDE/ARA maintains a registry of all incinerators within the State. Because of the requirements prohibiting single chamber incinerators, the requirement for a permit to operate, and the operator certification requirements, staff used the sum of the incinerators in the registry as representing the total area source emissions from incinerators of all types emitting less than 10 tons/VOC, 100 tons/yr CO and 50 tons per year NO_x. Incinerators from the registry with emissions above these thresholds are included in the point source inventory.

No seasonality is applied. The emission factor is chosen by type of incinerator: waste, pathological, hazardous, industrial, special medical, sewage sludge and municipal waste combustors. The burn rate is determined by stack test or AP-42. Hours of operation and tons of waste per day are supplied by the operator.

4.1.5.2 Publicly Owned Treatment Works (POTWs)

SCC: 26 30 020 000

Description

Wastewater is usually collected and treated at a public waterworks facility to be filtered and reused or discharged into surrounding waterways. While the wastewater is held and being treated VOCs are released into the air due to contaminates and byproducts in the water.

Pollutants

VOC

Method and Data Sources

The emissions from these facilities were calculated based on the method described in EPA EIIP II Chapter 5 Section 5.1.

Activity

The amount of actual flow for each POTW in Maryland was supplied by the MDE's Wastewater Management Administration (see Appendices). MDE staff multiplied this amount by the emission factor listed to get VOC emissions from each POTW. The individual POTW emissions were then totaled by county.

Emission Factor

EPA's Emission Inventory and Analysis Group supplied MDE with a new emission factor of 0.85 pounds $_{VOC}$ per million gallons of actual flow of wastewater discharged (February 19, 2019).

Point Source Adjustments

No point source adjustments were made

Adjustment for Controls

A seasonal adjustment factor of 1.4 was used when calculating ozone season or daily emissions not yearly.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

The equation used to estimate yearly emissions from POTWs is:

$$E_{POTWY} = \frac{ADF_{IJ} \mathbf{\ x\ } EF_{POTW} \mathbf{\ x\ 365\ days}}{2000}$$

For seasonal emissions:

$$E_{POTWS} = \frac{ADF_{IJ} \mathbf{\ x\ } EF_{POTW} \mathbf{\ x\ } SAF_{POTW}}{2000}$$

Where:

E_{POTWY}	=	VOC emissions in tons $_{VOC}$ per year from POTWs
ADF_{IJ}	=	Actual daily flow into POTW i in county j
EF_{POTW}[40]	=	VOC emission factor for POTWs
SAF_{POTW}[41]	=	Seasonal adjustment factor for peak ozone season which is 1.4
		Plant operation is 365 days a year

<u>2017 Sample Calculation for POTW VOC Emissions (Howard County)</u>:

Howard County has only one POTW,
Little Patuxent Treatment Plant statistics[42]**:**
Actual daily flow (MGD)[43]: 17.178

$$E_{POTWY} = \frac{(17.178) \mathbf{\ x\ } (0.85 \text{ lbs.}_{VOC} / \text{gal}) \mathbf{\ x\ } 365 \text{ days}}{2000}$$

$$\mathbf{E_{POTWY} = 2.664 \text{ tons}_{VOC} / \text{year}}$$

POTW for Howard County was found to have a
SAF = seasonal adjustment factor of 0.35
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted $E_{POTWY\mathbf{da}} = (E_{POTWY} / 365)*(SAF / POS)$

$E_{POTWY\mathbf{da}} = (\mathbf{1.625} / 365)*(0.35 / 0.25) =$ **1.02E-02 VOC tons/day**

[40] Emission factor taken from Procedures, Section 3.5.1
[41] Seasonal adjustment factor taken from Procedures, Table 5.8.1
[42] Supplied by the Maryland Water Management Administration (see Appendices)
[43] MGD : Million Gallons per Day

4.1.5.3 Open Burning – Land Clearing Debris

SCC: 26 10 000 500

Description

Open burning of land clearing debris refers to the clearing of land for new construction and the burning of organic material (i.e., trees, shrubs and other vegetation). The clearing of land for the construction of new buildings and highways often results in debris consisting of trees, shrubs, and brush. This debris may be burned in place but it is usually collected in piles for burning. The burning of land clearing wastes may be practiced by private individuals, corporations, and government agencies (e.g., highway construction department). There are no federal laws restricting the open burning of land clearing wastes, although state or local laws may exist.

Residential open burning without a permit is prohibited in Maryland COMAR 26.11.07, where trash and leaf collection is available. The basic difference between the regulation as it applies to counties in AQCRs III and IV and the rest of the state is the requirements under which the burn takes place, i.e., minimum setbacks from property lines, etc. In the more rural counties, areas with no available trash collection are more prevalent. MDE adopted a regulation that prohibits open burning during the peak ozone period (June to August). The seasonal prohibition only affects those counties that lie within serious and severe ozone nonattainment areas. Certain exemptions must be in place however so as not to adversely affect agriculture or restrict fire training and recreational activities. Commercial open burning without a permit is prohibited in Maryland.

Pollutants

VOC, NOx, SOx, CO, PM_{10} and $PM_{2.5}$

**Method and
Data Sources**

The method used to calculate emissions, is presented in EIIP[44], Chapter 16, Open Burning (Revised Final 2001).

Activity

The number of acres disturbed by residential, non-residential and roadway construction are estimated and then these values are added together to obtain a county-level estimate of total acres disturbed by land-clearing. County-level emissions from land clearing debris are then calculated by multiplying the total acres disturbed by construction by a weighted loading factor and emission factor.

The BELD database in BEIS was used to determine the number of acres of hardwoods, softwoods, and grasses in each county. Average loading factors were weighted according to the percent contribution of each type of vegetation class to the total land area for each county. The loading factors for slash hardwood and slash softwood were further adjusted

[44] Emission Inventory Improvement Program

by a factor of 1.5 to account for the mass of tree that is below the soil surface that would also be subject to burning once the land is cleared.

Fuel loading factors are as follows:

Fuel Type	Fuel Load Factor (tons/acre)	Adjusted Load Factor (tons/acre)
Hardwood	66	99
Softwood	37.5	56.25 rounded by EPA to 57
Grass	4.5	4.5

Average fuel loading factors were calculated as follows:

$$LF_{OB-LCD-COi} \quad \frac{(Acres_{HW-COi} \times LF_{Adj-HW}) + (Acres_{SW-COi} \times LF_{Adj-SW}) + (Acres_{GR-COi} \times LF_{Adj-GR})}{Acres_{TOT-COi}}$$

$LF_{OB-LCD-COi}$	=	Average Load Factor in County i
$Acres_{HW-COi}$	=	Acres of hardwood in County i from BELD database
LF_{Adj-HW}	=	Adjusted Load Factor for Hardwood
$Acres_{SW-COi}$	=	Acres of softwood in County i from BELD database
LF_{Adj-SW}	=	Adjusted Load Factor for Softwood
$Acres_{GR-COi}$	=	Acres of grasses in County i from BELD database
LF_{Adj-GR}	=	Adjusted Load Factor for Grasses
$Acres_{TOT-COi}$	=	Total Land Acres in County i

Emission Factors [45]

Emission factors in lbs. /ton were taken from AP-42 Table 2.5-1, Emission Factors for Open Burning of Municipal Refuse and are listed below:

VOC	11.6	Lbs. $_{VOC}$/ ton
SOx	0.0	Lbs. $_{SOx}$/ ton
CO	169	Lbs. $_{CO}$/ ton
PM_{10}	17	Lbs. $_{PM10}$/ ton
$PM_{2.5}$	17	Lbs. $_{PM2.5}$/ ton
NOx	5	Lbs. $_{NOx}$/ ton

Ozone Season Daily (OSD) emissions calculated by multiplying annual emissions by 0.25 then dividing by 92.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

[45] Emissions factors for VOC NOx, CO, SO_2, PM_{10} and $PM_{2.5}$ were obtained from AP-42 Table 2.5-1.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

Emissions are temporally allocated to months or seasons by the number of permits issued per month per county.

Emissions Calculation

Annual Emissions

$$E_{OB-LCD-Ann} = \frac{AD_{R\text{-}NR\text{-}Road} \times LF_{OB-LCD-COi} \times EF_{OBi}}{2000}$$

$E_{OB-LCD-Ann}$ = Annual emissions from open burning of land clearing debris
$AD_{R\text{-}NR\text{-}Road}$ = Acres disturbed from Residential, Non-residential and Roadway construction in the county
$LF_{OB-LCD-COi}$ = Average Load Factor in County i
$FL_{HW\text{-}SW\text{-}G}$ = Fuel loading factor for hardwoods, softwoods, and grasses
EF_{OBi} = Open burning emission factor for pollutant i in lbs. / ton

Ozone Season Daily Emissions

$$E_{OB-LCD-Day} = \frac{E_{OB-LCD-Ann}}{4 \times 92}$$

$E_{OB-LCD-Day}$ = Ozone Season Daily emissions from open burning
$E_{OB-LCD-Ann}$ = Annual emissions from open burning of land clearing debris
4 = Number of seasons in the year
92 = Days in the season

4.1.5.4 Open Burning – Residential Municipal Solid Waste

SCC: 26 10 030 000

Description

Open burning is the unconfined burning of wood, leaves, land clearing debris, household waste, and agricultural crop waste. Household waste often referred to as residential municipal solid waste (MSW), is a term for nonhazardous refuse produced by households (e.g., paper, plastics, metals, wood, glass, rubber, leather, textiles, and food wastes).

Open burning without a permit is prohibited in Maryland where trash and leaf collection is available, COMAR 26.11.07. The basic difference between the regulation as it applies to counties in AQCRs III and IV and the rest of the state is the requirements under which the burn takes place, i.e., minimum setbacks from property lines, etc. In the more rural counties, areas with no available trash collection are more prevalent. MDE adopted a regulation that prohibits open burning during the peak ozone period (June to August). The seasonal prohibition only affects those counties that lie within serious and severe ozone nonattainment areas. Certain exemptions must be in place however so as not to adversely affect agriculture or restrict fire training and recreational activities.

Pollutants

VOC, NOx, SOx, CO, PM_{10}, $PM_{2.5}$, and HAPs

Method and
Data Sources

The method used to calculate emissions is presented in a study/survey conducted by the Mid-Atlantic/Northeast Visibility Union (MANE-VU), titled "Open Burning in Residential Areas Emissions Inventory Development Report."[46]

Activity

The purpose of the survey was to obtain data for developing activity estimates and control information (e.g., bans on burning) that would form the basis of an improved open burning emission inventory for Mid-Atlantic/Northeast Visibility Union (MANE-VU) states and tribes for the year 2002. But for 2017, the percentages used to calculate emissions are the same; the emissions increase or decrease due to the estimated number of households that burn and the amount of material burned.

A rule effectiveness (RE) survey was also performed to estimate controlled emissions for areas that prohibit open burning. Household waste burning surveys were completed for 72 respondents or jurisdictions, while yard waste surveys were conducted for 181 respondents. The respondents for this survey were typically local fire wardens or chiefs.

[46] Open Burning in Residential Areas Emissions Inventory Development Report, Prepared by E.H. Pechan & Associates, Inc. for the Mid-Atlantic/Northeast Visibility Union, dated January 31, 2004.

Rule effectiveness surveys related to residential MSW rules were conducted for 49 respondents, while RE surveys for yard waste burning rules were performed for 51 respondents. In obtaining survey responses, Pechan collected activity data and control information for areas classified as urban, suburban, and rural, or a combination of these designations (defined using data from the 2000 U.S. Census). Pechan also developed a control database for each open burning category that describes the recommended control efficiency (CE) and rule penetration (RP) values by state and county, and by sub-county, where applicable.

Open burning activity estimates recorded from the survey were used directly to estimate emissions for the surveyed jurisdictions. For the non-surveyed areas, including tribal lands, the default activity data derived from all survey responses were applied. Households are defined as detached single-family unit dwellings as provided by the 2000 U.S. Census.

Emission Factors

Emission factors in lbs/ton total mass were taken from AP-42 Table 2.5-1. Emission Factors for Open Burning of Municipal Refuse and from a 1997 EPA research paper on open burning[47] are listed below:

SCC	Type of Waste	PM2.5 lb/ton	PM10 lb/ton	VOC lb/ton	NOX lb/ton	SO2 lb/ton	CO lb/ton
2610030000	**HH MSW**	**34.8**	**38**	**8.56**	**6**	**1**	**85**
2610000100	Leaf Waste	22	22	28	6.2	0.76	112
2610000400	Brush Waste	15.21	19.73	19	5	1.66	140

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

If an area has controls or prohibitions on residential burning, controlled emissions were calculated from uncontrolled emissions using the following equation:

$E_c = E_{uc} * [(1-(CE)(RP)(RE)]$

[47] EPA. 1997. Evaluation of Emissions from the Open Burning Of Household Waste in Barrels. EPA-600/R-97-134a. U.S. Environmental Protection Agency, Control Technologies Center. Research Triangle Park, North Carolina.

where:

E_c	=	Controlled area source emissions
E_{uc}	=	Uncontrolled area source emissions
CE	=	% Control efficiency varied 0 to 100%
RP	=	% Rule penetration varied 0 to 100%
RE	=	% Rule effectiveness was 96.8%

The following sections describe how values for CE, RP and RE were derived from the survey.

Rule Effectiveness

Pechan evaluated differences in RE between rural/suburban and urban areas, as well as differences in RE for MSW and yard waste burning. Although one may expect that RE would be higher for urban than for suburban or rural areas, ANOVA of the survey results from these geographic subdivisions, as well as for the different open burning categories, did not show that RE values were drawn from distinct populations. Therefore, the final selection of RE reflects a value for all areas and all burning categories.

There were a total of 26 RE survey responses that included information on the number of violating households. To calculate RE, Pechan used the number of households violating the rule, and the number of households expected to perform open burning for areas in the region where there is no rule (i.e., # households x fraction of open burning households by region from survey).

The RE values obtained from the survey responses will be used for the specific State or jurisdiction surveyed. Non-surveyed areas could not be assigned a jurisdiction-specific RE, because no survey responses were obtained for those areas. Pechan did not develop state specific RE values since we had no reason to believe that local jurisdictions in individual states implemented their rules differently than local jurisdictions in the rest of the MANE-VU region. To estimate a default RE value for the remaining areas, the survey data were statistically analyzed. After evaluating the data using the Census 2000 data, a mean value of 96.8 percent reflected the best estimator of central tendency. As such, Pechan applied a rule effectiveness of 96.8 percent to all areas and for both MSW and yard waste burning (Pechan, 2002b).

Control Efficiency and Rule Penetration

For those areas identified to have a control, CE is assumed to be 100 percent (since the control is typically a ban on burning activity). For MSW burning, with the exception of Pennsylvania, Pechan assigned 100 percent CE and 100 percent RP to urban and suburban areas in the MANE-VU region (i.e., even if the state did not have a statewide ban on burning). In Pennsylvania, unless a jurisdiction or county (e.g., Allegheny County) was determined via survey to have a ban, it will be assumed that suburban and rural areas allow open burning. For yard waste burning, Pechan assigned 100 percent CE and RP to all urban areas in the MANE-VU region. Yard waste emissions calculated for suburban and urban areas were assumed to be uncontrolled, unless the survey data or other statewide or local control information indicated otherwise. For municipal yard waste burning, areas were assumed to either perform this activity or have associated emissions, or did not conduct burns and therefore were assigned zero emissions.

In determining annual emissions for those areas with a seasonal ban, Pechan adjusted the RP by the length of the seasonal ban relative to the entire year. The RP value also depends on how the time period of the ban overlaps with the activity profile for the specific category of burning. For example, for brush waste burning, the survey data revealed an average activity profile as follows: Winter–20%; Spring–46%; Summer–6%; and Fall–28%. So, for an area that has a brush burning ban in the summer, although some percentage of burning is likely to be prevented during this season, we assume that 2 percent of the summer season brush burning in August is delayed until September when burning is permitted, resulting in an RP of 4 percent to apply to annual brush waste burning emissions. As mentioned in the discussion of temporal allocation profiles, this also has an effect on the monthly activity profile. A summer RP value of 4 percent would result in a revised temporal allocation profile to be: Winter–20%; Spring–46%; Summer– 4%; and Fall–30%.

Control Percentages used for each county:

STATE CO	SCC	RE	RP	CE
24001	2610030000	96.80%	82.61%	82.61%
24003	2610030000	96.80%	93.62%	100%
24005	2610030000	96.80%	94.80%	100%
24009	2610030000	96.80%	60.29%	100%
24011	2610030000	96.80%	28.57%	28.57%
24013	2610030000	96.80%	100%	100%
24015	2610030000	96.80%	62.50%	100%
24017	2610030000	96.80%	68.75%	100%
24019	2610030000	96.80%	33.33%	33.33%
24021	2610030000	96.80%	71.88%	100%
24023	2610030000	96.80%	14.29%	14.29%
24025	2610030000	96.80%	80%	100%
24027	2610030000	96.80%	92.68%	100%
24029	2610030000	96.80%	40%	40%
24031	2610030000	96.80%	98.31%	100%
24033	2610030000	96.80%	100%	100%
24035	2610030000	96.80%	25%	100%
24037	2610030000	96.80%	40%	40%
24039	2610030000	96.80%	50%	50%
24041	2610030000	96.80%	33.33%	33.33%
24043	2610030000	96.80%	0%	0%
24045	2610030000	96.80%	94.12%	94.12%
24047	2610030000	96.80%	75%	75%
24510	2610030000	96.80%	0%	0%

Spatial and Temporal Allocations

Spatial

Pechan collected activity data and control information for areas classified as urban, suburban, and rural, or a combination of these designations (defined using data from the 2000 U.S. Census).

Temporal

Activity estimates and associated emissions are calculated on an annual basis. Pechan proposes the following temporal allocation profiles to represent monthly, weekly, and daily activity profiles by SCC (see Tables II-2 through II-5). The monthly activity profiles were developed based on data obtained from the survey. The weekly and weekday/weekend profiles were developed based on engineering judgment. These profiles will be applied to annual activity for all areas of MANE-VU (i.e., variations in regional, State, or tribal areas are not accounted for).

Temporal Allocation Profile Formats (monthly)

	Month											
SCC	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2610030000	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
2610000400	0.067	0.067	0.153	0.153	0.153	0.020	0.020	0.020	0.093	0.093	0.093	0.067
2610040400	0.067	0.067	0.153	0.153	0.153	0.020	0.020	0.020	0.093	0.093	0.093	0.067
2610000100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.333	0.333	0.000

Temporal Allocation Profile Formats (weekly)

SCC	Day of Week						
	Mon	Tue	Wed	Thu	Fri	Sat	Sun
2610030000	0.111	0.111	0.111	0.111	0.111	0.222	0.222
2610000400	0.111	0.111	0.111	0.111	0.111	0.222	0.222
2610040400	0.200	0.200	0.200	0.200	0.200	0.000	0.000
2610000100	0.111	0.111	0.111	0.111	0.111	0.222	0.222

Temporal Allocation Profile Formats (daily; weekday)

	Weekday Hour											
SCC	**0100**	**0200**	**0300**	**0400**	**0500**	**0600**	**0700**	**0800**	**0900**	**1000**	**1100**	**1200**
2610030000	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610000400	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610040400	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610000100	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071

	Weekday Hour											
SCC	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**	**1900**	**2000**	**2100**	**2200**	**2300**	**0000**
2610030000	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610000400	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610040400	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610000100	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0

Temporal Allocation Profile Formats (daily; weekend day)

SCC	Weekend Day Hour											
	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200
2610030000	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610000400	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610040400	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610000100	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071

SCC	Weekend Day Hour											
	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	0000
2610030000	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610000400	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610040400	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610000100	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0

Emissions Calculation

Emissions were calculated at a census tract level and summed over a county for county level emissions. A county level sample emission calculation will not be presented here, however the equations for a particular census tract are presented below. All of the census tracts in a county would then be summed for county level emission estimates.

The equation for estimating the mass of waste burned is:

$$Wtm_{SW} = HH * Bt * M$$

Where:
Wt_{MSW} = Mass of waste burned per time period
HH = Number of households that burn (Question 1, Part 2 of survey)
Bt = Number of burns per time period (Question 3, Part 2)
M = Mass of waste per burn (Question 5, Part 3)

Uncontrolled emissions were then calculated using the following equation:

$$E_{UNC} = Wt_{MSW} * EF$$

where:
E_{UNC} = Uncontrolled area source emissions
Wt_{MSW} = Mass of waste burned per time period
EF = Emission factor per pollutant

Controlled emissions were then calculated using the following equation:

$$E_C = E_{UNC} * [(1-(CE)(RP)(RE)]$$

where:
E_C = Controlled area source emissions
E_{UNC} = Uncontrolled area source emissions

4.1.5.5 Open Burning – Residential Yard Waste

SCC: 26 10 000 100 (Leaf Debris)
SCC: 26 10 000 400 (Brush Debris)

Description

Open burning is the unconfined burning of wood, leaves, land clearing debris, household waste, and agricultural crop waste. Household waste often referred to as residential municipal solid waste (MSW), is a term for nonhazardous refuse produced by households (e.g., paper, plastics, metals, wood, glass, rubber, leather, textiles, and food wastes).

Open burning without a permit is prohibited in Maryland where trash and leaf collection is available, COMAR 26.11.07. The basic difference between the regulation as it applies to counties in AQCRs III and IV and the rest of the state is the requirements under which the burn takes place, i.e., minimum setbacks from property lines, etc. In the more rural counties, areas with no available trash collection are more prevalent. MDE adopted a regulation that prohibits open burning during the peak ozone period (June to August). The seasonal prohibition only affects those counties that lie within serious and severe ozone nonattainment areas. Certain exemptions must be in place however so as not to adversely affect agriculture or restrict fire training and recreational activities.

Pollutants

VOC, NOx, SOx, CO, PM_{10}, $PM_{2.5}$, and HAPs

Method and
Data Sources

The method used to calculate emissions is presented in a study/survey conducted by the Mid-Atlantic/Northeast Visibility Union (MANE-VU), titled "Open Burning in Residential Areas Emissions Inventory Development Report."[48]

Activity
The purpose of the survey was to obtain data for developing activity estimates and control information (e.g., bans on burning) that would form the basis of an improved open burning emission inventory for Mid-Atlantic/Northeast Visibility Union (MANE-VU) states and tribes for the year 2002. But for 2017, the percentages used to calculate emissions are the same; the emissions increase or decrease due to the estimated number of households that burn and the amount of material burned.

A rule effectiveness (RE) survey was also performed to estimate controlled emissions for areas that prohibit open burning. Household waste burning surveys were completed for 72 respondents or jurisdictions, while yard waste surveys were conducted for 181 respondents. The respondents for this survey were typically local fire wardens or chiefs.

[48] Open Burning in Residential Areas Emissions Inventory Development Report, Prepared by E.H. Pechan & Associates, Inc. for the Mid-Atlantic/Northeast Visibility Union, dated January 31, 2004.

Rule effectiveness surveys related to residential MSW rules were conducted for 49 respondents, while RE surveys for yard waste burning rules were performed for 51 respondents. In obtaining survey responses, Pechan collected activity data and control information for areas classified as urban, suburban, and rural, or a combination of these designations (defined using data from the 2000 U.S. Census). Pechan also developed a control database for each open burning category that describes the recommended control efficiency (CE), rule penetration (RP) values by state per county, and by sub-county, where applicable.

Open burning activity estimates recorded from the survey were used directly to estimate emissions for the surveyed jurisdictions. For the non-surveyed areas, including tribal lands, the default activity data derived from all survey responses were applied. Households are defined as detached single-family unit dwellings as provided by the 2000 U.S. Census.

Emission Factors

Emission factors in lbs/ton total mass were taken from AP-42 Table 2.5-1, Emission Factors for Open Burning of Municipal Refuse and from a 1997 EPA research paper on open burning[49] are listed below:

SCC	Type of Waste	PM2.5 lb/ton	PM10 lb/ton	VOC lb/ton	NOX lb/ton	SO2 lb/ton	CO lb/ton
2610030000	HH MSW	34.8	38	8.56	6	1	85
2610000100	Leaf Waste	22	22	28	6.2	0.76	112
2610000400	Brush Waste	15.21	19.73	19	5	1.66	140

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

If an area has controls or prohibitions on residential burning, controlled emissions were calculated from uncontrolled emissions using the following equation:

$E_c = E_{uc} * [(1-(CE)(RP)(RE)]$

[49] EPA 1997. Evaluation of Emissions from the Open Burning Of Household Waste in Barrels. EPA-600/R-97-134a. U.S. Environmental Protection Agency, Control Technologies Center. Research Triangle Park, North Carolina.

where:

E_c = Controlled area source emissions
E_{uc} = Uncontrolled area source emissions
CE = % Control efficiency varied 0% to 100%
RP = % Rule penetration varied 0% to 100%
RE = % Rule effectiveness 96.8%

The following sections describe how values for CE, RP, and RE were derived from the survey.

Rule Effectiveness

Pechan evaluated differences in RE between rural/suburban and urban areas, as well as differences in RE for MSW and yard waste burning. Although one may expect that RE would be higher for urban than for suburban or rural areas, ANOVA of the survey results from these geographic subdivisions, as well as for the different open burning categories, did not show that RE values were drawn from distinct populations. Therefore, the final selection of RE reflects a value for all areas and all burning categories.

There were a total of 26 RE survey responses that included information on the number of violating households. To calculate RE, Pechan used the number of households violating the rule, and the number of households expected to perform open burning for areas in the region where there is no rule (i.e., # households x fraction of open burning households by region from survey).

The RE values obtained from the survey responses will be used for the specific State or jurisdiction surveyed. Non-surveyed areas could not be assigned a jurisdiction-specific RE, because no survey responses were obtained for those areas. Pechan did not develop state specific RE values since we had no reason to believe that local jurisdictions in individual states implemented their rules differently than local jurisdictions in the rest of the MANE-VU region. To estimate a default RE value for the remaining areas, the survey data were statistically analyzed. After evaluating the data using the Census 2000 data, a mean value of 96.8 percent reflected the best estimator of central tendency. As such, Pechan applied a rule effectiveness of 96.8 percent to all areas and for both MSW and yard waste burning (Pechan, 2002b).

Control Efficiency and Rule Penetration

For those areas identified to have a control, CE is assumed to be 100 percent (since the control is typically a ban on burning activity). For MSW burning, with the exception of Pennsylvania, Pechan assigned 100 percent CE and 100 percent RP to urban and suburban areas in the MANE-VU region (i.e., even if the state did not have a statewide ban on burning). In Pennsylvania, unless a jurisdiction or county (e.g., Allegheny County) was determined via survey to have a ban, it will be assumed that suburban and rural areas allow open burning. For yard waste burning, Pechan assigned 100 percent CE and RP to all urban areas in the MANE-VU region. Yard waste emissions calculated for suburban and urban areas were assumed to be uncontrolled, unless the survey data or other statewide or local control information indicated otherwise. For municipal yard waste burning, areas were assumed to either perform this activity or have associated emissions, or did not conduct burns and therefore were assigned zero emissions.

In determining annual emissions for those areas with a seasonal ban, Pechan adjusted the RP by the length of the seasonal ban relative to the entire year. The RP value also depends on how the time period of the ban overlaps with the activity profile for the specific category of burning. For example, for brush waste burning, the survey data revealed an average activity profile as follows: Winter–20%; Spring–46%; Summer–6%; and Fall–28%. So, for an area that has a brush burning ban in the summer, although some percentage of burning is likely to be prevented during this season, we assume that 2 percent of the summer season brush burning in August is delayed until September when burning is permitted, resulting in an RP of 4 percent to apply to annual brush waste burning emissions. As mentioned in the discussion of temporal allocation profiles, this also has an effect on the monthly activity profile. A summer RP value of 4 percent would result in a revised temporal allocation profile to be: Winter–20%; Spring–46%; Summer– 4%; and Fall–30%.

Spatial and Temporal Allocations

Spatial

Pechan collected activity data and control information for areas classified as urban, suburban, and rural, or a combination of these designations (defined using data from the 2000 U.S. Census).

Temporal

Activity estimates and associated emissions are calculated on an annual basis. Pechan proposes the following temporal allocation profiles to represent monthly, weekly, and daily activity profiles by SCC (see Tables II-2 through II-5). The monthly activity profiles were developed based on data obtained from the survey. The weekly and weekday/weekend profiles were developed based on engineering judgment. These profiles will be applied to annual activity for all areas of MANE-VU (i.e., variations in regional, State, or tribal areas are not accounted for).

Temporal Allocation Profile Formats (monthly)

	Month											
SCC	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2610030000	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
2610000400	0.067	0.067	0.153	0.153	0.153	0.020	0.020	0.020	0.093	0.093	0.093	0.067
2610040400	0.067	0.067	0.153	0.153	0.153	0.020	0.020	0.020	0.093	0.093	0.093	0.067
2610000100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.333	0.333	0.000

Temporal Allocation Profile Formats (weekly)

SCC	Day of Week						
	Mon	Tue	Wed	Thu	Fri	Sat	Sun
2610030000	0.111	0.111	0.111	0.111	0.111	0.222	0.222
2610000400	0.111	0.111	0.111	0.111	0.111	0.222	0.222
2610040400	0.200	0.200	0.200	0.200	0.200	0.000	0.000
2610000100	0.111	0.111	0.111	0.111	0.111	0.222	0.222

Temporal Allocation Profile Formats (daily; weekday)

SCC	Weekday Hour											
	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200
2610030000	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610000400	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610040400	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610000100	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071

SCC	Weekday Hour											
	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	0000
2610030000	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610000400	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610040400	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610000100	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0

Temporal Allocation Profile Formats (daily; weekend day)

SCC	Weekend Day Hour											
	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200
2610030000	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610000400	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610040400	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071
2610000100	0	0	0	0	0	0	0.071	0.071	0.071	0.071	0.071	0.071

SCC	Weekend Day Hour											
	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	0000
2610030000	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610000400	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610040400	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0
2610000100	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0	0	0	0

Emissions Calculation

Emissions were calculated at a census tract level and summed over a county for county level emissions. A county level sample emission calculation will not be presented here, however the equations for a particular census tract are presented below. All of the census tracts in a county would then be summed for county level emission estimates.

The equation for estimating the mass of waste burned is:

$$Wtm_{SW} = HH * Bt * M$$

where:

Wt_{MSW} = Mass of waste burned per time period

HH = Number of households that burn (Question 1, Part 2 of survey)

Bt = Number of burns per time period (Question 3, Part 2)

M = Mass of waste per burn (Question 5, Part 3)

Uncontrolled emissions were then calculated using the following equation:
$E_{UNC} = Wt_{MSW} * EF$

where:
E_{UNC} = Uncontrolled area source emissions
Wt_{MSW} = Mass of waste burned per time period
EF = Emission factor per pollutant

Controlled emissions were then calculated using the following equation:

$E_C = E_{UNC} * [(1-(CE)(RP)(RE)]$

where:
E_C = Controlled area source emissions
E_{UNC} = Uncontrolled area source emissions
CE = % Control efficiency/100
RP = % Rule penetration/100
RE = % Rule effectiveness/100

4.1.5.6 Cremation – Animal and Human

SCC: 28 10 060 100 (Humans)
28 10 060 200 (Animals)

Description

Propane-fired burners (afterburner and ignition) are typically used at cemeteries for human body and animal cremation. Burners are usually rated at 2,115,000 Btu per hour capacity. Newer units installed in the late 1980's are equipped with a modulating ignition burner. When afterburner temperatures reach about 1800 F (980 C), the ignition burner modulates to a low-fire mode that will reduce the Btu per hour usage.

When the crematory reaches an operating temperature of 1,250 F (680 C) the body container is placed on the combustion chamber grate and the ignition burner is fired to attain a target combustion temperature sufficient for the proper reduction of human remains. The chamber preheats by the afterburner reaches 1,250 F (680 C) in about 30 to 45 minutes prior to ash removal. When the body container is introduced into the combustion chamber, and the burner is ignited, cremation begins at about 1600 to 1800 F (870 to 980 C). Flame impingement on the body takes two to three minutes; cremation occurs for about two hours. The remains are then raked towards the ignition burner for about two minutes. Cool-down follows for 45 minutes to 1.5 hours.

Pollutants

HAPs (Criteria Pollutants were not calculated supplied by sources)

Method and
Data Sources

Activity
In Maryland crematories are regulated under COMAR. COMAR now requires all crematories to obtain a permit to operate and any person who owns or operates a crematory must obtain certification from MDE and renew the certification annually.

MDE/ARA maintains a registry of all crematories within the State. Because of the requirement for a permit to operate, and the operator certification requirements, staff used the sum of the crematories in the registry as representing the total area source emissions from crematories of all types emitting less than 10 tons/VOC, 100 tons/yr CO and 50 tons per year NO_x.

Point Source
Adjustments

No subtraction of emissions from point sources is necessary.

4.1.5.7 Municipal Solid Waste Landfills

SCC: 26 20 030 000

Description

Municipal solid waste landfills receive household and commercial trash. VOC emissions are produced from volatilization, chemical reaction and biological decomposition of waste. Methane and Carbon dioxide are the primary constituents of landfill gas, and are produced during anaerobic decomposition of cellulose and proteins in the landfill waste. 98.7 percent of landfill emissions are methane and carbon dioxide according to the Volatile Organic Compounds Species Data Manual, an EPA publication. In addition to methane and carbon dioxide, non-methane organic carbons (NMOCs) are produced as a small fraction of the landfill gas emissions (less than 1%). NMOCs include hazardous air pollutants and reactive VOCs.

Pollutants

VOC

Method and Data Sources

The method used to calculate emissions, is presented in AP-42, Chapter 2.4, Municipal Solid Waste Landfills and EIIP[50], Volume III, Chapter 15, Landfills, dated September 1997.

Emission estimation assumptions were also made using supporting documents Standards of Performance for New Stationary Sources (NARA, 1991a) and Emission Guidelines for Control of Existing Sources (NARA, 1997b).

To estimate emissions for the various compounds present in landfill gas, total landfill gas emissions must first be estimated. Emissions of landfill gas were calculated using a computer program known as the Landfill Gas Emissions Model (LandGEM 3.02). The model equation is as follows:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where:

Q_{CH4} = annual methane generation in the year of the calculation (m^3/year)
i = 1 year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1 year time increment
k = methane generation rate ($year^{-1}$)
L_o = potential methane generation capacity (m^3/Mg)

[50] Emission Inventory Improvement Program

M_i = mass of waste accepted in the i_{th} year (Mg)
t_{ij} = age of the j_{th} section of waste mass M_i accepted in the i_{th} year (decimal years, e.g., 3.2 years)

Site-specific landfill information is generally available for variables M_i, n, and t_{ij}. A more detailed explanation on how to run the model can be found in the LandGEM 3.02 Users Guide at http://www.epa.gov/ttncatc1/dir1/landgem-v302-guide.pdf .

Landgem Model Parameters AP-42 Default Values

Lo : 100.00 m^3 / Mg	Methane Generation Potential
k : 0.0400 1/yr	Decay Rate/Rate of Decomposition
NMOC : 595.00 ppmv	Non-methane Concentration
Methane : 50.00 % volume	
Carbon Dioxide : 50..00 % volume	

Activity
Data was obtained from MDE's Solid Waste Program and from the landfill facilities directly.

Emission Factors
All factors are incorporated into the LandGEM model.

Point Source Adjustments

Thirteen municipal solid waste landfills were considered point sources and LandGEM model runs for these landfills were done, but keep out of the Area source emission estimates. Emission reductions were calculated for landfills that used control technology to reduce emissions.

Adjustments for Controls

Controlled emissions from landfills were calculated in the following manner:

Equation:

$$E_{CON\text{-}LF} = \{E_{UNC\text{-}LF} \times (1 - C_{EFF})\} + \{E_{UNC\text{-}LF} \times C_{EFF} \times [1 - (D_{EFF} \times RE)]\}$$

Where:

$E_{CON\text{-}LF}$	=	Controlled emissions from landfills
$E_{UNC\text{-}LF}$	=	Uncontrolled emissions from landfills (generated from the LandGEM model)
C_{EFF}	=	Landfill collection efficiency (EPA default = 75%)
D_{EFF}	=	Control device destruction efficiency (98%)
RE	=	Rule effectiveness (EPA default 80%)

Spatial and Temporal Allocations

Spatial
Data for spatial allocation is not available for this source.

Temporal
SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

4.1.6 SMALL STATIONARY SOURCE FOSSIL FUEL USE

4.1.6.1 Small Electric Utility Boilers

All small electric utility boilers are inventoried in the point source category. The list of small boilers from Inventory of Power Plants in the United States, DOE/EIA-0095(88) was obtained and indicated that all small electric boilers were included in the point source inventory.

4.1.6.2 Other Fuel Consumption

Coke and process gas emissions will be inventoried as point sources.

4.1.6.3 Fuel Oil Combustion

SCC: 21 04 011 000 (residential kerosene)
21 03 011 000 (commercial/institutional kerosene)
21 04 004 000 (residential distillate oil)
21 03 004 000 (commercial/institutional distillate oil)
21 03 005 000 (commercial/institutional residual oil)

Description

Data collection for fuel oil consumption covers the use of both distillate and residual oil. Distillate oil includes fuel oil grades 1, 2 and 4. Diesel fuel and kerosene also can be considered as distillate oils. Residential and commercial/institutional sources are the largest consumers of distillate oil, nationwide. Residual oil includes fuel oil grades 5 and 6. In most areas residual oil is not used by residential sources, but industrial and commercial/institutional users may consume significant amounts.

Pollutants

PM_{10}, $PM_{2.5}$, SOx, NOx, CO, VOC

Method and
Data Sources

Activity
Total sales statistics of kerosene, distillate oil, and residual oil in the State of Maryland were obtained from the Annual Report on Sales of Fuel Oil and Kerosene, 2016, published by Energy Information Administration, U.S. Department of Energy[51].

Emission Factors

Uncontrolled Emission Factors – AP-42 Tables 1.3-1 and 1.3-3 (hand-fed units)

Pollutant	Residential Distillate lbs/Kgal	Residential Kerosene lbs/Kgal	Commercial Distillate lbs/Kgal	Commercial Kerosene lbs/Kgal	Commercial Residual lbs/Kgal	Commercial Residual 1% S lbs/Kgal
PM10-FIL	1.080	1.080	1.080	1.080	13.494	7.703
PM2.5-FIL	0.830	0.830	0.830	0.830	5.011	2.861
PM-CON	1.300	1.300	1.300	1.300	1.500	1.500
NH3	1.000	1.000	0.800	0.800	0.800	0.800
SO2	43.200	41.657	43.200	41.657	318.000	159.000
NOx	18.000	18.000	20.000	20.000	55.000	55.000
CO	5.000	5.000	5.000	5.000	5.000	5.000
VOC	0.713	0.713	0.340	0.340	1.130	1.130

[51] Total residential distillate oil use in the State of Maryland in 2016 from U.S Department of Energy, Energy Information Administration, Office of Oil and Gas, Petroleum Marketing Monthly, "Annual Report on Sales of Fuel Oil and Kerosene, 2016".

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

This information on total sales of kerosene, distillate oil and residual oil was broken down to the county level using a spatial allocation factor documented and recommended by EIIP[52] in an Area Source Method Abstract for Residential and Commercial/Institutional Fuel Oil and Kerosene combustion.

MDE developed an allocation factor from local and state totals of annual heating-degree days and population with fuel oil to spatially allocate fuel oil consumption. The method is

A "heating-degree day" is a unit of measure used to indicate how cold it has been over a 24-hour period. Daily heating-degree days are calculated as the difference between the base value of 65°F and the mean temperature for the day (mean of the high and low temperatures for the day).

Annual heating degree days are the sum of the daily heating degree days. Heating degree data is available from the National Oceanographic and Atmospheric Administration (NOAA).[53]

$$SAF_{InventoryCounty} = \frac{HDD_{InventoryCounty} * POP_{InventoryCounty}}{\sum_{AllCountiesInState} (HDD_{County} * POP_{County})}$$

Where:

$SAF_{InventoryCounty}$	=	Spatial apportioning factor for inventory county
$HDD_{InventoryCounty}$	=	Annual heating degree days for inventory county
$POP_{InventoryCounty}$	=	Population of the inventory county
HDD_{County}	=	Annual heating degree days for each county in the state
POP_{County}	=	Population for each county in the state

[52] Emissions Inventory Improvement Program (EIIP) Area Source Method Abstract – Residential and Commercial/Institutional Fuel Oil and Kerosene Combustion, dated April 2011.

[53] http://www.noaa.gov (home page) or http://www.ncdc.noaa.gov/ol/climate/climateproducts.html#PUBS (for a list of available data)

The spatial apportioning factor is used to allocate the state fuel total to the county level using the following equation:

$$\text{Fuel}_{\text{INVENTORY COUNTY}} = \text{SAF}_{\text{INVENTORY COUNTY}} \times \text{Fuel}_{\text{TOTAL STATE}}$$

Where:

$\text{Fuel}_{\text{INVENTORY COUNTY}}$ = Total Fuel consumed annually in the inventory county

$\text{Fuel}_{\text{TOTAL STATE}}$ = Total Fuel consumed annually in the state

Temporal

Kerosene, distillate oil, and residual oil are almost entirely used for space heating. MDE made the assumption that the amount of fuel consumed in a county over the course of a month is proportional to the number of heat degree days in that county for the month.

The total amount of fuel consumed in the county annually is allocated from state totals using the following formula.

$$Fuel_{InventoryCountyAnnual} = SAF_{InventoryCounty} * Fuel_{TotalState}$$

Where:

$\text{Fuel}_{\text{InventroyCountyAnnual}}$ = Total Fuel consumed annually in the inventory county

$\text{Fuel}_{\text{TotalState}}$ = Total Fuel consumed annually in the state

The amount of fuel consumed in a month per county is proportional to the number heat degree days for the month in the county divided by the total number heat degree days for the year in the county.

$$Fuel_{InventoryCountyPerMonth} = Fuel_{InventoryCountyAnnual} * \frac{HDD_{InventoryCounty-Month}}{HDD_{InventoryCounty-Annual}}$$

Emissions Calculation

Activity Data Gathered

- Total amount of fuel (kerosene, distillate oil, and residual oil) consumed in the state.
- Number of heat degree days per county per month for the year of the inventory.

Calculate Spatial Apportioning Factor

$$SAF_{InventoryCounty} = \frac{HDD_{InventoryCounty} * POP_{InventoryCounty}}{\sum_{AllCountiesInState}(HDD_{County} * POP_{County})}$$

Apportion State Fuel Consumption to the County Level

$F_{I-CTY} = SAF_{CTY} \times F_{ST}$

Where

F_{I-CTY} = Fuel type I consumed in county

SAF_{CTY} = Spatial apportioning factor for inventory county

F_{ST} = Total fuel consumed in the state.

Calculate Annual Emissions

Emissions were calculated in tons/year for residential, commercial and industrial categories from each type of fuel combustion using following equations.

$EM_R = (F_{I-CTY} \mathbf{x} EF_R) / 2000$

Where

EM_R = Emissions from residential category.

F_{I-CTY} = Total annual residential sales of fuel i in the county.

EF_R = Residential emission factor for fuel i from AP-42

$EM_C = (F_{I-CTY} \mathbf{x} EF_C) / 2000$

Where

EM_C = Emissions from commercial/institutional category.

F_{I-CTY} = Total annual commercial/institutional sales of fuel i in the county.

EF_C = Commercial emission factor for fuel i from AP-42.

<u>2017 Residential Distillate Oil Combustion Sample Calculation (Baltimore County)</u>

Residential Distillate Oil Consumed State of Maryland = **2,006**[54] kbarrels (Thousand Barrels)

Spatial apportioning factor for Baltimore County:

$$SAF_{\text{Baltimore Co}} = \frac{HDD_{\text{Baltimore Co}} \times POP_{\text{Units Heating Baltimore Co}}{}^{55}}{\sum_{\text{ALL COUNTIES IN STATE}} (HDD_{\text{COUNTY}} \times POP_{\text{Units Heating State}})}$$

$SAF_{\text{Baltimore Co}}$ = **0.115411**

To calculate the total annual kilo gallons of distillate oil used in city of Baltimore for residential space heating:

$Fuel_{\text{Baltimore Co}}$ = $SAF_{\text{Baltimore City}} \times Fuel_{\text{TOTAL STATE}}$

$Fuel_{\text{Baltimore Co}}$ = **0.115411** x 2006 kbarrels

$Fuel_{\text{Baltimore Co}}$ = **231.51** kbarrels

$Fuel_{\text{Baltimore Co}}$ = **231.51** kbarrels x 42 Kgal per kbarrels

$Fuel_{\text{Baltimore Co}}$ = **9,723.61** Kgal

[54] From EIA: Adjusted Sales for Residential End Use: Distillate Fuel Oil and Kerosene, 2016 (Thousand Barrels)

[55] Population data from the U.S. Bureau of the Census, The Maryland Department of Planning

Annual Emissions Calculation

$E_{\text{Baltimore Co– Res - VOC}}$ = Fuel $_{\text{Baltimore County}}$ x EF $_{\text{VOC}}$

$E_{\text{Baltimore Co– Res - VOC}}$ = 9,723.61 Kgal x 0.713 lbs $_{\text{VOC PER}}$ Kgal

$E_{\text{Baltimore Co– Res - VOC}}$ 6,932.94 lbs $_{\text{VOC}}$ / year

$E_{\text{Baltimore Co– Res - VOC}}$ = 3.47 tons $_{\text{VOC}}$ / year

Daily Emissions Calculation
Distillate Oil for Baltimore County was found to have a
SAF = seasonal adjustment factor of 0.002765272
POS = peak ozone period of 1
Days of the Period 31 (average days in summer month)
Daily adjusted $E_{\text{Baltimore Co– Res - VOC}\mathbf{da}}$ = ($E_{\text{Baltimore Co– Res - VOC}}$ / 31)*(SAF / POS)

$E_{\text{Baltimore Co– Res - VOC}\mathbf{da}}$ = (3.47 / 31)*(0.002765272 / 1) = **3.09E-04 VOC tons/day**

All pollutants (PM, SOx, NOx, VOC, and CO) are calculated in a similar manner.

Commercial and industrial emissions from this source category are calculated in a similar manner with the exception that the number of days in an ozone season changes from 214 for residential to 168 for commercial and industrial. Residential ozone season days are based on 7 days per week activity. Commercial and industrial ozone season days are based on 6 days per week activity.

4.1.6.4 Coal Combustion

SCC: 21 04 002 000 (Residential Coal)
SCC: 21 03 002 000 (Commercial/Institutional Coal)

Description
Residential
Coal

This source category covers air emissions from coal combustion in the residential sector. Bituminous coal, mined here in Maryland, represents the bulk of the coal used residentially for space heating in the State. Although mined nearby in Pennsylvania, readily available, and cleaner burning, anthracite coal is not used much in Maryland because of its expense.

Pollutants

PM_{10}, $PM_{2.5}$, SOx, NOx, CO, VOC

Method and
Data Sources

Activity
The following assumptions were made in the computation of emissions from coal combustion from the residential sources.

(i) Number of Dwelling Units using Coal

The number of dwelling units using coal for space heating for 2014 was obtained from 2013 U. S. Census Profile on economic characteristics and the Maryland Office of Planning. MDE estimated that no new housing units would be equipped to burn coal as a home heating fuel.

(ii) Residential Coal Activity Consumption Data

The State Energy Data Report, Consumption Estimates, by the Energy Information Administration, provides information on estimated coal consumption. Bituminous coal is consumed by most of the hand-fired residential coal sources in the State of Maryland, but no coal usage activity was reported in 2017; resulting in no coal combustion emissions.

EXAMPLE CACULATIONS ARE STILL SHOWN BELOW FOR RESIDENTIAL AND COMMERCIAL COAL COMBUSTION.

Emission Factors

Emission factors were obtained from AP-42, Tables 1.1-3 and 1.1-4 (Residential-hand-fed units) and PM2.5 from ERTAC.

Coal Emission Factors						
	NOx (lbs./ton)	**CO (lbs./ton)**	**VOC (lbs./ton)**	**PM10-PRI (lbs./ton)**	**PM2.5-PRI (lbs./ton)**	**SO2 (lbs./ton)**
Residential	9.1	275	10	6.2	3.84	37.2

Maryland's 2008 average sulfur content in coal = 1.2% Sulfur (DOE/EIA State Electricity Profiles 2008, March 2010 Table 6. page 124)
AP42 Table 1.1-19 (hand fed units) Emission factor SO_2 = 31S
In formula S = 1.2, such that SO_2 EF =31*1.2 = 37.2 lb/ton

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

MDE developed an allocation factor from local and state totals of annual heating-degree days and housing units heating with coal to spatially allocated coal consumption. The method is documented and recommended by EIIP[56] in an Area Source Method Abstract for natural gas and LPG combustion. Because the emission factor was specifically adjusted to reflect seasonal emissions through heating degree days, no further seasonal adjustment factor is necessary.

A "heating-degree day" is a unit of measure used to indicate how cold it has been over a 24-hour period. Daily heating-degree days are calculated as the difference between the base value of 65°F and the mean temperature for the day (mean of the high and low temperatures for the day).

Annual heating-degree days are the sum of the daily heating-degree days. Heating degree data is available from the National Oceanographic and Atmospheric Administration (NOAA).[57]

$$SAF_{InventoryCounty} = \frac{HDD_{InventoryCounty} * CHU_{InventoryCounty}}{\sum_{AllCountiesInState} (HDD_{County} * CHU_{County})}$$

Where:

$SAF_{INVENTORY\ COUNTY}$	=	Spatial apportioning factor for inventory county
$HDD_{INVENTORY\ COUNTY}$	=	Annual heating degree days for inventory county
$CHU_{INVENTORY\ COUNTY}$	=	Housing units using coal in inventory county
HDD_{COUNTY}	=	Annual heating degree days for each county in the state
CHU_{COUNTY}	=	Housing units using coal for each county in the state

The spatial apportioning factor is used to allocate the state fuel total to the county level using the following equation:

$$Coal_{INVENTORY\ COUNTY} = SAF_{INVENTORY\ COUNTY} \times Coal_{TOTAL\ STATE}$$

Where:

$Coal_{INVENTORY\ COUNTY}$	=	Total Coal fuel consumed in the inventory county
$Coal_{TOTAL\ STATE}$	=	Total Coal fuel consumed in the state.

Temporal

MDE assumed that all residential coal combustion is used for space heating purposes. The total coal consumed in the county can be allocated by month or period using proportions of annual and monthly (or period) heating-degree days.

$$\text{Residential Fuel}_{MONTH} = \text{Residential Fuel}_{ANNUAL} \times \frac{HDD_{MONTH}}{HDD_{ANNUAL}}$$

where:

$\text{Residential Fuel}_{MONTH}$	=	Space heating fuel use for inventory month
$\text{Residential Fuel}_{ANNUAL}$	=	Space heating fuel use for inventory year
HDD_{MONTH}	=	Heating degree days for inventory month
HDD_{ANNUAL}	=	Heating degree days for inventory year

[57] http://www.noaa.gov (home page) or http://www.ncdc.noaa.gov/ol/climate/climateproducts.html#PUBS (for a list of available data)

Emissions Calculation

Equation:

$$E_{COALR} = \frac{(EF_{COAL\ i} \times Coal_{INVENTORY\ COUNTY})}{2000}$$

E_{COALR} = Yearly emissions from residential coal combustion
$EF_{COAL\ i}$ = Emission factor for coal combustion for pollutant i

Annual Emissions Calculation
Residential Coal Combustion Sample Calculation (Harford County) (tons / year)

Total Residential Coal Consumption – State of Maryland 2,000 tons (Bituminous Coal)

To calculate spatial apportioning factor for Harford County:

$$SAF_{HARFORD\ COUNTY} = \frac{HDD_{INVENTORY\ COUNTY} \times CHU_{INVENTORY\ COUNTY}}{\sum_{ALL\ COUNTIES\ IN\ STATE} (HDD_{COUNTY} \times CHU_{COUNTY})}$$

$SAF_{HARFORD\ COUNTY}$ = **0.07254565**

To calculate tons of coal used in Harford County:

$Residential\ Coal_{HARFORD\ COUNTY} = SAF_{HARFORD\ COUNTY} \times Coal_{TOTAL\ STATE}$
$Residential\ Coal_{HARFORD\ COUNTY} = 0.07254565 \times 2{,}000$
$Residential\ Coal_{HARFORD\ COUNTY} = 145.09$ tons

Equation:

Residential Coal SO2 Emission Calculation for Harford County

$$E_{COALR} = \frac{(EF_{COAL\ VOC} \times Coal_{HARFORD\ COUNTY})}{2000}$$

$$E_{COALR} = \frac{(10.0 \times 145.09)}{2000}$$

$\mathbf{E_{COALR} = 0.73\ tons_{VOC}\ year}$

Daily Emissions Calculation
Residential Coal Combustion for Harford County was found to have a
SAF = seasonal adjustment factor of 0.002765272
POS = peak ozone period of 1
Days of the Period 31 (average days in summer month)
Daily adjusted $E_{COALR\mathbf{da}}$ = (E_{COALR} / 31)*(SAF / POS)

$E_{COALR\mathbf{da}}$ = (**0.73** / 31)*(0.002765272 / 1) = **6.47E-05 VOC tons/day**

Description - Commercial and Institutional Coal

Commercial and Institutional sources of coal combustion above the point source threshold are included in the point source portion of the inventory. The following table lists area source emissions from commercial and institutional sources smaller than the threshold values.

Methods and
Data Sources

The following assumptions were made in the computation of emissions from coal combustion from the commercial and institutional sources not included in the point source inventory.

Activity
(i) Coal Consumption Data
The State Energy Data Report (SEDR) estimated that approximately 9,000 tons/year of total coal was used commercially by Maryland in 2013.

(ii) Number of Dwelling Units using Coal
The number of businesses using coal for space heating for 2014 was obtained from 2013 U. S. Census Profile on economic characteristics. MDE estimated that no businesses would be equipped to burn coal for heating fuel.

COMAR 26.11.09.04 prohibits the use of solid fuel-burning equipment that has a rated heat input of less than 35 million BTU per hour.

Emission Factors
EMISSION FACTORS WERE OBTAINED FROM AP-42, TABLES 1.1-3 AND VOCS (TNMOC) TABLE 1.1-19 (AVERAGE OF OVERFEED AND UNDERFEED STOKER). PM10 AND PM2.5 EF ON TABLES 1.1-10 AND 1.1-11

Coal Emission Factors						
	NOx (lbs./ton)	**CO (lbs./ton)**	**VOC (lbs./ton)**	**PM10-PRI (lbs./ton)**	**PM2.5-PRI (lbs./ton)**	**SO_2 (lbs./ton)**
Commercial / Institutional	8.5	8.5	0.675	6.1	3	41.4

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

Spatial temporal allocations to this source category were calculated in the same manner as the residential coal combustion category.

Temporal

Spatial and temporal allocations to this source category were calculated in the same manner as the residential coal combustion category.

Emissions Calculation

Annual Emissions Calculation

Commercial Coal Combustion Sample Calculation (Allegany County) (tons / year)

Total Commercial Coal Consumption – State of Maryland 9,000 tons

To calculate spatial apportioning factor for Allegany County:

$$SAF_{\text{ALLEGANY COUNTY}} = \frac{HDD_{\text{INVENTORY COUNTY}} \times CHU_{\text{INVENTORY COUNTY}}}{\sum_{\text{ALL COUNTIES IN STATE}} (HDD_{\text{COUNTY}} \times CHU_{\text{COUNTY}})}$$

$SAF_{\text{ALLEGANY COUNTY}}$ = **0.371317**

To calculate tons of coal used in Allegany County:

$$\text{Commercial Coal}_{\text{ALLEGANY COUNTY}} = SAF_{\text{ALLEGANY COUNTY}} \times \text{Coal}_{\text{TOTAL STATE}}$$

$$\text{Commercial Coal}_{\text{ALLEGANY COUNTY}} = 0.371317 \times 9{,}000$$

$$\text{Commercial Coal}_{\text{ALLEGANY COUNTY}} = 3{,}341.85 \text{ tons}$$

Equation:

Commercial Coal VOC Emission Calculation for Allegany County

$$E_{COALC} = \frac{(EF_{COAL\ VOC} \times Coal_{ALLEGANY\ COUNTY})}{2000}$$

$$E_{COALC} = \frac{(0.675 \times 3{,}341.85)}{2000}$$

$$\mathbf{E_{COALC} = 1.13\ tons_{VOC}\ year}$$

Daily Emissions Calculation
Commercial Coal Combustion for Allegany County was found to have a
SAF = seasonal adjustment factor of 0.002765272
POS = peak ozone period of 1
Days of the Period 31 (average days in summer month)
Daily adjusted $E_{COALC\mathbf{da}} = (E_{COALC} / 31)*(SAF / POS)$

$E_{COALC\mathbf{da}} = (\mathbf{1.13} / 31)*(0.002765272 / 1) =$ **1.01E-04 VOC tons/day**

4.1.6.5 Natural Gas Combustion

SCC:21 04 006 000 (Residential Natural Gas)
SCC:21 03 006 000 (Commercial/Institutional Natural Gas)

Description

This source category covers air emissions from natural gas combustion in the residential and commercial/institutional sectors for space heating, water heating, and cooking. This category includes small boilers, furnaces, heaters and other heating units that are not inventoried as point sources. Residential and commercial sectors comprise housing units; wholesale and retail businesses; health institutions; social and educational institutions; and Federal, state and local government institutions (e.g., military installations, prisons, office buildings). Natural gas is one of the major fuels used throughout the country. It is used mainly for power generation, for industrial process steam and heat production, and for domestic and commercial space heating. It is also used for domestic cooking and hot water heating.

Pollutants

PM_{10}, $PM_{2.5}$, SOx, NOx, CO, NH3, VOC

Method and Data Sources

The following assumptions were made in the computation of the emissions from natural gas combustion.

Activity

(i) Number of Dwelling Units using Natural Gas

The number of dwelling units using natural gas for space heating for 2017 was obtained from 2016 U. S. Census Profile on economic characteristics and the Maryland Office of Planning.

(ii) Residential and Commercial/Institutional Natural Gas Consumption Data

Total residential and commercial/institutional natural gas consumption data in the State of Maryland for 2017 was obtained from surveying the following companies: Baltimore Gas and Electric (*Constellation Energy Group*), Washington Gas Energy Services (Maryland Division), Chesapeake Utilities Corporation, Columbia Gas of Maryland, Easton Utility Commission, and Elkton Gas Company. The companies provided natural gas sales statistics for the year 2017 in therms or cubic feet for all counties in their service area for the residential, commercial, and industrial categories. These statistics were then converted into million cubic feet using a conversion factor of 1 therm equals 100 cubic feet.

Emission Factors

(iii) Emission Factors – Natural Gas

Emission factors for residential natural gas came from 2008 Emission Inventory Data & Documentation (http://www.epa.gov/ttn/chief/net/2008inventory.html) Nonpoint section for Residential Heating: Natural Gas factors for combustion of natural gas in commercial boilers are presented in Table 1.4-1 and 1.4-2 of Section 1.4 of *AP-42*. Commercial factors came from the ICI Workbook on the same website created by EPA and ERTAC committee through a joint study.

Natural Gas Emission Factors							
	NOx (lbs./10^6 scf)	**CO** (lbs./10^6 scf)	**VOC** (lbs./10^6 scf)	**PM 10** (lbs./10^6 scf)	**PM 2.5** (lbs./10^6 scf)	**NH3** (lbs./10^6 scf)	**SOx** (lbs./10^6 scf)
Residential	94	40	5.5	0.2	0.11	20	0.6
Commercial	100	84	5.5	0.2	0.11	0.49	0.6

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

The natural gas survey of suppliers provided MDE with county totals for natural gas consumption. Therefore MDE did not have to use an allocation factor derived from local and state totals of annual heating degree days and housing units heating with natural gas to spatially allocated natural gas consumption to the county level for most of the counties.

Temporal

In addition to space heating, natural gas is often used for cooking and water heating. For ozone and other seasonal inventories, consumption for cooking and water heating may be assumed to be constant through the year, but fuel used for space heating must be apportioned according to heating needs.

To separate residential space heating natural gas usage from cooking and water heating, MDE used data from the State Energy Data Report, Consumption Estimates, Energy Information Administration, Office of Energy Markets and End Use, U.S. Department of Energy. Specifically data was collected from Table 15 – Natural Gas Deliveries to Residential Customers, by State, 1998-2013. The residential deliveries for the month with the lowest deliveries can be assumed to be only for cooking and water heating. The percentage of residential natural gas consumption for cooking and water heating may then be calculated:

$$\text{Annual Non-Space Heating Percent} = \frac{12 * \text{Lowest Monthly Fuel Use}}{\text{Annual Fuel Use}} * 100$$

$$\text{Annual Non-Space Heating Percent} = \frac{12 * 1635}{80{,}447} * 100$$

$$\text{Annual Non-Space Heating Percent} = 24.389\ \%$$

The annual non-space heating percent can be calculated in a similar manner for commercial/institutional natural gas usage. The percentage of commercial/institutional natural gas consumption for non-space heating may then be calculated:

$$\text{Annual Non-Space Heating Percent} = \frac{12 * \text{Lowest Monthly Fuel Use}}{\text{Annual Fuel Use}} * 100$$

$$\text{Annual Non-Space Heating Percent} = \frac{12 * 2440}{65323} * 100$$

$$\text{Annual Non-Space Heating Percent} = 44.823\ \%$$

This percentage may be applied to the inventory area's total residential and/or commercial/institutional natural gas consumption to calculate the non-space heating portion of usage. This portion can be subtracted from the annual total, and the remaining consumption, which is being used for space heating, can be allocated by month or period using proportions of annual and monthly or period heating degree days.

$$\text{Space Heat Fuel}_{\text{MONTH}} = \text{Space Heat Fuel}_{\text{ANNUAL}} \times \frac{\text{HDD}_{\text{MONTH}}}{\text{HDD}_{\text{ANNUAL}}}$$

Where:

$\text{Space Heat Fuel}_{\text{MONTH}}$ = Space heating fuel use for inventory month

$\text{Space Heat Fuel}_{\text{ANNUAL}}$ = Space heating fuel use for inventory year

$\text{HDD}_{\text{MONTH}}$ = Heating degree days for inventory month

$\text{HDD}_{\text{ANNUAL}}$ = Heating degree days for inventory year

Emissions
Calculation

Emission Calculation – Residential Emissions

Equation:

$$E_{NatGas} = \frac{(EF_{NatGas\text{-}P} \times NG_i)}{2000}$$

E_{NatGas} = Yearly emissions from natural gas combustion
$EF_{NatGas\text{-}P}$ = Emission factor for natural gas combustion for pollutant i
NG_i = Natural gas consumed for county i

Total Residential Natural Gas Consumption – Baltimore County[58] 11,677.19 M ft^3

	Total Natural Gas Delivered	**(** M ft^3 **)**
	Residential	**Commercial**
State of Maryland	**74,103.60**	**74,748.51**

$$E_{NatGas} = \frac{(EF_{NatGas\text{-}voc} \times NG_{Bato.County})}{2000}$$

$$E_{NatGas} = \frac{(5.5 \times 11,677.19)}{2000}$$

E_{NatGas} **32.11 tons VOC year**

The same equation and methodology can be used to estimate emission of various pollutants.

Daily Emissions Calculation
Residential Natural Gas Consumption for Baltimore County was found to have a
SAF = seasonal adjustment factor of 0.06283113
POS = peak ozone period of 1
Days of the Period 31 (average days in summer month)
Daily adjusted $E_{NatGas\mathbf{da}}$ = (E_{NatGas} / 31)*(SAF / POS)

$E_{NatGas\mathbf{da}}$ = (**32.11** / 31)*(0.06283113 / 1) = **6.51E-02 VOC tons/day**

[56] Natural gas consumption data gathered from MDE survey – Baltimore County data from BGE

4.1.6.6 Liquefied Petroleum Gas Combustion

SCC: 21 04 007 000 (Residential LPG)
SCC: 21 03 007 000 (Commercial/Institutional LPG)

Description

This source category covers air emissions from liquefied petroleum gas (LPG) combustion in the residential and commercial sectors for space heating, water heating, or cooking. LPG includes propane, propylene, butane, and butylenes. The product used for domestic heating is composed primarily of propane. This category includes small boilers, furnaces, heaters and other heating units that are not inventoried as point sources. Residential and commercial sectors comprise housing units; wholesale and retail businesses; health institutions; social and educational institutions; and Federal, state and local government institutions (e.g., military installations, prisons, office buildings).

Pollutants

PM_{10}, $PM_{2.5}$, SOx, NOx, CO, NH3, VOC

Method and Data Sources

The following assumptions were made in the computation of the emissions from liquefied petroleum gas (LPG) combustion.

Activity

1. Number of Dwelling Units using LPG

The number of dwelling units using LPG for space heating for 2017 was obtained from 2016 U. S. Census Profile on economic characteristics and the Maryland Office of Planning.

2. Residential and Commercial LPG Activity Consumption Data

Total residential and commercial LPG consumption data for space heating in the State of Maryland (LPG_{ST}) for 2017 were obtained from State Energy Data Report, Consumption Estimates, Energy Information Administration, Office of Energy Markets, and End Use, U.S. Department of Energy.

Emission Factors

Emission factors for LPG came from 2008 Emission Inventory Data & Documentation (http://www.epa.gov/ttn/chief/net/2008inventory.html) Nonpoint section for Residential Heating: LPG Combustion Table 1. Commercial factors came from the ICI Workbook on the same website created by EPA and ERTAC committee through a joint study. Factors have been rounded to one and two decimal places.

LPG Emission Factors							
	NOx (lbs./kbbl)	CO (lbs./kbbl)	VOC (lbs./kbbl)	PM10-FIL (lbs./kbbl)	PM2.5-FIL (lbs./kbbl)	NH3 (lbs./kbbl)	SO2 (lbs./kbbl)
Residential	562.8	159.6	21.91	0.8	0.44	1.95	2.39
Commercial	597.66	334.74	21.84	0.84	0.42	2.1	2.52

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

MDE developed an allocation factor from local and state totals of annual heating degree days and housing units heating with liquid propane gas to spatially allocated liquid propane gas consumption. The method is documented and recommended by EIIP[59] in an Area Source Method Abstract for natural gas and LPG combustion.

A “heating degree day” is a unit of measure used to indicate how cold it has been over a 24-hour period. Daily heating degree days are calculated as the difference between the base value of 65°F and the mean temperature for the day (mean of the high and low temperatures for the day).

[59] Emissions Inventory Improvement Program (EIIP) Area Source Method Abstract – Natural Gas and LPG Combustion, dated 2011

Annual heating degree days are the sum of the daily heating degree days. Heating degree data is available from the National Oceanographic and Atmospheric Administration (NOAA).[60]

$$SAF_{\text{INVENTORY COUNTY}} = \frac{HDD_{\text{INVENTORY COUNTY}} \times LP\text{-}HU_{\text{INVENTORY COUNTY}}}{\sum_{\text{ALL COUNTIES IN STATE}} (HDD_{\text{COUNTY}} \times LP\text{-}HU_{\text{COUNTY}})}$$

Where:

$SAF_{\text{INVENTORY COUNTY}}$ = Spatial apportioning factor for inventory county
$HDD_{\text{INVENTORY COUNTY}}$ = Annual heating degree days for inventory county
$LP\text{-}HU_{\text{INVENTORY COUNTY}}$ = Housing units using LP gas for inventory county
HDD_{COUNTY} = Annual heating degree days for each county in the state
$LP\text{-}HU_{\text{COUNTY}}$ = Housing units using LP gas for each county in the state

The spatial apportioning factor is used to allocate the state fuel total to the county level using the following equation:

$$LPG_{\text{INVENTORY COUNTY}} = SAF_{\text{INVENTORY COUNTY}} \times LPG_{\text{TOTAL STATE}}$$

Where:

$LPG_{\text{INVENTORY COUNTY}}$ = Total LPG fuel consumed in the inventory county
$LPG_{\text{TOTAL STATE}}$ = Total LPG fuel consumed in the inventory county

Temporal

In addition to space heating, liquid propane gas is often used for cooking and water heating. For ozone and other seasonal inventories, consumption for cooking and water heating may be assumed to be constant through the year, but fuel used for space heating must be apportioned according to heating needs.

Emissions Calculation

Emission Calculation

$$E_{LPGi} = \frac{(EF_{LPG\,p} \times LPG_{County\,i})}{2000}$$

E_{LPGi} = Yearly emissions from liquid propane gas combustion in county i
$EF_{LPG\,p}$ = Emission factor for LPG combustion for pollutant p
$LPG_{County\,i}$ = LPG consumed for space heating in county i

[60] http://www.noaa.gov (home page) or http://www.ncdc.noaa.gov/ol/climate/climateproducts.html#PUBS (for a list of available data)

2017 Residential LPG Combustion Sample Calculation (Baltimore City) (tons/year)

Total Residential LPG Consumption – State of Maryland 1,654 thousand barrels (kbbl)
To calculate spatial apportioning factor for Baltimore City:

$$SAF_{\text{BALTIMORE CITY}} = \frac{HDD_{\text{INVENTORY COUNTY}} \times LP\text{-}HU_{\text{INVENTORY COUNTY}}}{\sum_{\text{ALL COUNTIES IN STATE}} (HDD_{\text{COUNTY}} \times LP\text{-}HU_{\text{COUNTY}})}$$

$$SAF_{\text{BALTIMORE CITY}} = \frac{3{,}328 \times 2{,}478}{289{,}267{,}603}$$

$$SAF_{\text{BALTIMORE CITY}} = 0.0285092$$

To calculate thousand barrels of liquefied petroleum gas (LPG) used in Baltimore City:

$$\text{Residential } LPG_{\text{BALTIMORE CITY}} = SAF_{\text{BALTIMORE CITY}} \times LPG_{\text{TOTAL STATE}}$$
$$\text{Residential } LPG_{\text{BALTIMORE CITY}} = 0.0285092 \times 1{,}654$$
$$\text{Residential } LPG_{\text{BALTIMORE CITY}} = \mathbf{47.15} \text{ kbbl}$$

Equation:

$$E_{LPGi} = \frac{(EF_{LPG\ voc} \times LPG_{County\ i})}{2000}$$

$$E_{LPGi} = \frac{(21.91 \times \mathbf{47.15})}{2000}$$

E_{LPGi} = 0.52 tons $_{VOC}$ per year

Daily Emissions Calculation
Residential LPG Consumption for Baltimore City was found to have a
SAF = seasonal adjustment factor of 0.06283113
POS = peak ozone period of 1
Days of the Period 31 (average days in summer month)
Daily adjusted $E_{LPGida} = (E_{LPGi} / 31)*(SAF / POS)$

E_{LPGida} = (**0.52** / 31)*(0.06283113 / 1) = **1.05E-03 VOC tons/day**

4.1.6.7 Wood Combustion

SCC: 21 04 008 000 (Residential Wood Combustion)

Description

This source category covers air emissions from wood combustion in the residential sectors primarily for space heating and aesthetics. The inventory includes emission estimates for indoor wood-burning equipment (e.g. fireplaces, woodstoves, pellet stoves, furnaces/boilers) and outdoor wood burning equipment (e.g. outdoor fireplaces, fire pits, wood-fired barbecues, chimneys).

Pollutants

NOx, CO, VOC, PM_{10}, $PM_{2.5,}$ NH3, SO2, and HAPs

Method and Data Sources

Maryland's Residential Wood Combustion Emission Inventory was calculated using a new EPA emissions estimation tool called the, RWC TOOL. A detailed explanation of how activity data and emission factors were developed in order to predict emissions for several states can be downloaded along with the RWC TOOL at EPA's FTP site. A collection of surveyed, census, housing tract, equipment use, and wood burned data was used in the tool along with EPA's estimation methodologies and statistics to create an emissions profile for Maryland that can be used repeatedly with a few periodic updates.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Emissions Calculation

MDE ran EPA's RWC TOOL and accepted the emissions generated by the tool as the best estimates of Maryland's residential wood combustion at the present time.

4.1.6.8 Commercial Cooking

SCC: 2302002100 (Conveyorized Charbroiling)
2302002200 (Under-fired Charbroiling)
2302003000 (Deep Fat Frying)
2302003100 (Flat Griddle Frying)
2302003200 (Clamshell Griddle Frying)

Description

This source category covers air emissions from commercial cooking in the Maryland area(s). These emissions (i.e. emissions from commercial cooking of meats) represent the "greatest sources of commercial cooking emissions. In particular, emissions of particulate matter (PM) and volatile organic compounds (VOCs) are the most significant. Of the cooking processes that have been identified, charbroiling is the most important air pollutant emissions contributor" [61]. It follows that this category includes the following meat sources: hamburger, steak, fish, pork, and chicken. And the five equipment types: chain-driven (conveyorized) charbroilers, under-fired charbroilers, deep fat fryers, griddles, and clam shell griddles.

Pollutants

PM, PM_{10}, $PM_{2.5}$, CO, VOC, HAPs

Method and Data Sources

The recommended methods for calculating emissions and emission factors to commercial cooking possessing sources was obtain from Pechan Technical Memorandum (December 2003) and EIIP Web site Volume III, Area Sources document series methods and web link: http://www.epa.gov/ttnchie1/eiip/techreport/volume03/charbroilingtechmemo_122303.pdf. http://www.epa.gov/ttnchie1/conference/ei13/pointarea/roe.pdf.

Activity

Total number of restaurants was collected from County Business Patterns 2016 - Maryland, NAICS: 722511, Full-Service Restaurants and 722513, Limited Service Restaurants. Year 2011 restaurants statistics for Maryland's counties were collected from the U.S. Census Bureau Internet Website address (http://www.census.gov/epcd/cbp/view/cbpview.html). Table - 4.1.6.8-a shows CBP total number of Maryland County restaurants. MDE staff calculated the percent of county restaurant types (i.e. Ethnic Food, Fast Food, Family Food, and Seafood) reported in the Pechan Technical Memorandum. Table 4.1.6.8-b1 shows the percent of each restaurant type per county calculated from the Pechan Technical Memorandum. This percentage was applied to the total number of restaurants collected from the County Business Patterns to determine the number of each type of restaurant facility in each county[62].

[61] Source: Adapted from PECHAN December 2003 Commercial Cooking Processes Technical Memorandum.
[62] Source: Adapted from County Business Patterns (CBP) and U.S. Census Bureau 2013 reports. Total may not be multiplier and divisional because of rounding.

Table 4.1.6.8-b2 shows the estimated number of restaurant types in each county. Table 4.1.6.8-c gives average number of equipment pieces by restaurant type. Table 4.1.6.8-d shows average pounds of meat cooked on each type of equipment per week (lbs/week). And Table 4.1.6.8-e gives emission factors (lb/ton meat).

Table 4.1.6.8-a 2016 CBPs' Total Number of County Restaurants

County Name	NAICS Code 722511 & 722513
Allegany	115
Anne Arundel	881
Baltimore County	1178
Calvert	111
Caroline	26
Carroll	229
Cecil	114
Charles	189
Dorchester	39
Frederick	357
Garrett	54
Harford	298
Howard	455
Kent	38
Montgomery	1448
Prince George's	1088
Queen Anne's	67
St Mary's	137
Somerset	17
Talbot	92
Washington	215
Wicomico	147
Worcester	257
Baltimore City	1069

Table 4.1.6.8-b1 Percent of Each County Restaurant Type[3]

County Name	Ethnic	Fast Food	Family	Seafood	Steak & Barbeque
Allegany	30.61	46.94	14.29	0.00	8.16
Anne Arundel	27.27	47.73	11.65	9.94	3.41
Baltimore Co.	29.65	48.06	11.66	7.77	2.86
Calvert	23.08	41.03	15.38	15.38	5.13
Caroline	15.38	69.23	7.69	7.69	0.00
Carroll	19.51	59.76	14.63	3.66	2.44
Cecil	23.44	51.56	12.50	7.81	4.69
Charles	27.69	44.62	13.85	9.23	4.62
Dorchester	10.34	44.83	13.79	27.59	3.45
Frederick	26.61	47.58	17.74	6.45	1.61
Garrett	9.09	54.55	31.82	0.00	4.55
Harford	23.66	53.44	8.40	9.92	4.58
Howard	33.76	52.23	7.64	3.82	2.55
Kent	10.00	40.00	30.00	20.00	0.00
Montgomery	45.29	42.81	6.78	2.15	2.98
Prince George's	29.85	51.77	7.31	6.05	5.01
Queen Anne's	7.69	46.15	2.56	38.46	5.13
St Mary's	17.65	41.18	15.69	15.69	9.80
Somerset	0.00	43.75	18.75	37.50	0.00
Talbot	18.92	45.95	10.81	21.62	2.70
Washington	24.69	50.62	14.81	8.64	1.23
Wicomico	27.59	43.10	10.34	15.52	3.45
Worcester	24.17	42.50	10.00	18.33	5.00
Baltimore City	25.70	57.36	7.08	7.64	2.23

Note: Divide decimal numbers in Table 4.1.6.8-b1 by 100 to change % into fraction values.

Table 4.1.6.8-b2 Number of Restaurant Types in Each County

County Name	Ethnic	Fast Food	Family	Seafood	Steak & Barbeque
Allegany	35	54	16	0	9
Anne Arundel	240	420	103	88	30
Baltimore Co.	349	566	137	92	34
Calvert	26	46	17	17	6
Caroline	4	18	2	2	0
Carroll	45	137	34	8	6
Cecil	27	59	14	9	5
Charles	52	84	26	17	9
Dorchester	3	13	4	8	1
Frederick	95	170	63	23	6
Garrett	5	29	17	0	2
Harford	71	159	25	30	14
Howard	154	238	35	17	12
Kent	4	15	11	8	
Montgomery	656	620	98	31	43
Prince George's	325	563	79	66	55
Queen Anne's	5	31	2	26	3
St Mary's	24	56	21	21	13
Somerset	0	7	3	6	0
Talbot	17	42	10	20	2
Washington	53	109	32	19	3
Wicomico	41	63	15	23	5
Worcester	62	109	26	47	13
Baltimore City	275	613	76	82	24

Table 4.1.6.8-c Percent of Restaurants with each type of cooking equipment [1, 2]

Restaurant Category	Chain-Driven Charbroilers (ufc) Rest	Underfired Charbroilers (ufc) Rest.	Deep-Fat Fryers (dff) Rest.	Flat Griddles (fg) Rest.	Clamshell Griddles (cg) Rest.
Ethnic	3.5	47.5	81.9	62.7	4
Fast Food	18.6	30.8	96.8	51.9	14.7
Family	10.1	60.9	91.4	82.9	1.4
Seafood	0	52.6	100	36.8	10.5
Steak & Barbeque	6.9	55.2	82.8	89.7	0

Table 4.1.6.8-d Average Number of Equipment Pieces by Restaurant Type [1, 2]

Restaurant Category	Chain-Driven Charbroilers (ufc) Rest	Underfired Charbroilers (ufc) Rest.	Deep-Fat Fryers (dff) Rest.	Flat Griddles (fg) Rest.	Clamshell Griddles (cg) Rest.
Ethnic	1.62	1.54	1.63	1.88	1.8
Fast Food	1.07	1.58	3.1	1.43	2.09
Family	1.71	1.29	2.34	2.03	0
Seafood	0	1.1	2.47	1.11	1.5
Steak & Barbecue	0	1.63	2.42	1.35	0

Table 4.1.6.8-e Average Pounds of Meat Cooked on Each Type of Equipment Per Week [1, 2] (lbs/week)

Type of Meat	Chain-Driven Charbroilers (ufc) Rest	Underfired Charbroilers (ufc) Rest.	Deep-Fat Fryers (dff) Rest.	Flat Griddles (fg) Rest.	Clamshell Griddles (cg) Rest.
Steak	236	180	181	166	94
Hamburger	798	270	274	362	1314
Poultry, with Skin	147	144	365	88	113
Poultry, Skinless	266	179	208	111	108
Pork	57.6	148	58.6	112	118
Seafood	119	143	159	92.1	632
Other	0	41.5	274	57.5	0

Emission Factors

Table 4.1.6.8-f Emission Factor (lb/ton meat)[1, 2]

Equipment Type (fuel)	SCC	Meat/Food	PM	PM10	PM2.5	CO	NOX	VOC
		Beef	16.2	15	14.2	327	4.8	9.4
		Beef (marinated)	19	18.4	17.4	335.2	7.2	11.6
Under fired-charbroiler (charcoal) (ufc) Rest.	2302002200	Chicken (marinated)	19.6	18.8	18.2	315.8	8.4	9
		Hamburger (25%fat)	65.4	65.4	63.8	27.44	0	7.88
		Steak	34.4	34.4	33.6	9.94	0	1.72
		Chicken (whole)	21.0	21.0	19.8	9.68	0	3.64
Under fired-charbroiler (natural gas) (ufc) Rest.	2302002200	Seafood	6.6	6.6	6.4	0	0	0.76
Conveyorized Charbroiler (natural gas) (cdc) Rest.	2302002100	Hamburger (21%fat)	14.8	14.8	14.6	16.58	0	4.54
		Shoestring potatoes	0	0	0	0	0	0.42
		Breaded chicken	0	0	0	0	0	0.24
Deep fat fryer (natural gas) (dff) Rest.	2302003000	Breaded fish	0	0	0	0	0	0.28
		Hamburger (24% fat)	10	10	7.6	0.76	0	0.14
		Chicken (boneless breast)	0	0	0	0.9	0	0.8
Griddle (electric) (fg) Rest.	2302003100	Seafood	0	0	0	0	0	0.22
		Hamburger (24% fat)	1.7	1.7	1.44	0	0	0.02
		Chicken	0	0	0	0	0	0.114285714
Double-sided (clamshell) Griddle (electric) (cg) Rest.	2302003200	Seafood	0	0	0	0	0	0.031428571

Point Source Adjustments

No point source subtraction of emissions.

Adjustments for Controls

No adjustments for controls in Maryland for this source.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is the number of restaurant per county from CBPs'.

Temporal

Emissions were averaged according to period of operation to a daily estimate. See section 2.2.1.

Emissions Calculation

The following steps were used to calculate commercial cooking emissions for Maryland:

i. Multiply total restaurants in a county (i.e. from CBPs' data source) by percent (%) type of restaurant (i.e. from Pechan document) Table 4.1.6.8-a, and Table 4.1.6.8-b1.

ii. Multiply county-level facility counts by the fraction (i.e. percent) of restaurants with each type of cooking equipment (Table 4.1.6.8-c).

iii. Multiply number of restaurants with each type of cooking equipment by number of pieces of equipment (Table 4.1.6.8-d).

iv. Sum number of pieces of cooking equipment across restaurant types.

v. Multiply total summed number of pieces of cooking equipment per restaurant types by average pounds of meat cooked on each type of equipment per week (Table 4.1.6.8-e).

vi. Finally, multiply results from v by emission factor (lb/ton meat) (Table 4.1.6.8-f) and divided emission values by 2000 by 365 for daily lbs/ton unit.

$$B_{poe}$$

$$E_{CC} = (N*(Frac_n/100))* D_{tn} * Sum_{all} * Meat_{type} * EF_{meat\ type}/2000$$

Where:

E_{CC} = Commercial Cooking Emissions in pound (lbs) per tons (i.e. Activity data times $EF_{meat\ type)}$ for county per restaurant food type and equipment type SCC.
N = Total number of food restaurants in county
$Frac_n$ = Fraction of restaurant type for that type of cooking equipment.
B_{poe} = Number of food restaurants for SCC with restaurants type of equipment.
Dtn = Total number of restaurants type of equipment at food restaurant.
$Sum_{all,}$ = Total number of summed of pieces of cooking equipment across restaurant type.
$Meat_{type}$ = Total pounds per week of meat type cooked on restaurants equipment in county.
$EF_{meat\ type}$ = Meat type emission factor (lb/ton meat).

Example 2017 Commercial Cooking Emission Calculation for Baltimore County, Fast Food Restaurant Type, SCC 2302002100, Chain-Driven Charbroiler (Conveyorzed). **Note:** Emissions are calculated for only a particular county, restaurant, food equipment, and food type. In order to determine emission for a particular county, all emission for meat types must be summed at the equipment level and multiply by the appropriate meat type emission factor.

Step i.

$E^{3}_{BC,cdc,FFood} = (N*(Frac_n/100)) = 1178 * (48.06/100) = 566$

Total number of businesses in Baltimore County times % of FF restaurant by CBP
Number of fast food (FF) restaurants in Baltimore County is 566

Step ii.

$E^{3}_{BC,cdc,FFood} = 566*(18.6/100) = 105.3$

The number of FF restaurants times % of restaurants with cdc equipment
The number of cdc restaurants in Baltimore County is 105.3

Step iii.

$E^{3}_{BC,cdc,Fast\ food} = 105.3 * 1.07 = 112.7$

The number of cdc restaurants times average cdc pieces of equipment for that restaurant type

Step iv.

$Sum_{all,} E^{3}_{BC,cdc,Fast\ food} = 112.7$

Total pieces of cdc equipment for fast food restaurants in Baltimore County.

Step v.

Do steps 1 thru 4 again for the following restaurants: Ethnic, Family, Seafood, and Steak and Barbecue. The total pieces of cdc equipment for each restaurant type are:

Ethnic	**19.8**
Fast Food	**112.6**
Family	**23.7**
Seafood	**0.0**
Steak & Barbecue	**0.0**

Sum_{all} = 156 Total number of summed of pieces of cdc equipment across restaurants
Average amount of meats cooked on cdc equipment each week
Steak 236 lbs
Hamburger 798 lbs
Poultry, with skin 147 lbs
Poultry, skinless 266 lbs
Pork 57.6 lbs
Seafood 119 lbs

Calculating VOC for Chain-Driven Charbroilers (cdc) restaurant in Baltimore County
Step vi.

$Meat_{steack}$ = 156 x 236 = 36,838 lbs
$Meat_{Hamburger}$ = 156 x 798 = 124,564 lbs
$Meat_{Poultryskin}$ = 156 x 147 = 22,946 lbs
$Meat_{Poultryskinless}$ = 156 x 266 = 41,521 lbs
$Meat_{Pork}$ = 156 x 57.6 = 8,991 lbs
$Meat_{Seafood}$ = 156 x 119 = 18,575 lbs

$E_{CCSteackCDC}$ = (36,838 x 1.72) / 2000 / 39 = 0.81 tons VOC

$E_{CCHamburgerCDC}$ = (124,564 x 4.54) / 2000 / 39 = 7.25 tons VOC

$E_{CCPoultryskin}$ = (22,946 x 3.64) / 2000 / 39 = 1.07 tons VOC

$E_{CCPoultryskinlessCDC}$ = (41,521 x 3.64) / 2000 / 39 = 1.94 tons VOC

$E_{CCPorkCDC}$ = (8,991 x 3.64) / 2000 / 39 = 0.42 tons VOC

$E_{CCSeafoodCDC}$ = (18,575 x 0.76) / 2000 / 39 = 0.18 tons VOC

Total Baltimore County Ecc for CDC Conveyorzed (sum all emissions)

$E_{CCBaltoCOCDC}$ = 11.67 tons VOC per year

Daily Emissions Calculation
Chain-Driven Charbroilers for Baltimore County was found to have a
SAF = seasonal adjustment factor of 0.3333333
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted **$E_{CCBaltoCOCDCda}$** = (**$E_{CCBaltoCOCDC}$** / 365)*(SAF / POS)

$E_{CCBaltoCOCDCda}$ = (**11.67** / 365)*(0.3333333 / 0.25) = **4.26E-02** VOC **tons/day**

4.1.7 FUGITIVE SOURCES

Other area sources include forest fires, slash and prescribed burning, agricultural burning, structure fires, orchard heaters, leaking underground storage tanks and natural organic sources. Although often intermittent in nature, many of these sources can produce large quantities of air pollutant emissions.

4.1.7.1 Residential Construction Activity

SCC: 23 11 010 000

Description

This source category covers fugitive dust emissions from residential construction activities.

Pollutants

PM_{10}, $PM_{2.5,}$ and HAPs

Method and Data Sources

Activity

For residential construction, housing permit data for single-family units, two-family units, and apartments were obtained at the county level from the U.S. Department of Commerce's (DOC) Bureau of the Census.

Estimated the number of buildings in each category, and then estimated the total acres disturbed by construction by applying conversion factors to the housing start data for each category as follows:

- Single-family ¼ acre/building
- Two-family ⅓ acre/building
- Apartment ½ acre/building

Housing construction PM10 emissions are calculated using an emission factor of 0.032 tons PM10/acre/month, the number of housing units created a units-to-acres conversion factor, and the duration of construction activity. The duration of construction activity for houses is assumed to be 6 months.

Apartment construction emissions are calculated separately using an emission factor of 0.11 tons PM10/acre/month; with a 12 months period assumed for apartment construction.

For areas in which basements are constructed to estimate the cubic yards of dirt moved per house, an average value of 2000 square feet is assumed for both single family and two-family homes. Multiplying the average total square feet by an average basement depth of 8 feet and adding in 10 percent of the cubic feet calculated for peripheral dirt removed produces an estimate of the cubic yards of earth moved during residential construction. The percentage of one-family houses with basements was obtained from the DOC. The percentage of houses per Census region (Northeast, Midwest, South, and West) that contain full or partial basements is applied to the housing start estimates for each of these respective regions. The best available control measures (BACM) Level 2 equation (emission factor of 0.011 tons PM10/acre/month plus 0.059 tons PM10/1000 cubic yards of on-site cut/fill) is applied once the number of acres disturbed due to the estimated number of houses built with basements is determined.

Table 4.1.7.1-a *Emission Factors*

	Single-family Construction ton PM_{10}/acre/month	**Two-family Construction** ton PM_{10}/acre/month	**Multi-family Construction** ton PM_{10}/acre/month
PM_{10} Emission Factor	0.032	0.032	0.11
Duration of Activity	6 months	6 months	12 months

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial
Data for spatial allocation is not available for this source.

Temporal
SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

$$E_{RC\ I} = E_{RC-SFH} + E_{RC-2FAM} + E_{RC-MF}$$

Where:

$E_{RC\ i}$ = Emissions of pollutant i in tons per year from residential construction activity

E_{RC-SFH} = Emissions of pollutant i in tons per year from residential single-family home construction activity

$E_{RC-2FAM}$ = Emissions of pollutant i in tons per year from residential two-family home construction activity

E_{RC-MF} = Emissions of pollutant i in tons per year from residential multi-family construction activity

and:

$$E_{RC-SFH} = E_{RC-SFH,\ w\ BM} + E_{RC-SFH,\ w/o\ BM}$$

Where:

$E_{RC-SFH,\ w\ BM}$ = Emissions of pollutant i in tons per year from residential single-family home construction activity of homes with basements

$E_{RC-SFH,\ w/o\ BM}$ = Emissions of pollutant i in tons per year from residential single-family home construction activity of homes without basements

$$E_{RC-SFH,\ w/o\ BM} = \frac{HS_{SFH} \times (1 - HS_{SFH,w\ BM}) \times (AD_{RC-SFH}) \times (PD_{RC-SFH}) \times EF_{RC-SFH}}{2000}$$

Where:

$E_{RC-SFH,\ w/o\ BM}$ = Emissions of pollutant i in tons per year from residential single-family home construction activity

HS_{SFH} = Residential single-family housing starts

$HS_{SFH,\ w\ BM}$ = Percent of residential single-family housing starts with basements

AD_{RC-SFH} = Acres disturbed per housing type (residential single-family)

PD_{RC-SFH} = Average project duration in months

$EF_{RC-SFH\ i}$ = Emissions factor in tons PM10/acre/month for pollutant i

$E_{RC-SFH,\ w\ BM}$ = Emissions from residential construction + Emissions from basement excavation

$$E_{RC-SFH,\ w\ BM} = \frac{[HS_{SFH} \times HS_{SFH,w\ BM} \times (AD_{RC-SFH}) \times (PD_{RC-SFH}) \times EF_{RC-SFH}] + [HS_{SFH} \times HS_{SFH,w\ BM} \times AHS_{RC-SFH} \times ABD_{RC-SFH} \times PDE_{RC-SFH} \times EF_{Acres\text{-}Disturb}]}{2000}$$

where:

$E_{RC – SFH, w BM}$ = Emissions of pollutant i in tons per year from residential single-family home construction activity

HS_{SFH} = Residential single-family housing starts

$HS_{SFH, w BM}$ = Percent of residential single-family housing starts with basements

$AD_{RC - SFH}$ = Acres disturbed per housing type (residential single-family)

$PD_{RC - SFH}$ = Average project duration in months

$EF_{RC – SFH i}$ = Emissions factor in tons PM10/acre/month for pollutant i

$AHS_{RC - SFH}$ = Average residential single-family house size (national default = 2000 ft^2)

$ABD_{RC - SFH}$ = Average basement depth for residential single-family homes (national default = 8 ft)

$PDE_{RC – SFH}$ = Peripheral dirt excavated for residential single-family homes (national default = 10 percent)

$EF_{Acres-Disturb}$ = Emissions factor for the acres disturbed during basement excavation activities during residential single-family home construction in tons PM_{10}/1000 cubic yards

4.1.7.2 Heavy Construction Activity

SCC: 23 11 020 000

Description

Emissions produced from the construction of nonresidential buildings are estimated using the value of construction put in place. The national value of construction put in place is obtained from the Bureau of the Census[63]. The national value of construction put in place is allocated to the state level using non-residential building construction employment data within NAIC Code 2362 obtained from 2010 County Business Patterns[64]. The state value of construction put in place is allocated to the county level using non-residential building construction employment data within NAIC Code 2362 obtained from the 2010 County Business Patterns for the State of Maryland.

Pollutants

PM_{10} and $PM_{2.5}$

Method and Data Sources

Activity

ARA used data from the U.S. Census Bureau on the national value of construction put in place- Not Seasonally Adjusted. The national value of construction put in place is allocated to the state level and then to the county level using non-residential building construction employment data within NAIC 2362 obtained from 2016 County Business Patterns.

A conversion factor of 2.2902276 acres/10^6 dollars ($) is applied to the construction valuation data. This conversion factor is developed by adjusting the1999 value of 2 acres/$$10^6$ to 1999 - 2017 constant dollars using The Bureau of Labor Statistics *Producer Price Index*[65] for Construction. The duration of construction activity for nonresidential construction is estimated to be 11 months.

Employee numbers were taken from County Business Patterns 2016 - Maryland, NAIC 2362, Non-residential Building Construction (see Appendices). Some county employment data is represented by a letter code indicating a range for the number of employees for that NAIC. In this case the arithmetic average number of employees per letter code per county was adjusted so that the state total employment in a NAIC matched the sum of the number of employees reported per county.

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[63] Bureau of Census, Annual Value of Construction Put in Place - Not Seasonally Adjusted in the United States: 2016

[64] U.S. Census Bureau, County Business Patterns, NAIC Code 2362, Industry Nonresidential Building Construction 2016

[65] U.S. Census Bureau, County Business Patterns, 2016

Table 4.1.7.2-a *Emission Factors*

	PM_{10} (tons/acre/month)	$PM_{2.5}$ (tons/acre/month)
Emissions	0.11	20% of PM_{10}
Duration of Project	11 months	

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial
Data for spatial allocation is not available for this source.

Temporal
SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

Value of Construction Work in the U.S. - HC_J $**347,666,000,000**
Number of Employees within NAIC 2362 in the U.S. – EMPus 562,270
Number of Employees within NAIC 2362 in Maryland 12967

where:
$E_{HC,i}$ = Emissions of pollutant i in tons per year from heavy construction
HC_J = Value of Heavy construction in US j in 2014
EMPus = Employment NAICS 2362 US in 2013
EMPj = Employment NAICS 2362 County j in 2013
CF_{HC} = Conversion factor (acres/million dollars) for heavy construction (2.29)
$AEF_{HC\ i}$ = Adjusted Emissions factor in tons per acre per month for pollutant i
DC_{HC} = Duration of construction activity (11 months)

2014 Sample Calculation Heavy Construction (Baltimore City)

Number of Employees within NAIC 2362 in Baltimore City	470

PE = precipitation-evaporation value for each State,
S = % dry silt content in soil for area being inventoried

$AEF_{HC\ PM10}$ = Initial $EF_{HC\ I}$ x (24/PE) x (S/9%)

$AEF_{HC\ PM10}$ = 0.19(PM $_{10)}$ x (24/114.1) x (52/9%)

$AEF_{HC\ PM10}$ = 0.2309

$E_{HC\ PM10}$ = HC_j **x** (EMPj / EMPus) x CF_{HC} **x** $EF_{HC\ i}$ **x** DC_{HC}

$E_{HC\ PM10}$ = **347,666 x** (470 / 562,270) x 2.2902276 **x** 0.2309 **x** 11

$E_{HC\ PM10}$ = 1690.54 tons/year PM $_{10}$

Daily Emissions Calculation
Heavy Construction for Baltimore City was found to have a
SAF = seasonal adjustment factor of 0.260459225
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted $E_{HC\ PM10da}$ = ($E_{HC\ PM10}$ / 365)*(SAF / POS)

$E_{HC\ PM10da}$ = (**1690.54** / 365)*(0.260459225 / 0.25) = **4.83E+00 PM $_{10}$ tons/day**

4.1.7.3 Road Construction Activity

SCC: 23 11 030 000

Description

This source category covers fugitive dust emissions from road construction activity. PM_{10} emissions produced by road construction are estimated using an emission factor for heavy construction and the State capital outlay for new road construction.

Pollutants

PM_{10} and PM_{25}

Method and Data Sources

Activity

To estimate the acres disturbed by road construction, the Federal Highway Administration (FHWA) has *Highway Statistics, Section IV - Highway Finance, Table SF-12A, State Highway Agency Capital Outlay*[1] for 2016 which outlines spending by state in several different categories. For this SCC, the following columns are used: New Construction, Relocation, Added Capacity, Major Widening, and Minor Widening. These columns are also differentiated according to the following six classifications:

- Interstate, urban
- Interstate, rural
- Other arterial, urban
- Other arterial, rural
- Collectors, urban
- Collectors, rural

Dollar expenditures are converted to miles constructed using data obtained from the North Carolina Department of Transportation (NCDOT) in 2000. A conversion of $4 million/mile is applied to the interstate expenditures. For expenditures on other arterial and collectors, a conversion factor of $1.9 million/mile is applied, which corresponds to all other projects.

.

Miles are converted to acres for each of the 6 road type areas using the following estimate of acres disturbed per mile:

- Interstates: Urban, Rural, and Urban Other Arterial - 15.2 Acres Disturbed/mile
- Rural, Other Arterials - 12.7 Acres Disturbed/mile
- Urban, Collectors - 9.8 Acres Disturbed/mile
- Rural, Collectors - 7.9 Acres Disturbed/mile

Emission Factors

A PM_{10} emission factor of 0.42 tons/acre/month is used to account for the large amount of dirt moved during the construction of roadways. The duration of construction activity for road construction is estimated to be 12 months.

PM_{25} emissions are estimated by applying a particle size multiplier of 0.10 to PM_{10} emissions.

Soil Moisture Level

To account for the soil moisture level, base emissions were multiplied by 24 divided by the precipitation-evaporation (PE) value. Precipitation-Evaporation (PE) values were obtained from Thornthwaite's PE Index. Average PE values for each State were estimated based on PE values for specific climatic divisions within a State.

Silt Content

To account for the silt content, base emissions were multiplied by percent dry silt content in soil divided by 9 percent. A data base containing county-level dry silt values were applied to PM_{10} emissions for each county. These values were derived by applying a correction factor developed by the California Air Resources Board to convert wet silt values to dry silt values.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

For construction emissions, a control efficiency of 50 percent is used for both PM_{10} and $PM_{2.5}$ for PM nonattainment areas. It is assumed that water techniques used statewide, reduce emissions by 50%.

Spatial and Temporal Allocations

Spatial

State-level estimates of acres disturbed are distributed to counties according to the housing starts per county, estimated for the residential construction category.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

$$E_{RC,i} = \frac{Exp \times MC_i \times ADi \times EF_{RC\,i} \times DUR}{2000}$$

where:

$E_{RC,i}$	=	Emissions of pollutant i in tons per year from road construction
$Exp_{RC,i}$	=	Expenditures per road type i
$MC_{RC,i}$	=	Miles constructed per road type i
AD_i	=	Acres disturbed per road type i
$EF_{RC\,i}$	=	Emissions factor (tons per acre per month for pollutant i)
DUR	=	Duration of project (months)

This calculation would have to be made for each road classification in a county and then summed to get total for that pollutant for that county.

4.1.7.4 Agricultural Land Preparation

SCC: 28 01 000 003

Description

The land preparation source category includes estimates of the airborne soil particulate emissions produced during the preparation of agricultural lands for planting and after harvest activities. Operations included in this methodology are dicing, tilling, leveling, chiseling, plowing, and other mechanical operations used to prepare the soil. Dust emissions are produced by the mechanical disturbance of the soil by the implement used and the tractor pulling it. Soil preparation activities tend to be performed in the early spring and fall months.

Particulate emissions from land preparation operations are computed by multiplying an emission factor (EF) by an activity factor. The agricultural tilling emission factor provided in the 4th edition of U.S. EPA's AP-42 document is used to estimate soil preparation emissions. The activity factor is based on the number of acres of each crop in production for each county in the State. Because different crops need different operations to prepare the soil, each crop also has its own acre-pass value. Acre-passes are the number of passes, per acre, that are typically needed to prepare a field for planting a particular crop. By combining the crop acreage, crop specific acre-pass data, and the agricultural tilling emission factor, we estimate the particulate matter produced by agricultural land preparation operations.

Agricultural soil preparation particulate dust emissions are estimated *for each crop* in each county in Maryland using the following equation:

$\text{Emissions}_{\text{CROP}} = \text{Emission Factor} \times \text{Acres}_{\text{CROP}} \times \text{Acre-passes/acre}_{\text{CROP}}$

The crop emissions for each county are summed to produce the county and statewide particulate matter (PM) and PM emission estimates.

Pollutants

PM_{10} and $PM_{2.5}$

Method and Data Sources

Activity

The acreages used for estimating soil preparation emissions were collected from the United States Department of Agriculture and the National Agricultural Statistics Service. A summary of crop acreage harvested in 2017 from individual county agricultural commissioner reports was used to calculate emissions. In computing land preparation PM emissions, acre-passes are the number of passes typically performed to prepare a crop for planting. These operations may occur following harvesting or closer to planting, and can include dicing, tilling, land leveling, and other operations. Each crop is different in the type of soil operations performed and when they occur. MDE used acre-pass estimates compiled by the California Air Resources Board (CARB). For the crops that were not explicitly updated, we either applied an updated crop profile from a similar crop, or used one of the existing CARB profiles.

Emission Factors

The emission factor used to estimate the dust emissions from agricultural land preparations is from U.S. EPA's AP-42[66]. This emission factor was developed in 1981 based on test data measured in California and Kansas by Midwest Research Institute. Because of a lack of more detailed estimates, this single emission factor is used for all land preparation operations, all locations, and all seasons. The form of the emission factor is:

Emission Factor (lbs PM/acre-pass) = k (4.8) $(s)^{0.6}$

Where:

k = particle size fraction of interest (EPA default = 0.042 for $PM_{2.5}$ or 0.21 for PM_{10})
s = average percent soil silt content (EPA default = 18%)

For PM the value of 'k' used in California is 0.148. This is based on the EPA estimate that 33% of the total particulate entrained to the air during agricultural operations is 30 microns or less. Of this, analysis of California soil samples indicates that about 45% of the 30 micron or less sized particles are 10 microns or less in aerodynamic size (i.e., PM). So, the California PM particle size multiplier is 0.148 (i.e., 0.33 x 0.45 = 0.148). Maryland decided to use the EPA default values listed above for the particle size fraction. For the percent soil silt value, the EPA default value of 18% soil silt is used for most counties.

	$PM_{2.5}$ (Lbs. $PM_{2.5}$ /acre-pass)	PM_{10} (Lbs. PM_{10} /acre-pass)
Emission Factor	1.141968254	5.709841268

The EPA emission factor does not include an association between soil moisture and emissions. Because it is known that dust emissions are reduced when soil moisture is higher, California ARB staff has incorporated an emission correction during the wettest months of the year. The correction was based on some limited agricultural dust source test data, as well as the control factor used for watering at construction sites and their best judgment. During December and March, California ARB reduced the emission factor by 25% from the standard uncorrected value. In January and February, often the wettest months, the emission factor is reduced by 50%. This produces a seasonal emissions profile that is more consistent with California's actual ambient air dust levels, and also better reflects that soil preparation operations typically do not occur while the soil is excessively wet or muddy.

[66] U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, AP-42, Section 11.2.2, Fourth Edition September 1985.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial
Crop acreages are collected on a county basis.

Temporal
Data for temporal allocation is not available for this source in Maryland.

In collecting updated acre-pass data, California also collected detailed information on when agricultural operations occur. Using these data, it was possible to create detailed temporal profiles that help to indicate when PM emissions from land preparations may be highest. The more detailed background document includes detailed crop calendars for each crop with updated information. For all of the acre-pass and crop calendar information, the farmers and other agricultural experts of the San Joaquin Valley were instrumental in helping us to update our crop information.

Emissions Calculation

$$E_{ALP\ i} = \frac{EF_{ALP\ i} \times A_I \times AP_I}{2000}$$

where:

E_{ALP}	=	Annual PM emissions of pollutant i in tons per day from agricultural land preparations.
$EF_{ALP\ i}$	=	Emissions factor in pounds per acre-pass for pollutant i
A_i	=	Acres of crop I harvested in county j in 2014
AP_i	=	Acre-passes per acres for crop i

2014 Sample Calculation Agricultural Land Preparation (Baltimore County)

$$E_{ALP\ PM2.5} = \frac{EF_{ALP\ PM2.5}\ \mathbf{x}\ [(A_{wheat}\ \mathbf{x}\ AP_{wheat}) + (A_{corn\text{-}gr}\ \mathbf{x}\ AP_{corn\text{-}gr}) + (A_{hay}\ \mathbf{x}\ AP_{hay}) + (A_{soy}\ \mathbf{x}\ AP_{soy}) + (A_{barley}\ \mathbf{x}\ AP_{barley})}{2000}$$

$E_{ALP\ PM2.5}$ = (1.141968254 x [(0 x 1) + (17,700 x 4) + (0 x 1) + (14,400 x 6) + (0 x 1)) / 2000

$E_{ALPPM2.5}$ = (1.141968254 x 157,200)/2000

$E_{ALPPM2.5}$ = 89.76 tons per year of $PM_{2.5}$

Daily Emissions Calculation
Agricultural Land Preparation for Baltimore County was found to have a
SAF = seasonal adjustment factor of 0.25
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted $E_{ALPPM2.5da}$ = ($E_{ALPPM2.5}$ / 365)*(SAF / POS)

$E_{ALPPM2.5da}$ = (**89.76** / 365)*(0.25 / 0.25) = **2.46E-01 $PM_{2.5}$ tons/day**

4.1.7.5 Paved Roads

SCC: 22 94 000 000

Description

This source category covers fugitive dust emissions from activity on paved roads.
ONLY A GENERAL OUTLINE OF HOW THIS SOURCE WAS CALCULATED WILL BE GIVEN DUE TO THE LARGE NUMBER OF CALCULATIONS NEEDED TO SHOW A SAMPLE CALCULATION FOR ANY ONE COUNTY.

Pollutants

PM_{10} and $PM_{2.5}$

Method and Data Sources

Activity

The basis for the activity data for fugitive dust emissions from paved roads is the state-level vehicle miles traveled per paved road type and the state-level vehicle miles traveled per unpaved road per road type.

Emission Factors

To calculate emissions for Paved Roads we used The Predictive Emission Factor Equation 13.2.1.3 from AP-42, Fifth Edition Vol. I Chapter 13: Miscellaneous Sources and the particle size multipliers, k from Table 13.2.1-1. Several factors used for Paved Road emissions calculations came from 2008 Emission Inventory Data & Documentation http://www.epa.gov/ttn/chief/net/2008inventory.html) Nonpoint section for Paved Roads. Such as, Silt Loading factors for Maryland from Table 2, factors below:

Roadway Class	*sL* (g/m^2)
Rural Interstate	0.015
Rural Other Principal Arterial	0.03
Rural Minor Arterial	0.06
Rural Major Collector	0.2
Rural Minor Collector	0.2
Rural Local	0.6
Urban Interstate	0.015
Urban Other Freeways and Expressways	0.015
Urban Other Principal Arterial	0.03
Urban Minor Arterial	0.03
Urban Collector	0.06
Urban Local	0.2

EF_N = $[(k) \times (sL)^{0.91} \times (W)^{1.0\,2}] \times (1\text{-}P/4N)$
EF_N = A calculated emission factor for a given road type in a month having *N* days

k = particle size multiplier; particle size range and units used were 0.015 (lb/VMT) for PM10, and 0.0037 (lb/VMT) for PM2.5 from EPA AP-42 Table 13.2.1-1. PARTICLE SIZE MULTIPLIERS FOR PAVED ROAD EQUATION

sL = road surface silt loading (grams per square meter) (g/m^2),

W = average weight (tons) of the vehicles traveling the road (Maryland estimates the average wt. to be 6,360 pounds or 3.18 tons)

P = Number of days in a month with greater than or equal to 0.1 inch of precipitation, BUT > 0.01 inches

N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly).

A temporal VMT fraction factor was supplied by which was used to breakdown yearly VMT into seasonal and then monthly VMT (millions of miles by road type).

Table 4.1.7.5-a

Look-Up	RUR_URB	SEASON	VMTFRAC
RURALWINTER	RURAL	WINTER	0.2199
RURALSPRING	RURAL	SPRING	0.2403
RURALSUMMER	RURAL	SUMMER	0.2845
RURALFALL	RURAL	FALL	0.2553
URBANWINTER	URBAN	WINTER	0.236
URBANSPRING	URBAN	SPRING	0.2547
URBANSUMMER	URBAN	SUMMER	0.264
URBANFALL	URBAN	FALL	0.2453

A Transport factor (***TF***) also of 1, was used in estimation.
Allegany County Rural Interstate emissions example calculation:
EF_N = $[(k) \times (sL)^{0.91} \times (W)^{1.02}] \times (1\text{-}P/4N)$
EF_N = $[(0.0022) \times (0.015)^{0.91} \times (6360/2000)^{1.02}] \times (1\text{-}5/4(31))]$
EF_N = 0.000150407 lb/mile

Table 4.1.7.5-b **2014 Annual Rural Traffic VMT (millions of miles)**

FUNCTIONAL CLASS	Inter-State	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Local	TOTAL RURAL
ALLEGANY	167	18	25	17	15	49	**291**
ANNE ARUNDEL	104	27	145	36	26	67	**405**
BALTIMORE	288	29	76	178	35	123	**729**
CALVERT	0	23	0	24	26	10	**83**
CAROLINE	0	117	110	72	38	64	**401**
CARROLL	0	41	188	91	58	69	**447**
CECIL	218	34	109	38	40	86	**525**
CHARLES	0	114	70	72	55	55	**366**
DORCHESTER	0	92	77	31	29	43	**272**
FREDERICK	248	206	90	162	84	152	**942**
GARRETT	175	68	65	71	45	81	**505**
HARFORD	67	71	133	89	54	77	**491**
HOWARD	275	67	74	69	31	104	**620**
KENT	0	32	45	51	26	28	**182**
MONTGOMERY	74	0	72	80	30	48	**304**
PRINCE GEORGE'S	0	32	27	63	35	26	**183**
QUEEN ANNE'S	0	309	75	76	46	99	**605**
ST. MARY'S	0	174	167	86	68	92	**587**
SOMERSET	0	88	35	25	23	32	**203**
TALBOT	0	206	95	33	26	72	**432**
WASHINGTON	505	23	91	82	51	151	**903**
WICOMICO	0	146	11	47	39	44	**287**
WORCESTER	0	220	31	59	26	67	**403**
BALTIMORE CITY	0	0	0	0	0	0	**0**
GRAND TOTALS	**2121**	**2137**	**1811**	**1552**	**906**	**1639**	**10166**

Table 4.1.7.5-c **2014 Annual Urban Traffic VMT (millions of miles)**

FUNCTIONAL CLASS	Inter-state	Freeways & Express-ways	Other Principal Arterial	Minor Arterial	Collector	Local	TOTAL URBAN
ALLEGANY	158	0	176	92	37	33	**496**
ANNE ARUNDEL	1186	1618	969	792	483	358	**5406**
BALTIMORE	3612	465	1148	1260	582	502	**7569**
CALVERT	0	32	440	52	94	44	**662**
CAROLINE	0	0	0	0	0	0	**0**
CARROLL	37	0	467	136	126	54	**820**
CECIL	329	13	184	143	62	52	**783**
CHARLES	0	0	534	176	118	59	**887**
DORCHESTER	0	0	62	11	12	6	**91**
FREDERICK	802	319	301	211	288	136	**2057**
GARRETT	0	0	1	0	0	0	**1**
HARFORD	704	136	441	310	222	129	**1942**
HOWARD	1074	1065	247	448	316	224	**3374**
KENT	0	0	12	10	5	2	**29**
MONTGOMERY	2475	434	2085	1057	561	469	**7081**
PRINCE GEORGE'S	2994	1534	1826	996	713	572	**8635**
QUEEN ANNE'S	0	47	240	3	22	22	**334**
ST. MARY'S	0	9	180	52	45	20	**306**
SOMERSET	0	45	10	7	5	5	**72**
TALBOT	0	0	150	11	15	12	**188**
WASHINGTON	504	0	200	204	109	72	**1089**
WICOMICO	0	188	215	127	106	45	**681**
WORCESTER	0	26	209	42	38	22	**337**
BALTIMORE CITY	1061	136	1128	629	215	225	**3394**
GRAND TOTALS	**14936**	**6067**	**11225**	**6769**	**4174**	**3063**	**46234**

VMT should be converted into monthly totals by county by road type using seasonal fraction factors.

Ert = $\boldsymbol{EF}_N$ x *VMT* x ***TF***

Where:

Ert = is the emissions for a particular road type

VMT = the vehicle miles traveled in millions of miles on a particular road type

TF=1

$E_{PM10Allegany}$ = $\boldsymbol{EF}_N$ x (*VMT* x *VMTFRACwinter)* x ***TF***

$E_{PM10Allegany}$ = 0.000150407 x (167 x 0.2199*)* x ***1***

$E_{PM10Allegany}$ = 0.9408 tons per winter of PM_{10} Inter-State Rural traffic emissions

The previous calculations must now be repeated for each of 12 months using seasonal *VMTFRAC* for 13 different road types in Allegany and then summed to obtain the total emission for the county. The same process must be repeated for all counties to get a state total.

Daily Emissions Calculation

Paved Road for each Maryland County was found to have a

SAF = seasonal adjustment factor of 0.28

POS = peak ozone period of 0.25
Days of the Period 365

Daily adjusted $\mathbf{E}_{\mathbf{\mathit{PM10-PRIannual\ ad}}}$ = ($E_{PM10-PRIannual}$ / 365)*(SAF / POS)
You can total emissions for a given county and apply the daily parameters in the adjusted emissions equation above to obtain its daily emissions. The same method is used to calculate $PM_{2.5}$.

4.1.7.6 Unpaved Roads

SCC: 22 96 000 000

Description

This source category covers fugitive dust emissions +from activity on unpaved roads.

Pollutants

PM_{10}-PRI, PM_{10}-FIL, PM_{25}-PRI, PM_{25}-FIL

Method and Data Sources

Activity

Same method used in 2011 was used in 2014 and 2017 to calculate unpaved road emissions. The following examples were used in 2011. The basis for the activity data for fugitive dust emissions from unpaved roads is the county-level miles of unpaved roads. The unpaved road mileage is converted to county-level vehicle miles traveled per unpaved road type by the following equation:

$$VMT_{UNPAVED\,(x,\,i)} = \frac{ADTV_{(i)} * MILES_{UNPAVED\,(x,\,i)} * DAYS_{YR}}{1{,}000{,}000}$$

Where:

$VMT_{UNPAVED\,(x,\,i)}$:	Annual vehicle miles traveled for county x and road type i (in millions)
$ADTV_{(i)}$:	Average Daily Traffic Volume for road type i
$MILES_{UNPAVED\,(x,\,i)}$:	Miles of unpaved roads in county x and road type i
$DAYS_{YR}$:	Days per year (365) conversion of daily traffic to annual traffic

Maryland received unpaved road mileage by county from the Maryland State Highway Administration. The unpaved road mileage data was divided into two functional classes, (Rural Local and Urban Local). The Rural Local and Urban Local roads were further divided into Rural Unpaved and Urban Unpaved roads. The VMT for Unpaved and Unimproved urban and local roads was calculated and then summed by county.

Mileage on urban and rural local roads was broken down into two groups of average daily travel volume (ADTV) in the 1996 Highway Statistics publication (the last year that data was published). These groups are shown in Table 4.1.7.6-a. Maryland used a reasonable assumption that no more than 50 vehicles travel its urban and rural local unpaved roads daily. The assumed ADTV is 5 for both urban and rural groups (<50 Rural Local volume group).

Table 4.1.7.6-a Assumed Values for Average Daily Traffic Volume by Volume Group

Rural Roads				
Volume Category (vehicles per day per mile)	< 50	50-199	200-499	> 500
Assumed ADTV	5*	125**	350**	550***
Urban Roads				
Volume Category (vehicles per day per mile)	< 200	200-499	500-1999	> 2000
Assumed ADTV	20*	350**	1250**	2200***

Notes: *10% or volume group's maximum range endpoint, ** Average of volume group's range endpoints, *** 110% or volume group's minimum

Table 4.1.7.6-b Daily VMT by County and Road Class

County Name	2011 Daily VMT Rural rt210	2011 Daily VMT Urban rt330
ALLEGANY	0.2076	0.5947
ANNE ARUNDEL	0.0032	0.0529
BALTIMORE	0.0024	0.0368
CALVERT	0.1063	0.1260
CAROLINE	0.4473	0.0000
CARROLL	0.1949	0.2587
CECIL	0.0467	0.0424
CHARLES	0.0215	0.0422
DORCHESTER	0.1420	0.0983
FREDERICK	0.1695	0.4235
GARRETT	0.1852	0.0000
HARFORD	0.0896	0.3122
HOWARD	0.0023	0.0162
KENT	0.0031	0.0011
MONTGOMERY	0.0076	0.2619
PRINCE GEORGE'S	0.0041	0.1557
QUEEN ANNE'S	0.0553	0.0365
ST. MARY'S	0.0246	0.0150
SOMERSET	0.0456	0.0427
TALBOT	0.0086	0.0051
WASHINGTON	0.0544	0.1170
WICOMICO	0.0762	0.1659
WORCESTER	0.0437	0.0759
BALTIMORE CITY	0.0000	0.0542

Unpaved road VMT was calculated first by State and roadway class using temporally allocated NAPAP Inventory factors (seasonal temporal allocations factors or VMT fractions – VMTFRAC values). These factors are provided in the EPA publication, "Paved and Unpaved Road VMT temp factors.xls". The seasonal VMT fractions were then multiplied by the ratio of the number of days in a month to the number of days in a season to adjust to monthly VMTFRAC. The emission factors were then applied to estimate emissions by month.

Below is Table 4.1.7.6-c and d

Seasonal VMT Fractional Values by Road Class

Rural rt210 EPA SEASON	VMTFRAC
WINTER	**0.2199**
SPRING	**0.2403**
SUMMER	**0.2845**
FALL	**0.2553**

Urban rt330 EPA SEASON	VMTFRAC
WINTER	**0.2360**
SPRING	**0.2547**
SUMMER	**0.2640**
FALL	**0.2453**

Emission Factors:

Re-entrained road dust emissions for unpaved roads were estimated using unpaved road VMT and the emission factor equation from AP-42[1]:

$$EF = \frac{\left[k * \left(s/12\right)^a * \left(SPD/30\right)^b\right]}{\left(M/0.5\right)^c} - C$$

where k, a, b, and c are empirical constants given in Table 1 and

EF = size specific emission factor (lb/VMT)
s = surface material silt content (%)
SPD = mean vehicle speed (mph)
M = surface material moisture content (%)
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)

Table 4.1.7.6-e **Constants for Unpaved Roads Re-entrained Dust Emission Factor Equation**

Constant	PM_{25}	PM_{10}
K (lb/VMT)	0.18	1.8
a	1	1
b	0.5	0.5
c	0.2	0.2
C	0.00036	0.00047
Source: AP-42		

Average State-level unpaved silt content values, developed as part of the 1985 National Acid Precipitation Assessment Program (NAPAP) Inventory, were obtained from the Illinois State Water Survey[2]. Silt contents of over 200 unpaved roads from over 30 States were obtained. Average silt contents of unpaved roads were calculated for each State that had three or more samples for that State. For States that did not have three or more samples, the average for all samples from all States was used. Samples and default values were provided by state. Silt content (%) from (AP-42 Table 13.2.2-1) of **3.9** was used for the Unpaved/Unimproved roads.

[1] United States Environmental Protection Agency, Office of Air Quality Planning and Standards. "Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.2 Unpaved Roads." Research Triangle Park, NC. 2003.
[2] G. Stensland, Illinois State Water Survey, personal communication with W. Barnard of E.H. PECHAN & Associates, Inc., Durham, NC. 1989.

Table 4.1.7.6-f State-Level Unpaved Road Surface Material Silt Content Values used in MANE-VU Fugitive Dust Calculations

State	Unpaved Road Surface Material Silt Content (%)	Data Source
Connecticut	3.9	DEFAULT
Delaware	0	No Unpaved Roads
DC	0	No Unpaved Roads
Maine	3.9	DEFAULT
Maryland	3.9	DEFAULT
Massachusetts	3.9	DEFAULT
New Hampshire	3.9	DEFAULT
New Jersey	3.9	DEFAULT
New York	4.7	SAMPLES
Pennsylvania	3.3	SAMPLES
Rhode Island	3.9	DEFAULT
Vermont	3.9	DEFAULT

Table 4.1.7.6-g lists the speeds modeled on the unpaved roads by roadway type. These speeds were determined based on national average speeds modeled for onroad emission calculations and weighted to determine a single average speed for each of the roadway types. The value of 0.5 percent for M was chosen as the national default as sufficient resources were not available to determine more locally-specific values for this variable.

Table 4.1.7.6-g Speeds Modeled by Roadway Type on Unpaved Roads

Unpaved Roadway Type	Speed (mph)
Rural Minor Arterial	39
Rural Major Collector	34
Rural Minor Collector	30
Rural Local	30
Urban Other Principal Arterial	20
Urban Minor Arterial	20
Urban Collector	20
Urban Local	20

The emission factor for paved roads is calculated from the empirical AP-42 formula and then is adjusted for precipitation. Correction factors were applied to the emission factors to account for the number of days with a sufficient amount of precipitation to prevent road dust resuspension. Monthly-corrected emission factors by State and roadway classification were calculated using the following equation:

$$EF_{CORR} = EF * \left[\frac{(D - p)}{D} \right]$$

Where:

EF_{CORR} = unpaved road dust emission factor corrected for precipitation effects
EF = uncorrected emission factor
D = number of days in the month
p = number of days in the month with at least 0.01 inches of precipitation

The number of days in each county with at least 0.01 inches of precipitation in each month was obtained from the National Climatic Data Center[3]. For counties with more than one precipitation collection station with valid data from the NCDC data set, an average number of precipitation days were calculated for each month from all valid stations in the county. Counties with no precipitation collection station or no valid data were assigned the data from an adjacent county. The 2011 monthly precipitation data for MANE-VU counties were updated and are shown in Table 4.1.7.6-h. This method of assigning monthly precipitation days by county improves on the NEI approach of assigning monthly precipitation data by State. These are the same precipitation data used to calculate paved road emissions for the MANE-VU States.

Table 4.1.7.6-h 2011 Number of Days with at Least 0.01 Inches of Precipitation

State	County	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MD	ALLEGANY	7	9	12	20	14	12	9	15	15	14	10	9
MD	ANNE ARUNDEL	9	9	12	14	12	10	8	16	16	11	9	7
MD	BALTIMORE	4	5	7	8	8	3	3	2	13	10	8	6
MD	CALVERT	9	4	14	12	11	12	9	10	12	9	11	9
MD	CAROLINE	11	10	11	12	11	11	8	14	12	15	11	6
MD	CARROLL	12	9	11	16	15	10	7	17	22	14	8	11
MD	CECIL	8	12	11	15	10	9	9	14	19	14	10	5
MD	CHARLES	9	4	14	12	11	12	9	10	12	9	11	9
MD	DORCHESTER	9	4	14	12	11	12	9	10	12	9	11	9
MD	FREDERICK	10	9	12	16	16	10	6	14	22	11	9	7
MD	GARRETT	20	16	18	20	17	12	11	13	14	18	11	15
MD	HARFORD	8	12	11	15	10	9	9	14	19	14	10	5
MD	HOWARD	7	6	14	14	10	2	7	8	10	11	8	8
MD	KENT	11	8	9	15	8	8	7	16	13	11	7	6
MD	MONTGOMERY	10	9	12	17	12	7	7	13	18	12	8	11
MD	PRINCE GEORGE'S	9	10	12	15	13	8	6	11	14	16	9	9
MD	QUEEN ANNE'S	11	10	11	12	11	11	8	14	12	15	11	6
MD	ST. MARY'S	8	6	12	10	11	7	9	11	13	10	9	6
MD	SOMERSET	10	7	12	10	7	8	9	12	12	9	12	9
MD	TALBOT	9	7	11	12	11	11	9	14	12	13	9	10
MD	WASHINGTON	11	10	14	15	16	5	10	16	16	12	8	7
MD	WICOMICO	12	9	12	9	9	14	9	13	13	11	10	8
MD	WORCESTER	10	7	12	10	7	8	9	12	12	9	12	9
MD	BALTIMORE CITY	9	10	10	13	11	8	7	16	13	11	7	6

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

[3] U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Summary of the Day Element TD-3200, 2002 data provided on CD. National Climatic Data Center 2003

Adjustment for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

BMC provided miles of unpaved roads at the county-level to spatially allocate emission estimates.

Temporal

The unpaved road VMT data were temporally allocated by month using the NAPAP [4] temporal allocation factors. SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

AP-42 Unpaved Roads Emission Factor Formula

$$EF = \frac{\left[k * \left(s/12\right)^{a} * \left(SPD/30\right)^{b}\right]}{\left(M/0.5\right)^{c}} - C$$

Where k, a, b, and c are empirical constants given in Table 1 and

EF = size specific emission factor (lb/VMT)
s = surface material silt content (%)
SPD = mean vehicle speed (mph)
M = surface material moisture content (%)
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)

Calculate Local Unpaved Roads Emission Factors
Example: Anne Arundel County - Local Rural Unpaved Roads – PM_{25}

$$EF_{PM25} = \frac{\left[k * \left(s/12\right)^{a} * \left(SPD/30\right)^{b}\right]}{\left(M/0.5\right)^{c}} - C$$

[4] U.S. Environmental Protection Agency, "The 1985 NAPAP Emissions Inventory: Development of Temporal Allocation Factors," EPA-600/7-89-010d, Air & Energy Engineering Research Laboratory. Research Triangle Park, NC. April 1990.

$$EF_{PM25} = \frac{\left[0.27 * \left(3.9/12\right)^{1} * \left(30/30\right)^{0.5}\right]}{\left(0.5/0.5\right)^{0.2}} - 0.00036$$

$$EF_{PM25} = 0.08739$$

Adjust Emission Factor Formula for Precipitation

$$EF_{CORR} = EF * \left[\frac{(D-p)}{D}\right]$$

Where:

EF_{CORR} = unpaved road dust emission factor corrected for precipitation effects
EF = uncorrected emission factor
D = number of days in the month
p = number of days in the month with at least 0.01 inches of precipitation

Calculate Unpaved Roads Emission Factors Adjusted for Precipitation
(Example Calculation: Anne Arundel County – July – PM_{25})

$$EF_{PM25-CORR} = EF_{PM25} * \left[\frac{(D-p)}{D}\right]$$

$$EF_{PM25-CORR} = 0.08739 * \left[\frac{(31-8)}{31}\right]$$

$$EF_{PM25-CORR} = 0.064838$$

Emission Equation:

$$EM_{PM25} = \frac{EF_{PM25-CORR} * VMT * VMTFRAC}{2000} * \left[1 - (CE * RE * RP)\right]$$

Where:

EM_{PM25} = PM_{25} emissions in tons per year for unpaved roads in county i
VMT_i = Annual VMT (million miles of Vehicle Miles Traveled for county i)
VMTFRAC = Temporal Allocation Factor
$EF_{PM25\text{-}CORR\ I}$ = Unpaved road emission factor adjusted for precipitation in county i
CE = Control efficiency of 0% applied to Urban and Rural roads
RE = Rule effectiveness of 100% applied to Urban and Rural roads
RP = Rule penetration of 100% applied to Urban and Rural roads

Sample Calculation Unpaved Roads (Anne Arundel County - July)

$$EM_{PM25} = \frac{EF_{PM25-CORR} * VMT * VMTFRAC}{2000} * \left[1 - (CE * RE * RP)\right]$$

$$EM_{PM25} = \frac{0.0648377 * 0.0001533 * 0.09586}{2000} * \left[1 - (0 * 100 * 100)\right]$$

EM_{PM25} = 4.764E-10 tons PM_{25} for July in Ann Arundel County Rural traffic emissions

Daily Emissions Calculation
Paved Road for each Maryland County was found to have a
SAF = seasonal adjustment factor of 0.28
POS = peak ozone period of 0.25
Days of the Period 365

Daily adjusted $\mathbf{E}_{PM25annual\ ad} = (E_{PM25annual} / 365)*(SAF / POS)$
You can total emissions for a given county and apply the daily parameters in the adjusted emissions equation above to obtain its daily emissions.

4.1.8 FIRE SOURCES

Some fires are produced from sources such as forest fires, slash and prescribed burning, agricultural burning, structure fires, and vehicle fires.

4.1.8.1 EPA Accepted Fires --- Wild Fires, Prescribed Fires, and Slash Fires

EPA has developed new tools by which they use to estimate fire emissions for each state from a verity of sources. Using data collected from national fire database and activity on fire incidents and events around the county; with climate data and grid mapping EPA has estimated emissions for counties in each state. The emissions data are posted as csv files for every state on their FTP site. The methods used by EPA reflect use of the SMARTFIRE2 (SF2) framework. For the 2017 PEI MDE reviewed the data and estimations by EPA and decided to accept and use EPA's emissions for:

Wild Fires / Forest Fires /smoldering -- SCC: 2810001001
Wild Fires / Forest Fires /flaming -- SCC: 2810001002

Prescribed Burns /smoldering -- SCC: 2810015001
Prescribed Burns /flaming -- SCC: 2810015002
Slash Burns were included with the (Prescribed Burns) emissions by EPA.

4.1.8.2 Vehicle Fires

SCC: 28 10 050 000

Description

This emission guidance report covers air emissions from accidental vehicle fires. Vehicles included are any commercial or private mode of transportation that is authorized for use on public roads.

Pollutants

PM_{10}, NOx, CO, VOC

Method and Data Sources

Activity

Local data was collected from state or local fire marshals and public safety departments. See the spatial apportioning section for available information sources.

Emission Factors

Emission factors are available for open burning of automobile components including upholstery, belts, hoses, and tires (AP-42, Section 2.5 Open Burning) (EPA, 1996)[5]. The amount of vehicle material burned (the fuel loading) in a vehicle fire must be estimated to use these factors. A conservative assumption is that an average vehicle has 500 pounds of components that can burn in a fire, based on a 3,700 pound average vehicle weight (CARB, 1995)[6]. Maryland used a more conservative assumption based on a 2,000 pound average vehicle weight. EPA and ERTAC committee through a joint study estimated PM2.5-PRI to be 100 lbs per ton of material burned in fire. Also, we used EIIP Vehicle Fires – January 1999 and 2000 guidance.

Pollutant	Lbs/ton burned
VOC	32
NOx	4
CO	125
PM10-PRI	100
PM2.5-PRI	100

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

[5] EPA 1996 *Compilation of Air Pollutant Emission Factors--Volume I: Stationary Point and Area Sources. Fifth Edition AP-42.* U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. (GPO 055-000-00251-7) Research Triangle Park, North Carolina

[6] CARB 1995. Emission Inventory Procedural Manual, Vol. III: Methods for Assessing Area Source Emissions. California Environmental Protection Agency: Air Resources Board.

Adjustment for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

The activity data for vehicle fires was collected at a county-level. No other method to spatially profile the vehicle fire source category was used.

Temporal

SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

$$E_{VF,\,i} = \frac{VB_j \times FLF_{VF} \times EF_{VF\,i}}{2000}$$

where:

$E_{VF,i}$ = Emissions of pollutant i in tons per year from vehicle fires

VB_J = Vehicles burned in county j in 2017

FLF_{VF} = Fuel loading factor 0.25 tons/vehicle burned

$EF_{VF\,i}$ = Emissions factor in pounds per ton burned for pollutant i

2017 Example Calculation Vehicle Fires (Anne Arundel County)

$$E_{VF,\,Ann} = \frac{VB_j \times FLF_{VF} \times EF_{VOC}}{2000}$$

$$E_{VF,\,Ann} = \frac{(210 \times (0.25) \times 32)}{2000}$$

$E_{VF,\,Ann}$ = 0.84 tons VOC per year emitted from vehicle fires in Anne Arundel County in 2017

Daily Emissions Calculation

Vehicle Fires for Anne Arundel County was found to have a

SAF = seasonal adjustment factor of 0.25

POS = peak ozone period of 0.25

Days of the Period 365

Daily adjusted $E_{VF,\,Annda} = (E_{VF,\,Ann} / 365) * (SAF / POS)$

$E_{VF,\,Annda}$ = (**0.91** / 365)*(0.25 / 0.25) = **2.30E-03 VOC tons/day**

4.1.8.3 Agricultural Burning

SCC: 21 01 500 000

Description

This source category covers agricultural burning practices used to clear and/or prepare land for planting. Operations included under this category are stubble burning, burning of agricultural crop residues, and burning of standing field crops as part of harvesting (e.g., sugar cane).

Pollutants

PM_{10} and $PM_{2.5,}$

Method and Data Sources

Emissions from this source were assigned to the open burning category because the county permits issued in 2017 did not require information distinguishing the amount of agricultural waste to be burned versus other materials.

4.1.8.4 Structure Fires

SCC: 28 10 030 000

Description

Building fires produce short-term emissions of organic compounds.

Pollutants

PM_{10} and $PM_{2.5,}$ NOx, CO, VOC

Method and Data Sources

MDE staff used emission factors, fuel loading factors and methodology documented in EIIP[7], Structure Fires, dated July 1999.

Activity

The Maryland State Fire Marshal's office provided the number of structure fires by county.

4.1.8.3-a *Emission Factors*

	VOC (lbs./ton)	**NOx (lbs./ton)**	**CO (lbs./ton)**	**PM10-PRI (lbs./ton)**
Emissions	11.0	1.4	60.0	10.8
Fuel loading factor:	1.15	Tons/fire		

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

[7] Emission Inventory Improvement Program

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

The activity data for structure fires was collected at a county-level. No other method to spatially profile the prescribed burning source category was used.

Temporal

Because structure fires occur at different times of the year, ARA used no seasonal adjustment factor. The activity level is seven days per week.

Emissions Calculation

$$E_{SF\ i} = \frac{SF_k \mathbf{\ x\ } EF_{SF\ i} \mathbf{\ x\ } FLF_{SF}}{2000}$$

where:

$E_{FF,i}$ = Emissions of pollutant i in tons per year from structure fires

FLF_{SF} = Fuel loading factor (tons/acre burned) for structure fires

SF_k = Structure fires in county k in 2017

$EF_{SF,i}$ = Emission factor for pollutant i in pounds per ton

ARA used an activity level of 7 days a week with no seasonal variation as given in Table 5.8-1 in the EIIP document.

<u>2017 Example Calculation Structure Fires (Baltimore County)</u>
<u>Equation:</u>

$$E_{SF\ BCo} = \frac{SF_k \mathbf{\ x\ } EF_{SF\ i} \mathbf{\ x\ } FLF_{SF}}{2000}$$

$$E_{SF\ BCo} = \frac{367 \mathbf{\ x\ } 11 \mathbf{\ x\ } 1.15}{2000}$$

$$\mathbf{E_{SF\ BCo} = 2.32\ tons\ }_{VOC}\mathbf{\ /\ year}$$

Daily Emissions Calculation
Structure Fires for Baltimore County was found to have a
SAF = seasonal adjustment factor of 0.2
POS = peak ozone period of 0.25
Days of the Period 365
Daily adjusted $E_{SF\ BCo\mathbf{da}}$ = ($E_{SF\ BCo}$ / 365)*(SAF / POS)

$E_{SF\ BCo\mathbf{da}}$ = (**2.32** / 365)*(0.2 / 0.25) = **5.09E-03 VOC tons/day**

4.1.8.5 Orchard Heaters

SCC: 28 01 520 000

Description

In areas of the country where frost threatens orchards, heaters may be used in cold portions of the growing season.

Pollutants

PM_{10} and $PM_{2.5}$

Method and Data Sources

Calls to several orchards in Washington and Frederick Counties (where most of the orchards in Maryland are located), revealed that no heaters were used. One orchard used fans to move air on still nights when there would be danger of frost to fruit tree blossoms. Therefore, orchard heaters are not included in Maryland's baseline inventory.

4.1.9 AMMONIA SOURCES

4.1.9.1 INTRODUCTION

Currently, there is a significant amount of uncertainty concerning the contribution of soil to ammonia emission levels. High quality emission factors for this category do not exist, and even the physics of ammonia-surface exchange is not well understood. Soils emit and uptake ammonia so it is difficult to evaluate the net contribution, emissions may be potentially significant in some regions if the uptake is not substantial. Indeed, the literature shows that a soil-plant canopy system can be a source of ammonia emissions under certain conditions and a sink under other conditions. Because of this uncertainty, the State of Maryland has decided not to include emissions from soils. MDE inventoried the following sources for ammonia emissions.

- Agricultural Livestock Production Operations
- Agricultural Fertilizer Application
- Mobile Sources
- Publicly Owned Treatment Works (POTWs)
- Human activity

4.1.9.2 Emission Calculations Methodology

Normally, the Department uses the Carnegie Mellon University Ammonia Model (CMU-Ammonia Model version 3.6) [8] computer program to develop an ammonia emissions inventory. However, for the 2017 NEI emissions inventory cycle, MDE has accepted EPA's 2017 emissions inventory data.

The CMU-Ammonia Model program is an approve methodology by EPA for developing ammonia source categories emissions inventory. Basically, the CMU-Ammonia Model program multiplies emission factors per source category by its particular activity data

4.1.9.3 Ammonia SOURCE EMISSION CATEGORIES

4.1.9.4 Agricultural Livestock Production Operations

Livestock waste is one of the most important sources of ammonia when considering the sheer magnitude of the emissions. Existing ammonia inventories indicate that livestock wastes are responsible for 50-70% of national ammonia emissions. The United States Department of Agriculture publishes the Census of Agriculture (USDA, 2012), conducted every five years, which includes accurate inventories for livestock; however, the categories of animals reported at the county level differ from the categories of animals for which current emission factors exist. 2017 activity data were used from the USDA Census of Agriculture data to develop the 2017 ammonia emission inventory.

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[8] Copyright 2004 *CMU- NH3 Ammonia Model Inventory Version 3.6 computer program,* Departments of Civil and Environmental Engineering and Engineering and Public Policy Porter Hall Room 119, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA 15213

4.1.9.5 Beef and Dairy cattle (cows)

SCC: 2805002000 (Beef Cattle)
2805018000 (Dairy Cows)

Description

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

Pollutants

NH_3, VOC

Method and Data Sources

Conceptually, the method for estimating emissions from cattle is to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

Activity
The U.S. Census Bureau, 2017 was use to obtain activity level data for this category.

Emission Factors

Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

The CMU ammonia model automatically applies controls, when applicable for a given year.

Spatial and Temporal Allocations

Spatial
The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

Temporal
The CMU-NH3 ammonia model temporally allocates activity data to the different months of the year or annually (yearly). Emissions were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

Equation:

2014 TPY ammonia emissions for cows in an individual county

$$EM_{COWS\text{-}2014\ Total} = 2014EM_{BC} + 2014\ EM_{MC} + 2014\ EM_{HF} + 2014\ EM_{ST}$$

Where:

$EM_{COWS\text{-}2014\ Total}$ = Total NH3 emissions from cows, all categories

EM_{BC} = 2014 Uncontrolled emissions from beef cows

EM_{DC} = 2014 Uncontrolled emissions from dairy cows

Where:

$EM_{BC} = AC_{BC} * EF_{BC}$

$EM_{DC} = AC_{BC} * EF_{DC}$

Where:

AC_{BC} = Activity level (number) of beef cows

AC_{DC} = Activity level (number) of dairy cows

EF_{BC} = Emission factor for beef cows

EF_{DC} = Emission factor for dairy cows

4.1.9.6 Hogs and Pigs

SCC: 28 05 025 000 (Swine Composite)

Description

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

Pollutants

NH_3, VOC

Method and Data Sources

Conceptually, the method for estimating emissions from hogs and pigs are to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

Activity
The U.S. Census Bureau, 2017 was used to obtain activity level data for this category.

Emission Factors

Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

The CMU ammonia model automatically applies controls, when applicable for a given year.

Spatial and Temporal Allocations

Spatial
The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

Temporal
The CMU-NH3 ammonia model temporally allocates activity data to the different months of the year or annually (yearly). Emissions were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

Equation:

2014 TPY ammonia emissions for swine in an individual county

$$EM_{SWINE\text{-}2014\ Total} = 2014\ EM_{HOGS} + 2014\ EM_{PIGS}$$

Where:

$EM_{SWINE\text{-}2014\ Total}$ = Total NH_3 emissions from swine, all categories
EM_{HOGS} = 2014Uncontrolled emissions from hogs
EM_{PIGS} = 2014 Uncontrolled emissions from pigs

Where:

$$EM_{HOGS} = (AC_{HOGS} * EF_{HOGS})$$
$$EM_{PIGS} = (AC_{PIGS} * EF_{PIGS})$$

Where:

AC_{HOGS} = Activity level (number) of hogs
AC_{PIGS} = Activity level (number) of pigs
EF_{HOGS} = Emission factor for hogs
EF_{PIGS} = Emission factor for pigs

4.1.9.7 Chickens (Layers and Broilers)

SCC: 28 05 007 100 (Chickens Layers)
28 05 009 100 (Broilers, Poultry)

Description

These animals and livestock are sources of ammonia emissions that are due to the biological decomposition of their waste products.

Pollutants

NH_3, VOC

Method and Data Sources

Conceptually, the method for estimating emissions from chickens composite is to count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU Ammonia Model v.3.6 program utilizes this approach, a methodology approved by EPA for developing the emissions inventory for other categories.

Activity
The U.S. Census Bureau, 2017 was used to obtain activity level data for this category.

Emission Factors
Emission factors are the defaulted values in the CMU ammonia model (version 3.6).

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

The CMU ammonia model automatically applies controls, when applicable for a given year.

Spatial and Temporal Allocations

Spatial
The CMU ammonia model spatially allocates activity data emissions. Input files specify the state or county then set up county-level allocations factor files for the chosen state.

Temporal
The CMU-NH3 ammonia model temporally allocates activity data to the different months of the year or annually (yearly). Emissions were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

Equation:

2014 TPY ammonia emissions for chickens in an individual county

$$EM_{\text{CHICKENS-2014 Total}} = 2014\ EM_{LAYER} + 2014\ EM_{BROILER}$$

Where:

$EM_{\text{CHICKENS-2014 Total}}$ = Total NH_3 emissions from chickens, all categories

EM_{LAYER} = 2014 Uncontrolled emissions from layers
$EM_{BROILER}$ = 2014 Uncontrolled emissions from broilers

Where:

$EM_{LAYER} = AC_{LAYER} * EF_{LAYER}$
$EM_{BROILER} = AC_{BROILER} * EF_{BROILER}$

Where:

AC_{LAYER} = Activity level (number) of layer chickens
$AC_{BROILER}$ = Activity level (number) of broiler chickens
EF_{LAYER} = Emission factor for layer chickens
$EF_{BROILER}$ = Emission factor for broiler chickens

4.1.9.8 Agricultural Fertilizer Application

SCC: 28 01 700 099 (Miscellaneous Fertilizers)

Description:

The following description comes directly from the EPA's agricultural fertilizer application documentation.

"Fertilizer in this category refers to any nitrogen-based compound, or mixture containing such a compound, that is applied to land to improve plant fitness.

The approach to estimate 2017 fertilizer emissions consists of these general steps:

- Run the Fertilizer Emissions Scenario Tool for CMAQ (FEST-C[1]) and CMAQ[2] model with bidirectional ("bidi") NH_3 exchange to produce year 2011 nitrate (NO_3) Ammonium (NH_4, including Urea), and organic (manure) nitrogen fertilizer estimates and gaseous ammonia NH_3 emission estimates respectively.
- Run the Environmental Policy Integrated Climate (EPIC[3]) modeling system to produce year 2017 NO_3, Ammonium (including Urea), and organic (manure) nitrogen fertilizer estimates.
- Compute emission factors from the FEST-C outputs to use in estimating year 2017 NH_3 emissions.
- All emissions are assigned to one SCC: "…Miscellaneous Fertilizers" (2801700099).

FEST-C reads land use data from the Biogenic Emissions Landuse Dataset (BELD) version 4, meteorological variables from the Weather Research and Forecasting (WRF[4]) model, and nitrogen deposition data from a previous or historical average CMAQ simulation.

Pollutants

NH_3

Emission Factors

The emission factors were derived from the 2011 FEST-C outputs. Total fertilizer emission factors for each month and county were computed by taking the ratio of total fertilizer NH_3 emissions (short tons) to total nitrogen fertilizer application (short tons).

Sample Calculations

EPA's modeling system is too large and many spreadsheets would be needed to show chemical make and transport modeling, making it very difficult to show a sample calculation.

5.0 NONROAD SOURCES

5.1 Introduction NONROAD VEHICLES/ENGINES

This section contains the nonroad source emission inventory for volatile organic compounds (VOCs), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), particulate matter (PM2.5 and PM10), ammonia (NH3), and toxic air pollutants. Nonroad mobile sources include motorized vehicles and equipment that are normally not operated on public roadways to provide transportation. Nonroad mobile sources are broken up into the following categories:

- Lawn and garden equipment
- Airport service equipment
- Logging equipment
- Recreational marine equipment
- Light commercial equipment
- Industrial equipment
- Construction and Mining equipment
- Agricultural or farm equipment
- Recreational land vehicles or equipment
- Railroads
- Commercial aviation
- Air taxis
- General aviation
- Military aviation
- Commercial marine vessels

The Department used the most current version of EPA's NONROAD2008a model, which is incorporated into MOVES2014a Model to develop the inventory for nonroad mobile sources. The NONROAD2008a model includes more than 80 basic and 260 specific types of nonroad equipment and further stratifies equipment types by horsepower rating. Fuel types include gasoline, diesel, compressed natural gas (CNG), and liquefied petroleum gas (LPG).

EPA allowed the use of the NONROAD Model and associated default inputs in the development of inventories supporting State Implementation Plans (SIPs).

5.2 NONROAD MODEL

NONROAD2008a supersedes all previous versions of NONROAD models. It calculates past, present, and future emission inventories in tons of pollutant for all nonroad equipment categories. It does not calculate commercial marine, aircraft, or rail locomotive emissions. The model estimates exhaust and evaporative hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), particulate matter (PM), sulfur dioxide (SO2), and carbon dioxide (CO2). The user may select a specific geographic area like the nation, a state, or county and time period like annual, monthly, seasonal, or daily for which to generate emissions.

The model estimates emissions for each specific type of nonroad equipment by multiplying the following input data estimates:

- Equipment population for base year (or base year population grown to a future year), distributed by age, power, fuel type, and application;
- Average load factor expressed as average fraction of available power;
- Available power in horsepower;
- Activity in hours of use per year; and
- Emission factor with deterioration and/or new standards.

The emissions are then temporally and geographically allocated using appropriate allocation factors. There are several input files that provide necessary information to calculate and allocate emissions estimates. These input files correspond to the basic data needed to provide the calculations: emission factors, base year equipment population, activity, load factor, average lifetime growth estimates, and geographic and temporal allocation. Default values are provided for all input files. The user can replace the default data files when better information becomes available, either from EPA for national defaults or from local sources for locality-specific data. The input files are also modifiable to test control strategies.

The NONROAD model consists of three separate components: a graphical user interface written in Visual Basic, the core model written in FORTRAN, and a reporting utility written in Microsoft ACCESS. The install utility supplied with the model easily installs all three components of the model onto a personal computer.

The primary purpose of the user interface is to provide the user with an easy method to specify the options for a model run. With simple Windows-type screens and pull-down menus, the user can quickly set up, execute, and view a modeling scenario. Once the model options are specified, the user can then run the FORTRAN core model from within the interface, and then can move directly to the reporting utility to view and summarize the modeling results.

The core model of NONROAD, written in FORTRAN, contains all of the algorithms used by the model for calculating emissions estimates. The core model can be operated as a stand-alone application; however, as a stand-alone application it requires some basic knowledge of the DOS operating system. Also, note that while the user interface runs the core model for one specified set of conditions, it cannot run multiple runs in batch mode. Multiple runs can be performed by creating and running a batch file in DOS or in a DOS window environment.

The reporting utility, written using Microsoft's ACCESS database software, is used to create standardized reports using output data generated in the core model. Like the graphical user interface, the reporting utility is a fully operational Windows program, with pull-down menus, designed as a separate module in order to take advantage of the many reporting and formatting options available when using a database application. Although the reporting utility is written in ACCESS, it is a stand-alone application, and you do not need to know how to use ACCESS to generate reports.

The NONROAD model estimates emissions for six exhaust pollutants: hydrocarbons (HC), NO_X, carbon monoxide (CO), carbon dioxide (CO_2), sulfur oxides (SO_X), and PM. The user selects among five different types for reporting HC — as total hydrocarbons (THC), total organic gases (TOG), non-methane organic gases (NMOG), non-methane hydrocarbons (NMHC), or volatile organic compounds (VOC). Particulate matter can be reported as PM of 10 microns or less (PM_{10}) or PM of 2.5 microns or less ($PM_{2.5}$). The model also estimates emissions of non-exhaust HC for four modes — diurnal, refueling spillage, vapor displacement, and crankcase emissions. All emissions are reported as short tons (i.e., 2000 lbs).

5.2.1 Emission Calculation Methodologies

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Emission factors activity data are stored in the model defaulted National County Data (NCD) county database input files. Adjustments are defaulted automatically made within the model based on the age of equipment and controls applied for given time frames and inventory year. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

NONROAD2008a model estimates the 2017 annual and average ozone season day emissions for VOC, NO_X, CO, SO_2, $PM_{2.5}$-PRI, and NH_3. The NONROAD2008a model estimates emissions for each specific type of nonroad equipment by multiplying the following input data estimates:

- Equipment population for the base year, distributed by age, power, fuel type, and application;
- Average load factor expressed as average fraction of available power;
- Available power in horsepower;
- Activity in hours of use per year; and
- Emission factors reflecting deterioration and/or new standards.

The emissions are then temporally and geographically allocated using appropriate allocation factors.

The MOVES2014a Model incorporates the latest version of the NONROAD2008 model to calculate nonroad emissions. The model produces county-level mobile source emissions inventories from a National County Database (NCD), which includes onroad and nonroad data for each state. The NCD uses these nonroad inputs in the model to estimate and process county-level outputs on an annual, monthly, or daily basis in a single model run. The MOVES2014a model automatically applies controls, when applicable, for a given year.

Several input files provide necessary information to the model. These input files include information such as: emission factors, base year equipment population, activity, load factors, average lifetime, scrappage function, growth estimates, and geographic and temporal allocations. Default values are provided for all input files. The user may replace the default data files when better information becomes available, either from EPA for national defaults or from local sources for locality-specific data.

The NONROAD2008 model software was ran for all twelve months in 2017 to develop average ozone season day and annual emissions for the Cecil County MD area. All emissions sources in the software were included in the run. Average ozone season day emissions were estimated by dividing total emissions in July by the total number of days (31) in July. Emissions for all twelve months in 2017 were added together to develop annual emissions. Model inputs (temperature, fuel, and other parameters) used in this analysis were included in the NCD county database. The NONROAD2008 model is intended for Windows 98 and later. Its primary use is for estimation of air pollution inventories by professional mobile source modelers, such as state air quality officials and consultants. NONROAD2008 updates NONROAD2005 to include new nonroad emission standards promulgated in 2008 related to small gasoline engines and pleasure craft.

5.3 NONROAD CATEGORIES

The following is a list of each nonroad category with its description, data sources, methods used, a sample calculation, and a table with results for each county.

5.3.1 Lawn and Garden Equipment

SCC:

(2-Stroke) 2260004***	(4-Stroke) 2265004***		(LPG) 2267004***	(Diesel) 2270004***
2260004015	2265004010	2265004041	2267004066	2270 004000
2260004016	2265004011	2265004046		
2260004020	2265004015	2265004051		
2260004021	2265004016	2265004055		
2260004025	2265004025	2265004056		
2260004026	2265004026	2265004066		
2260004030	2265004030	2265004071		
2260004031	2265004031	2265004075		
2260004035	2265004035	2265004076		
2260004036	2265004036			
2260004071	2265004040			

Description

Lawn and garden equipment includes a variety of types of machinery used in the maintenance of lawns and gardens. Examples of the types of equipment included in this category are trimmers/edgers/brush cutters, lawn mowers, leaf blowers, rear engine riding mowers, front mowers, chainsaws (<4HP), shredders (<5HP), tillers (<5HP), lawn and garden tractors, wood splitters, snow blowers, chippers/stump grinders, commercial turf equipment, and other lawn and garden equipment. Emissions result from operation of the internal combustion engines that power the equipment.

Pollutants

$PM_{2.5}$, SOx, NOx, CO, VOC and HAPs

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran the NONROAD2008a model to determine the emission estimate for 2017. MDE-ARA opted to choose monthly seasonal (Annual and Summer) period totals as the output files from the model.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions monthly. The month of July was chosen and emissions were divided by 31 to give average daily emissions.

Emissions Calculation

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. These emission factors are stored in NONROAD2008a's data input files. NONROAD2008a adjusts these emission factors as necessary to account for the effects of fuel sulfur. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

5.3.2 Airport Service Equipment

SCC: 22 60 008 000 (2-Stroke)
22 65 008 000 (4-Stroke)
22 65 008 005 (4-Stroke)
22 67 008 005 (LPG)
22 70 008 000 (Diesel)
22 70 008 005 (Diesel)

Description

Airport service equipment includes a variety of types and sizes of machinery used to tow airplanes or for transferring luggage between a terminal and an airplane. Examples of the types of equipment included in this category are aircraft support equipment and terminal tractors. Emissions result from operation of the internal combustion engines that power the equipment.

Pollutants

PM_{10}, $PM_{2.5}$, SOx, NOx, CO, VOC

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran NONROAD2008a model to determine the emission estimates for 2017. MDE-ARA opted to choose monthly seasonal (annual and summer) period totals as the output files from the model.

Ground Support Equipment (GSE) emissions were estimated using NONROAD2008a nonroad modeling for all airports except for very large and military airports that were calculated using the EPA EDMS.[1]

[1] Emissions & Dispersion Modeling System (EDMS) Version 4.12 for Windows from CSSI, Inc

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year. The latest version of the EDMS model was used.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions monthly. The month of July was chosen and emissions were divided by 31 to give average daily emissions.

Emissions Calculation

The MOVES2014a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Emission factors activity data are stored in MOVES2014a's data input files. Adjustments are made within the model based on the age of equipment and controls applied for given time frames. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

[86] Emissions & Dispersion Modeling System (EDMS) Version 5.1 for Windows from CSSI, Inc

5.3.3 Recreational Land Vehicles

SCC:

2260001010	2-Stroke	motorcycles
2260001020	2-Stroke	snowblowers
2260001030	2-Stroke	ATVs
2260001060	2-Stroke	Specialty vehicles - carts
2265001010	4-Stroke	motorcycles
2265001030	4-Stroke	ATVs
2265001050	4-Stroke	golf carts
2265001060	4-Stroke	Specialty vehicles - carts
2267001060	LPG	Specialty vehicles - carts

Description

Recreational vehicles include a variety of types of vehicles used off normal roads for pleasure use. Examples of the types of vehicles included in this category are motorcycles, minibikes, and golf carts. Emissions result from operation of the internal combustion engines that power these vehicles.

Pollutants

$PM_{2.5}$ -PRI, SOx, NOx, CO, VOC and HAPs

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran NONROAD2008a model to determine the emission estimates for 2017. MDE-ARA opted to choose monthly seasonal (annual and summer) period totals as the output files from the model.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions. The emissions for the month of July was chosen and then divided by 31 (days) to get an average day for that month.

Emissions Calculation

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. These emission factors are stored in NONROAD2008a's data input files. NONROAD2008a adjusts these emission factors as necessary to account for the effects of fuel sulfur. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

5.3.4 Recreational Marine Equipment

SCC:

2282005010	2-Stroke	Outboard
2282005015	2-Stroke	Personal Water Craft
2282010005	4-Stroke	Inboard/Sterndrive

Description

Recreational marine equipment includes engines used to power recreational motor boats and sailboat auxiliary engines. Emissions result from operation of these engines.

Pollutants

$PM_{2.5}$ -PRI, SOx, NOx, CO, VOC and HAPs

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran NONROAD2008a model to determine the emission estimates for 2017. MDE-ARA opted to choose monthly seasonal (annual and summer) period totals as the output files from the model.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions. The emissions for the month of July was chosen and then divided by 31 (days) to get an average day for that month.

Emissions Calculation

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. These emission factors are stored in NONROAD2008a's data input files. NONROAD2008a adjusts these emission factors as necessary to account for the effects of fuel sulfur. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

5.3.5 Light Commercial Equipment

SCC:

2260006005	2-Stroke	generator set
2260006010	2-Stroke	pump
2260006015	2-Stroke	air compressors
2260006035	2-Stroke	hydro-power units
2265006005	4-Stroke	generator set
2265006010	4-Stroke	pump
2265006015	4-Stroke	air compressors
2265006025	4-Stroke	welders
2265006030	4-Stroke	pressure washers
2265006035	4-Stroke	hydro-power units
2267006005	LPG	generator set
2267006010	LPG	pump
2267006015	LPG	air compressors
2267006025	LPG	welders
2267006030	LPG	pressure washers
2267006035	LPG	hydro-power units
2268006005	CNG	generator set
2268006010	CNG	pump
2268006015	CNG	air compressors
2268006020	CNG	gas compressors

Description

Light commercial equipment includes a variety of types and sizes of machinery used in small commercial applications. Examples of the types of equipment included in this category are pumps, generators, compressors, and welders. Emissions result from operation of the internal combustion engines that power the equipment.

Pollutants

$PM_{2.5}$ -PRI, SOx, NOx, CO, VOC and HAPs

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-

R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran NONROAD2008a model to determine the emission estimates for 2017. MDE-ARA opted to choose monthly seasonal (annual and summer) period totals as the output files from the model.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions. The emissions for the month of July was chosen and then divided by 31 (days) to get an average day for that month.

Emissions Calculation

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. These emission factors are stored in NONROAD2008a’s data input files. NONROAD2008a adjusts these emission factors as necessary to account for the effects of fuel sulfur. Emission changes with the age of the engine, often called ‘deterioration’, are also applied by the model.

5.3.6 Industrial Equipment

SCC:

2260003030	2-Stroke	sweepers/scrubbers
2260003040	2-Stroke	other general industrial equipment
2265003010	4-Stroke	aerial Lifts
2265003020	4-Stroke	forklifts
2265003030	4-Stroke	sweepers/scrubbers
2265003040	4-Stroke	other general industrial equipment
2265003050	4-Stroke	other material handling equipment
2265003060	4-Stroke	ac\refrigeration
2265003070	4-Stroke	terminal tractors
2265010010	4-Stroke	other oil field equipment
2267003010	LPG	aerial Lifts
2267003020	LPG	forklifts
2267003030	LPG	sweepers/scrubbers
2267003040	LPG	other general industrial equipment
2267003050	LPG	other material handling equipment
2267003070	LPG	terminal tractors

Description

Industrial equipment includes a variety of types and sizes of machinery. Examples of the types of equipment included in this category are forklifts, mobile refrigeration units, auxiliary engines for hydraulic pump service on garbage trucks and other large vehicles, generator and pump service for utilities, airports, and state maintenance organizations, logging, mining, quarrying, oil field operations, and portable well drilling equipment. Emissions result from the operation of the internal combustion engines that power the machines.

Pollutants

$PM_{2.5}$ -PRI, SOx, NOx, CO, VOC and HAPs

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran NONROAD2008a model to determine the emission estimates for 2017. MDE-ARA opted to choose monthly seasonal (annual and summer) period totals as the output files from the model.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions. The emissions for the month of July was chosen and then divided by 31 (days) to get an average day for that month.

Emissions Calculation

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. These emission factors are stored in NONROAD2008a's data input files. NONROAD2008a adjusts these emission factors as necessary to account for the effects of fuel sulfur. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

5.3.7 Construction and mining Equipment

SCC:

2260002006	2265002021	2265002060	2267002033
2260002009	2265002024	2265002066	2267002039
2260002021	2265002027	2265002072	2267002045
2260002027	2265002030	2265002078	2267002054
2260002039	2265002033	2265002081	2267002057
2260002054	2265002039	2267002003	2267002060
2265002003	2265002042	2267002015	2267002066
2265002006	2265002045	2267002021	2267002072
2265002009	2265002054	2267002024	2267002081
2265002015	2265002057	2267002030	2268002081

2-Stroke, 4-Stroke, CNG, and LPG equipment

Description

Construction and mining equipment includes a variety of types and sizes of machinery used in the construction of roadways, buildings, digging, and tunneling. Examples of the types of equipment included in this category are bulldozers, power shovels, scrapers, haulers, and motor graders. Emissions result from the internal combustion engines used to power this equipment.

Pollutants

$PM_{2.5}$ -PRI, SOx, NOx, CO, VOC and HAPs

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran NONROAD2008a model to determine the emission estimates for 2017. MDE-ARA opted to choose monthly seasonal (annual and summer) period totals as the output files from the model.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions. The emissions for the month of July was chosen and then divided by 31 (days) to get an average day for that month.

Emissions Calculation

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. These emission factors are stored in NONROAD2008a's data input files. NONROAD2008a adjusts these emission factors as necessary to account for the effects of fuel sulfur. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

5.3.8 Agricultural Equipment

SCC: 22 60 005 000 (2-Stroke)
22 65 005 000 (4-Stroke)
22 67 005 000 (LPG)
22 68 005 000 (CNG)
22 70 005 000 (Diesel)

Description

The two types of sources within the agricultural equipment category are tractors and all other motorized equipment. Tractors account for most of the emissions produced from agricultural equipment. The primary types of equipment, other than tractors, are combines, balers, harvesters, and general-purpose machines. Emissions result from operation of the internal combustion engines that power the equipment.

Pollutants

$PM_{2.5}$ -PRI, SOx, NOx, CO, VOC and HAPs

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran NONROAD2008a model to determine the emission estimates for 2014. MDE-ARA opted to choose monthly seasonal (annual and summer) period totals as the output files from the model.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions. The emissions for the month of July was chosen and then divided by 31 (days) to get an average day for that month.

Emissions Calculation

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. These emission factors are stored in NONROAD2008a's data input files. NONROAD2008a adjusts these emission factors as necessary to account for the effects of fuel sulfur. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

5.3.9 Logging Equipment

SCC: 22 60 004 000 (2-Stroke)
22 65 004 000 (4-Stroke)
22 70 004 000 (Diesel)

Description

Logging equipment includes chainsaws, shredders, and skidders. Emissions result from operation of the internal combustion engines that power the equipment.

Pollutants

$PM_{2.5}$ -PRI, SOx, NOx, CO, VOC and HAPs

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran NONROAD2008a model to determine the emission estimates for 2017. MDE-ARA opted to choose monthly seasonal (annual and summer) period totals as the output files from the model.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions. The emissions for the month of July was chosen and then divided by 31 (days) to get an average day for that month.

Emissions Calculation

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. These emission factors are stored in NONROAD2008a's data input files. NONROAD2008a adjusts these emission factors as necessary to account for the effects of fuel sulfur. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

5.3.10 Railway Maintenance

SCC: 22 85 002 015 (4-Stroke) Gasoline
22 85 004 015 (Diesel)
22 85 006 015 (LPG)

Description

Railway maintenance equipment is equipment specifically used for repair, maintenance, and construction of rail lines. Examples of some rail equipment are ballast handlers, rail and tie handlers, and rail straightening equipment.

Pollutants

$PM_{2.5}$ -PRI, SOx, NOx, CO, NH3, and HAPs

Method and Data Sources

Data sources

- EPA NONROAD2008a Emissions Model contains an overview of the model, equipment types, pollutants reported, geographic and temporal coverage, the model components, model inputs, and output options. The EPA's NONROAD2005 (202 pp, 1.6MB, EPA420-R-05-013) user guide documents how to install and run the model and the associated reporting utilities. Websites: NONROAD2005 User's Guide (PDF) (202 pp, 1.6MB, EPA420-R-05-013) and NONROAD2008a: https://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.

- MOVES2014a Website: https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves.

Methods sources

Based upon EPA's requirements for determining nonroad emissions, the Department ran NONROAD2008a model to determine the emission estimates for 2017. MDE-ARA opted to choose monthly seasonal (annual and summer) period totals as the output files from the model.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

The NONROAD2008a model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD2008a model spatially allocates equipment populations and emissions. Input files specify the state or county then sets up the population and allocation factor data files for the chosen state.

Temporal

The NONROAD2008a model allocates activity and emissions. The emissions for the month of July was chosen and then divided by 31 (days) to get an average day for that month.

Emissions Calculation

The NONROAD2008a model estimates the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. These emission factors are stored in NONROAD2008a's data input files. NONROAD2008a adjusts these emission factors as necessary to account for the effects of fuel sulfur. Emission changes with the age of the engine, often called 'deterioration', are also applied by the model.

5.4 RAILROADS

SCC: 22 85 002 006 (Class I - Line Haul)
SCC: 22 85 002 007 (Class II and III)
SCC: 22 85 002 008 (Passenger)
SCC: 22 85 002 009 (Commuter)
SCC: 22 85 002 010 (Yard Engines)

Description

Railroad locomotives used in the United States are primarily of two types: electric and diesel-electric. Electric locomotives are powered by electricity generated at stationary power plants. Emissions are produced only at the electrical generation plant, which is considered a point source and therefore not included here. Diesel-electric locomotives, on the other hand, use a diesel engine and an alternator or generator to produce the electricity required to power its traction motors. Emissions produced by these diesel engines are of interest in emission inventory development. Other sources of emissions from railroad operations include the small gasoline and diesel engines used on refrigerated and heated rail cars. These engines are thermostatically controlled, working independently of train motive power, and fall in the category of nonroad equipment, addressed elsewhere in this document.

Locomotives can perform two different types of operations: Line Haul and Yard. Line haul locomotives, which perform the line haul operations, generally travel between distant locations, such as from one city to another. Yard locomotives, which perform yard operations, are primarily responsible for moving railcars within a particular railway yard. The use of these engines can be further divided into subcategories such as, Class 1, Class 2, Class3, Passenger, and Commuter.

Rail Classification –

1. Class I railroad: is a large freight railroad company, with annual operating revenue in access of $250 million dollars as defined by the Surface Transportation Board (STB) and Bureau of Labor Statistics (BLS)

2. Class II railroad: mid-sized freight-hauling railroads with revenues greater than $20.5 million, but less than $250 million for at least three consecutive years. Switching and terminal railroads are excluded from Class II status

3. Class III railroad: annual operating revenue is less than $20 million. Class III railroads are typically local short line railroads, serving a few towns or industries; many Class III railroads were once part of larger railroads

Class II and Class III are also defined by different labor regulations creating the two classes.

4. Passenger Railroad: passenger trains or passenger-carrying vehicles. It may be a self powered railcars, or else a combination of one or more engines and one or more unpowered trailers. These trains travel station to station or to a depot where passengers board and get off, usually operate on a fixed schedule

5. Commuter rail: called **suburban rail**, transport passengers, but only between a city and outer suburbs or nearby towns where people need to travel to on a daily basis, for reasons like working. Commuter trains also operate by schedules

Pollutants

PM2.5-PRI, SOx, NOx, CO, VOC and HAPs

Method and Data Sources:

The following eleven railroad companies operated in Maryland and were asked to provide the amount of fuel used in 2017, and the distribution of the company's track mileage by Maryland County:

Railroad Company	Railroad Classification
1. AMTRAK	Passenger Railroad
2. Canton Railroad Company	Class III **- Only Yard Railroad**
3. CSX Transportation, Incorporated	Class I – Plus Yard Railroad
4. Bay Coast Railroad	Class II Railroad
5. Maryland & Delaware Railroad Company	Yard Railroad in MD
6. Maryland Midland Railway, Incorporated	Class II
7. Norfolk and Southern Railway Company	Class I – Plus Yard Railroad
8. Western Maryland Scenic Railroad	Passenger Railroad
9. Winchester and Western Railroad Company	Class III Railroad
10. MARC	Commuter Railroad
11. Walkersville Southern Railroad	Passenger Railroad

Class 1 railroads CSX and Norfolk operating statistics contained in R-1 reports were obtained from the Surface Transportation Board under the Office of Economics, Environmental Analysis and Administration were used to add in estimating the amount of fuel used within the state.

MDE received fuel usage and track mileage data from all the railroads. Fuel usage was proportioned to each county by the amount of track miles each company utilized in a county.

Activity

A survey of railroad petroleum consumption and track mileage was conducted.

Emission Factor
Emission factors were obtained from the US EPA's and OTAC's Emissions Factors for Locomotives, Technical Highlights document, EPA-420-F-09-025 April 2009. The factors were in grams per gallon, but were converted to pounds per gallon for easier conversion of pollutant totals to tons later.

Emission Factor for Locomotives

	Line Haul		Yard
VOC	0.0107 lbs/gal	**VOC**	0.0274 lbs/gal
NOx	0.2513 lbs/gal	**NOx**	0.4542 lbs/gal
CO	0.0587 lbs/gal	**CO**	0.0631 lbs/gal
SO2	0.0001 lbs/gal	**SO2**	0.0001 lbs/gal
PM10	0.0064 lbs/gal	**PM10**	0.0099 lbs/gal
PM25	0.0062 lbs/gal	**PM25**	0.0096 lbs/gal

SO_2 emissions were calculated based on a sulfur content percent weight.

EPA estimates that yard locomotives operate 365 days per year (assuming that when a yard engine is taken in for repairs it is replaced during this period) and consumes an average of 228 gallons per day.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustments for Controls

Controls through Tier regulations were included in the EPA estimated emission factors.

Spatial and Temporal Allocations

Spatial
Emission estimates are based on fuel consumption. Company supplied state total fuel usage was allocated to the county level by the proportion of track miles used in a particular county.

Temporal
SAF was applied to emissions and were averaged according to period of operation to a daily estimate. See section 2.2.1.1

Emissions Calculation

When specific county information was not provided, the following equations were used to compute the amount of fuel consumed by each railroad in each Maryland County.

$$G_{CTY} = \frac{M_{CTY}}{M_{ST}} * G_{ST}$$

Where:

M_{CTY} = mileage of company tracks in the county
M_{ST} = mileage of company tracks in the state
G_{ST} = amount of total fuel used in gallons by the company in the state
G_{CTY} = amount of total fuel used in gallons by the company in the county

The following equation was used to calculate the emissions for line haul locomotives from each railroad company operating in a county.

$$E_{LH-i-CTY\,j} = \frac{Fuel_{CTY} \text{ x } EF_{LH}}{2000}$$

Where:

$E_{LH-i-CTY\,j}$ = Emissions from line haul railroad locomotives for pollutant i in County j
$Fuel_{CTY\,j}$ = Total amount of fuel consumed by every railroad operating in the calculated county
$Fuel_{CTY\,j}$ = $(G_{cty1} + G_{cty2} + ... + G_{cty12})$
EF_{LH} = line haul locomotive emission factor for a given pollutant

The following equation was used to calculate the yearly emissions for yard locomotives from each railroad company operating in a county.

$$E_{YL-i-CTY\,j} = \frac{N_{YL-i-CTY\,j} \text{ x } 228 \text{ x } EF_{YL} \text{ x } 365}{2000}$$

Where:

$E_{YL-i-CTY\,j}$ = Emissions from yard locomotives for pollutant i in County j
$N_{YL-i-CTY\,j}$ = number of yard locomotives operated by each railroad company in county j
$N_{YL-i-CTY\,j}$ = $(N_{cty1} + N_{cty2} + ... + N_{cty12})$
EF_{YL} = Yard locomotive emission factor for a given pollutant

Example Calculations:

Allegany County Passenger Rail Emissions (only part of emissions table)

Line Haul Emission Estimate

AMTRAK and Western Maryland Scenic Railroad operated line haul locomotives in the county.

Amount of fuel used in gallons provided by railroads:

$G_{ctyAMTRAK}$ = 20,579 gallons used in Allegany Co. per year by AMTRAK

$G_{ctyWMDSENIC}$ = 30,000 gallons used in Allegany Co. per year by Western Maryland Scenic

EPA Tier controlled VOC emission factor for 2017 is 0.0107 lbs. $_{VOC}$/gal
VOC Emissions from line haul locomotives in Allegany County:

$$EM_{AlleganyPassVOC} = \frac{(20{,}579 \text{ gal / yr} + 30{,}000 \text{ gal / yr}) * 0.0107 \text{ lbs. }_{VOC}\text{/gal}}{(2000 \text{ lbs. per ton})}$$

$EM_{AlleganyPassVOC}$ = **0.27 tons $_{VOC}$ / year**

EPA Tier controlled NOX emission factor for 2017 is 0.2513 lbs. $_{NOX}$/gal
NOx Emissions from line haul locomotives in Allegany County:

$$EM_{AlleganyPassNOX} = \frac{20{,}579 \text{ gal / yr} + 30{,}000 \text{ gal / yr}) * 0.2513 \text{ lbs. }_{VOC}\text{/gal}}{(2000 \text{ lbs. per ton})}$$

$EM_{AlleganyPassNOX}$ = **6.36 tons $_{NOX}$ / year**

EPA Tier controlled CO emission factor for 2017 is 0.0587 lbs. $_{CO}$/gal
CO Emissions from line haul locomotives in Allegany County:

$$EM_{AlleganyPassCO} = \frac{20{,}579 \text{ gal / yr} + 30{,}000 \text{ gal / yr}) * 0.0587 \text{ lbs. }_{VOC}\text{/gal}}{(2000 \text{ lbs. per ton})}$$

$EM_{AlleganyPassCO}$ = **1.48 tons $_{CO}$ / year**

Yard Locomotives Emission Estimate
CSX reportedly operated 4 yard locomotives in Anne Arundel County at 304 cumulative duty hours for the year at a rate of 247.18 gallons of fuel per hour.

CSX_{FUEL} = (304 x 247.18) = 75,143 gallons

VOC Emissions from *yard* locomotives in Anne Arundel County:
EPA Tier controlled VOC emission factor for 2017 is 0.0274 lbs. $_{VOC}$/gal

$$EM_{CSXVOC} = \frac{(75{,}143 \text{ gal / yr}) \text{ x } (0.0274 \text{ lbs. }_{VOC}\text{/gal})}{(2000 \text{ lbs. per ton})}$$

EM_{CSXVOC} = 1.03 tons $_{VOC}$ / year

NOx Emissions from *yard* locomotives in Anne Arundel County:
EPA Tier controlled NOX emission factor for 2017 is 0.4542 lbs. $_{NOX}$ /gal

$$EM_{CSXNOX} = \frac{(75{,}143 \text{ gal / yr}) \times (0.4542 \text{ lbs. }_{NOX}\text{/gal})}{(2000 \text{ lbs. per ton})}$$

EM_{CSXNOX} = 17.06 tons $_{VOC}$ / year

CO Emissions from *yard* locomotives in Anne Arundel County:
EPA Tier controlled CO emission factor for 2017 is 0.0613 lbs. $_{CO}$ /gal

$$EM_{CSXCO} = \frac{(75{,}143 \text{ gal / yr}) \times (0.0613 \text{ lbs. }_{CO}\text{/gal})}{(2000 \text{ lbs. per ton})}$$

EM_{CSXCO} = 2.30 tons $_{CO}$ / year

Daily emissions for rail were calculated by taking the annual emissions and dividing them by 365 (days).

EM_{CSXCO} = 6.31E-03 tons $_{CO}$ / day

5.5 AIRCRAFT

SCC: 22 75 020 000 (Commercial Aircraft)
SCC: 22 75 050 000 (General Aviation)
SCC: 22 75 060 000 (Air Taxi)
SCC: 22 75 001 000 (Military Aviation)

Description:

This category includes three sub-categories identified as: commercial aircraft, general aviation, and military aircraft. Commercial aircraft are used in regularly scheduled flights transporting passengers, freight, or both. General aviation, which includes air taxis and commuter aviation, is used for recreational flying, business travel, personal transportation, and various other activities. Military aviation is the operation and activities of military aircraft at airports in Maryland. Air Taxi operation can be separated into its own subcategory.

Pollutants

PRI-PM_{10}, PRI-$PM_{2.5}$, SOx, NOx, CO, VOC

Method and Data Sources

ARA used a variety of sources for data and emission calculation methods as follows:

Data sources

1) Federal Aviation Administration (FAA) website contains airport activity statistics for some Maryland airports and air fields by subcategory description, plane, and engine types.

2) Landing and takeoff cycle information was obtained from the Maryland Aviation Administration for BWI, Martin State, Military Bases, several large, and several small airport and air fields.

3) The MDE's Emission Inventory section also performed a statewide survey to obtain LTO, engine type, location, and usage data from over 200 individual airports and air fields.

Methods sources

1) For general aviation ARA used emission factors supplied in Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, EPA's Office of Mobile Sources, 1992. This source provided emission factors for specific commercial engine types, and alternative fleet average factors for general aviation, air taxis, and commuter aircraft.

2) For military aircraft ARA used a composite factor from section 5.2.5, Table 5-7 of Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, 1988. This method required ARA to collect LTO data rather than specific aircraft data. For the 2017 inventory ARA requested operation data for military aircraft from Maryland Army, Navy, and Air Force base environmental support offices.

3) For commercial aviation ARA used FAA's EDMS[1] emissions model and databases. EDMS is designed to assess the air quality impacts of airport emission sources, particularly aviation sources, which consist of aircraft, auxiliary power units, and ground support equipment. EDMS features the latest aircraft engine emission factors from the International Civil Aviation Organization (ICAO) Engine Exhaust Emissions Data Bank, vehicle emission factors from EPA MOBILE 6.2, and EPA-validated dispersion algorithms. Aircraft activity includes landside and airside operations. EDMS defines four distinct modes of aircraft operation based upon EPA and FAA guidance: approach, taxi/idle, takeoff, and climb out. Together, these four modes constitute one Landing and Takeoff (LTO) cycle. EDMS calculates aircraft emissions based on these four modes.

4) For all aircraft types, ARA used a default mixing height value of 3,000 feet above ground level. The mixing height is the layer of air where airplane emissions affect ground level emission concentrations. Above the mixing level, pollutants are transported away according to sections 5.2.2 of the 1992 Procedures. Because of the mixing height, ARA assigned all aircraft emissions from a particular airport to the county where that airport was located. We assumed no seasonal variation and a seven day per week activity level.

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial
Data for spatial allocation is not available for this source.

Temporal
In EDMS actual weather (annual average values or hourly values) are in used for both modeling. **Daily emissions for rail were calculated by taking the annual emissions and dividing them by 365 (days).**

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[1] Emissions & Dispersion Modeling System (EDMS) Version 5.1 for Windows from CSSI, Inc

5.5.1 Commercial Aircraft

SCC: 22 75 020 000

Steps in Creating and Airport Emission Inventory in EDMS:

1) Open the EDMS model and create a new study for the airport in question. Choose the airport identification code. Enter the parameters (name, measuring and reporting units, and analysis year you want modeled).
2) Provide EDMS with information to compute the emissions inventory. Begin by matching engines with aircraft and assigning them to the study. Select the aircraft to be used in the study (data that is collected from the airport) by picking the aircraft name from the menus. EDMS automatically associates specific aircraft with certain engine types (Choose from list).
3) For each aircraft fill in the yearly LTO cycles provided by surveying the airport.
4) Each time you fill in LTOs the model will automatically default the taxi time and queue time specific to the specified airport or use the EDMS provide default values.
5) Continue to add each aircraft/engine type, LTO cycle until all are LTOs are entered for that study.
6) EDMS has tables built into the model that associate aircraft type with the number of engines, auxiliary power units and ground support equipment. The model also assigns default values for Takeoff Time (typically 0.3 minutes), Climbout Time (typically 5 minutes), and Approach Time (typically 6 minutes).
7) If emissions from parking lots, roadways, stationary sources, and training fires are also required, complete the dialog boxes associated with each of these subcategories.
8) Run the EDMS emission inventory program and view the results.

Emissions Calculation

The data for aircraft engines listed below in Table 5.5.1-a are defaults used to calculate emissions within the EDMS Model. Each mode of operation, such as, annual LTO operations, average taxi time, approach, climb-out, takeoff, and annual queue times are used in the estimation of emissions, but LTO operations was taken from FAA and airport records.

TABLE 5.5.1-a EDMS Aircraft & Engine Estimated Averages and Defaults Data

Aircraft Name	Aircraft Type	Engine Assigned	Approach Time (min)	Climbout Time (min)	Takeoff Time (min)	Annual LTO	Taxi Time (min)	Queue Time (min)
Falcon 100	GA	TFE731-3	1.60	0.50	0.40	1825	10.50	3.00
P-337P Skymaster	GA	TSIO-360C	4.50	2.50	0.50	9490	10.50	3.00
550 Citation	GA	JT15D-4 (B,C,D)	1.60	0.50	0.40	2190	10.50	3.00
A320	Comm	CFM56-5B4	4.00	2.20	0.70	2555	10.50	3.00
AH-1	Military	T53-L-11D	6.80	6.80	0.00	1825	10.50	3.00
ATR42	Comm	PW120	4.50	2.50	0.50	2190	10.50	3.00
B727-100	Comm	JT8D-7A	4.00	2.20	0.70	8030	10.50	3.00
B737-200	Comm	JT8D-15A	4.00	2.20	0.70	21900	10.50	3.00

Aircraft Name	Aircraft Type	Engine Assigned	Approach Time (min)	Climbout Time (min)	Takeoff Time (min)	Annual LTO	Taxi Time (min)	Queue Time (min)
B737-300	Comm	CFM56-3B	4.00	2.20	0.70	13140	10.50	3.00
B737-400	Comm	CFM56-3B	4.00	2.20	0.70	3650	10.50	3.00
B737-500	Comm	CFM56-3B	4.00	2.20	0.70	8030	10.50	3.00
B737-700	Comm	CFM56-3C-1	4.00	2.20	0.70	730	10.50	3.00
B747-100	Comm	JT9D-7A	4.00	2.20	0.70	183	10.50	3.00
B757-200	Comm	PW2037	4.00	2.20	0.70	7665	10.50	3.00
B767-200	Comm	CF6-80A (A1)	4.00	2.20	0.70	1095	10.50	3.00
BAE ATP	Comm	PT6A-45	4.00	2.20	0.70	2555	10.50	3.00
BH-1900	Comm	PT6A-65B	1.60	0.50	0.40	3285	10.50	3.00
C-12A/B/C	Military	PT6A-41	3.50	0.80	0.40	730	10.50	3.00
C-130 Hercules	Military	T56-A-16	5.10	1.20	0.40	365	10.50	3.00
C-9A	Military	JT8D-9	5.10	1.20	0.40	365	10.50	3.00
Canadair Reg-100	Comm	CF34-3A1	4.00	2.20	0.70	730	10.50	3.00
Cessna 150	GA	O-200	6.00	5.00	0.30	5110	10.50	3.00
Convair liner	Comm	RDA10	4.50	2.50	0.50	365	10.50	3.00
DC10-10	Comm	CF6-50C	4.00	2.20	0.70	730	10.50	3.00
DC9-10	Comm	JT8D-7A	4.00	2.20	0.70	4380	10.50	3.00
DHC-8	Comm	PW120	4.50	2.50	0.50	3650	10.50	3.00
DHC-8-400	Comm	PW123	4.50	2.50	0.50	18250	10.50	3.00
F-16	Military	F100-PW-100	3.50	0.80	0.40	183	10.50	3.00
F-27 Series	Military	RDa7	4.50	2.50	0.50	365	10.50	3.00
Fokker 100	GA	TAY650	4.00	2.20	0.70	365	10.50	3.00
H-46 Sea Knight	Military	T58-GE-8F	6.80	6.80	0.00	183	10.50	3.00
Kingair B200	GA	PT6A-41	1.60	0.50	0.40	5840	10.50	3.00
Learjet 25B	GA	CJ610-6	1.60	0.50	0.40	1460	10.50	3.00
MD-11	Comm	CF6-80C2D1F	4.00	2.20	0.70	730	10.50	3.00
MD-80	Comm	JT8D-209	4.00	2.20	0.70	4563	10.50	3.00
MD-80-88	Comm	JT8D-217	4.00	2.20	0.70	1825	10.50	3.00
MD-90-10	Comm	V2525-D5	4.00	2.20	0.70	365	10.50	3.00
Porter PC6/B2	Military	PT6A-27	4.50	2.50	0.50	730	10.50	3.00

Aircraft Name	Aircraft Type	Engine Assigned	Approach Time (min)	Climbout Time (min)	Takeoff Time (min)	Annual LTO	Taxi Time (min)	Queue Time (min)
SF-340-A	Comm	CT7-5	4.50	2.50	0.50	730	10.50	3.00
Swearingen Merlin	Comm	TPE331-3	4.50	2.50	0.50	2920	10.50	3.00
Swearingen Merlin	Comm	TPE331-3	4.50	2.50	0.50	365	10.50	3.00

Once all of the data is entered into the model, the model produces an emission inventory. **Defaults data is updated as new revisions of the model are posted**. For the latest Annual emission totals inventory are listed in the table below:

The model will also produce an inventory specific to each aircraft type, which allows the data to be separated into types (commercial, general aviation, and military) of operation. For BWI the separation results in the following:

TABLE 5.5.1-b BWI Category Emissions Summary Using EDMS

NAME	CO Tons/year	VOC Tons/year	NOX Tons/year	SOX Tons/year	PM10 Tons/year	PM2.5 Tons/year
Commercial Aircraft	992.81	219.07	1,048.49	110.86	29.90	29.90
General Aviation	60.80	13.42	64.21	6.79	1.83	1.83
Air Taxi	140.94	31.10	148.85	15.74	4.24	4.24
Military Aviation	5.04	1.11	5.33	0.56	0.15	0.15
Total	**1,199.60**	**264.70**	**1,266.88**	**133.96**	**36.13**	**36.13**

The model was run for all aircraft at BWI, Martin State, Hagerstown Regional, Ocean City Municipal, Frederick County, Phillips Air Field, Weide Army Air Field and Andrews Air Force

5.5.2 General Aviation

SCC: 22 75 050 000

Emission Calculation

An estimate of emissions was calculated after information on the LTO operations of aircraft operation type was obtained from Maryland's airports. This method used the alternative fleet-average procedure of Section 5.2.4.2 of Procedures, 1992. The composite emission factors used are listed in the table below.

TABLE 5.5.2-a EPA Emission Factors for Aircraft

Aviation Category	CO (lbs./LTO)	VOC (lbs./LTO)	NOx (lbs./LTO)	SO2 (lbs./LTO)	PM10-PRI (lbs./LTO)	PM2.5-PRI (lbs./LTO)
General Aviation	12.014	0.382	0.065	0.100	0.020	0.020
Air Taxis	28.130	1.223	0.158	0.015	0.020	0.020
Military	48.800	27.10	9.160	1.430	15.23	15.23

* Requires Hydrocarbon to VOC conversion factor of 0.9708 for General Aviation and 0.9914 for Air Taxis.

1) $Emiss_{VOC}$ = LTO (GA) * EF $(GA)_{VOC}$

Where:
LTO (GA) = LTOs for General Aviation
EF $(GA)_{xx}$ = Emission Factors for General Aviation

2) $Emiss_{VOC}$ = LTO (AT) * EF $(AT)_{VOC}$

Where:
LTO (AT) = LTOs for Air Taxis
EF $(AT)_{xx}$ = Emission factors for Air Taxis

Sample Calculation – General Aviation:
This calculation is for Harford County. Harford had 11,832 General Aviation LTOs over a twelve month period.

$Emiss_{VOC}$ = [LTO (GA) * EF $(GA)_{HC}$] * CF (VOC/HC)
$Emiss_{VOC}$ = [(11,832 LTOs / Year * 0.383 (lbs. HC / LTO)] * 0.9708 (lbs. VOC / lbs. HC))]
$Emiss_{VOC}$ = 4,388 lbs. VOC / Year
$Emiss_{VOC}$ = 2.19 Tons VOC / Year

Daily: $Emiss_{VOCDaily}$ = $Emiss_{VOC}$ / 365
$Emiss_{VOCDaily}$ = 2.19 / 365
$Emiss_{VOCDaily}$ = 6.01E-03 Tons VOC / Day

Military Aircraft

SCC: 22 75 001 000

There are five military airports in Maryland. They are Andrews Air Force Base, Fort Meade/Tipton, Aberdeen, Patuxent River Naval Air Station, and Martin State Airport. ARA received LTO and onsite emission information from some military airports and emission totals from others due to national security concerns. Most of the county airports also receive a small number of military operations.

Method and Data Sources

Since ARA asked for and received LTO information by aircraft operation type, ARA used composite emission factors from Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, 1988 and the EDMS model (version 5.1).

TABLE 5.5.3-a EPA Emission Factors for Military Aircraft

	CO (lbs./LTO)	VOC (lbs./LTO)	NOx (lbs./LTO)	SO2 (lbs./LTO)	PM (lbs./LTO)
Military Aircraft	48.80	27.10	9.160	1.43	15.230

1) $Emiss_{VOC} = L(MA) * EF(MA)_{VOC}$

Where:
L(MA) = LTOs for Military Aircraft
$EF(MA)_{xx}$ = Emission factors for Military Aircraft

Emissions Calculation

Sometime military bases use commercial or other local fields. It was reported the military made 13 LTOs at Tipton Airport and 100 at Reservoir Airport in Anne Arundel County.

$Emiss_{VOC}$ = [L(MA) * $EF(MA)_{HC}$]
$Emiss_{VOC}$ = [(13 LTOs / Year * 27.10 (lbs. VOC / LTO)]
$Emiss_{VOC}$ = 352.30 lbs. VOC / Year
$Emiss_{VOC}$ = 1.76E-01 Tons VOC / Year

$Emiss_{CO}$ = [13 LTOs / Year * 48.80 (lbs. CO / LTO)]
$Emiss_{CO}$ = 634.40 lbs. of CO / Year
$Emiss_{CO}$ = 3.17E-01 Tons CO / Year

Daily calculation can be made for each county (see example below)
Military emissions in Anne Arundel County CO total were:
$Emiss_{CO}$ = 3.17E-01 / 365 Tons CO / Day
$Emiss_{CO}$ = 8.69E-04 Tons CO / Day

5.6 MARINE VESSELS

SCC: 2280002100 (Diesel Oil – Port Emissions)
2280002200 (Diesel Oil – Underway Emissions)
2280003100 (Residual Oil – Port Emissions)
2280003200 (Residual Oil – Underway Emissions)

Description

Commercial Marine Vessels (CMV) includes all boats and ships used either directly or indirectly for commerce or military activity. These include vessels ranging in size from 20-foot charter boats to the largest tankers and military vessels, which can exceed 1,000 feet in length. "The CMV source category does not include recreational marine vessels, which are generally less than 100 feet in length, most being less than 30 feet, and powered by either inboard or outboard engines. The NONROAD model calculates these emissions.

Pollutants

PM2.5-PRI, PM10-PRI, SO_2, NOx, CO, CO_2, VOC, NH3, and HAPS

Method and Data Sources

Historically, MDE used marine vessels data prepared by the Baltimore Maritime Exchange (BME) to develop and calculated commercial marine vessels emissions inventory and referenced with the marine emission inventory guidance method outlined in Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data (EPA-450-R-00-002), February 2000. However, EPA offers the most recent descriptions and current methodologies used for the calculations for CMVs inventory. As an as result, MDE performed comparison analyses between MDE and EPA's 2016 beta platform modeling emission for the 2017 CMVs emissions inventory estimates. After the analyses comparisons, The Department decided to adopt EPA's 2016 beta platform modeling (Sparse Matrix Operating Kernel Emissions (SMOKE) modeling system version 4.6) emissions estimates and methodology for Maryland's 2017 CMV inventory cycle.

The EPA used the Sparse Matrix Operating Kernel Emissions (SMOKE[1]) modeling system version 4.6, to model Commercial Marine Vessels (CMV), Category 1 and Category 2 sectors (cmv_c1c2), and Category 3 (cmv_c3) sector for the 2016ff beta platform emissions inventory. National and state-level emission summaries for key pollutants are provide.[2]

CMV_c1c2 Modeling Method:

The cmv_c1c2 inventory sector contains small to medium-size engine CMV emissions. Category 1 (C1) and Category 2 (C2) marine diesel engines typically range in size from about 700 to 11,000 hp. These engines are used to provide propulsion power on many kinds of vessels including tugboats, towboats, supply vessels, fishing vessels, and other commercial vessels in and around ports. They are also used as

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[1] http://www.smoke-model.org/index.cfm

[2] EPAs *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C1/C2 Sources* http://views.cira.colostate.edu/wiki/wiki/10197; 2016beta Platform Inventory Collaborative Wiki.

stand-alone generators for auxiliary electrical power on many types of vessels. C1 represents engines up to 7 liters per cylinder displacement. C2 includes engines from 7 to 30 liters per cylinder.

The cmv_c1c2 inventory sector contains sources that traverse state and federal waters and that are in the 2014NEIv2.[1] Where the Category 3 CMV (cmv_c3) inventory is modeled as point sources with plume rise, the cmv_c1c2 sources are modeled as area sources with emissions that occur only near the Earth's surface.[2] The cmv_c1c2 sources in the 2016beta inventory are categorized as operating either in-port or underway and are encoded using the two source classification codes (SCCs) listed in Table 5.6.1.

Table 5.6.1 2016 beta platform SCCs for cmv_c1c2 sector

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2280002100	Mobile Sources	Marine Vessels, Commercial	Diesel	Port emissions
2280002200	Mobile Sources	Marine Vessels, Commercial	Diesel	Underway emissions

The cmv_c1c2 inventory sector contains sources that traverse state and federal waters and that are in the 2014NEIv2. Where the Category 3 CMV (cmv_c3) inventory is modeled as point sources with plume rise, the cmv_c1c2 sources are modeled as area sources with emissions that occur only near the Earth's surface.[3]

In developing the 2016 beta platform cmv_c1c2 inventory, EPA used CMV_c1c2 emissions from the 2014NEIv2 and projected to 2016 using factors derived from the Regulatory Impact Analysis (RIA) Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters per Cylinder[4]. Emissions projection factors were specified by pollutant and applied nationally, except for vessels registered in California. Volatile Organic Compound (VOC) projection factors were applied to both VOC and the VOC Hazardous Air Pollutants (HAPs). Table 5.6.2 lists the pollutant-specific projection factors to 2016 that were used for cmv_c1c2 sources outside of California.

Table 5.6.2 National projection factors for cmv_c1c2[5]

Pollutant	2014-to-2016
CO	-1.44%
NOX	-7.44%
PM10	-11.04%
PM2.5	-11.04%
SO2	-60.28%
VOC	-7.96%

Spatial Allocation

Spatial allocation of cmv_c1c2 sector emissions was

[1] https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data
[2] https://www.epa.gov/sites/production/files/2015-10/documents/fy12-marine-rule-flowchart.pdf
[3] EPAs *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C1/C2 Sources* http://views.cira.colostate.edu/wiki/wiki/10197; 2016beta Platform Inventory Collaborative Wiki.
[4] EPAs *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C1/C2 Sources* http://views.cira.colostate.edu/wiki/wiki/10197; 2016beta Platform Inventory Collaborative Wiki.
And https://nepis.epa.gov/Exe/ZyPDF.cgi/P10023S4.PDF?Dockey=P10023S4.PDF
[5] EPAs *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C1/C2 Sources* http://views.cira.colostate.edu/wiki/wiki/10197

used to a national 36km and 12km modeling grids is accomplished using spatial surrogates. Spatial surrogates map county polygons to the uniformly spaced grid cells of a modeling domain. The cmv_c1c2 sector uses surrogate (Ports NEI2014 Activity) for port emissions and surrogate (2013 Shipping Density) for underway emissions.

Temporal Allocation

Month-of-year temporalization for the cmv_c1c2 sector is flat, except for emissions in the Great Lakes which uses 2014-based monthly profiles provided by LADCO[1]. As the day-of-week and hour-of-day temporal profiles are flat for all cmv_c1c2 sources, air quality model-ready emissions were only prepared for one representative day per month. Because day-of-week temporalization is flat for all sources, a single representative day per month was processed. The cmv_c1c2 sector was processed through SMOKE as nonpoint/area sources. This is a 2-D sector in which all emissions are output to a single layer, gridded emissions file.

The Great Lakes vessels use the profiles that include "GLCMV" in the monthly profile name; the rest of the sources in the U.S. use the flat monthly profile for the 2016beta emissions.

CMV_c3 Modeling Method:

The cmv_c3 sector contains large engine CMV emissions. Category 3 (C3) marine diesel engines are those at or above 30 liters per cylinder, typically these are the largest engines rated at 3,000 to 100,000 hp. C3 engines are typically used for propulsion on ocean-going vessels including container ships, oil tankers, bulk carriers, and cruise ships. Emissions control technologies for C3 CMV sources are limited due to the nature of the residual fuel used by these vessels.[2]

The cmv_c3 sector contains sources that traverse state and federal waters and that are in the NEI2014v2; plus sources in waters not covered by the NEI. Where the Category 3 CMV (cmv_c3) inventory is modeled as point sources with plume rise, the cmv_c1c2 sources are modeled as area sources with emissions that occur only near the Earth's surface.

The cmv_c3 sources that operate outside of state waters but within the federal Emissions Control Area (ECA) are encoded with a Federal Information Processing Standard (FIPS) state code of 85. The ECA areas include parts of the Gulf of Mexico, and parts of the Atlantic and Pacific coasts. As the U.S. federal waters around Puerto Rico and Alaska are outside the continental U.S. (CONUS) modeling domain, cmv_c3 sources for these regions are not included in the 2016beta inventory. The cmv_c3 sources in the 2016beta inventory are categorized as operating either in-port or underway and are encoded using the two source classification codes (SCCs) listed in Table 5.6.3. In addition to C3 sources in state and federal waters, the cmv_c3 sector includes emissions in waters not covered by the NEI and taken from the "ECA-IMO-based"

[1] EPAs *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C1/C2 Sources;* Details are available in the workbook TemporalProfiles_byLake_UNC_14Mar2017.xlsx
[2] *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C3 Sources*
https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-marine-vessels

C3 CMV inventory[1]. The ECA-IMO inventory is also used for allocating the county-level emissions to geographic locations.

Table 5.6.3 2016 beta platform SCCs for cmv_c3 sector[2]

SCC	**Tier 1 Description**	**Tier 2 Description**	**Tier 3 Description**	**Tier 4 Description**
2280003100	Mobile Sources	Marine Vessels, Commercial	Residual	Port emissions
2280003200	Mobile Sources	Marine Vessels, Commercial	Residual	Underway emissions

The EPA development the 2016 beta platform cmv_c3 inventory consisted of two steps: converting the NEI2014v2 nonpoint C3 emissions to point format, and projecting those emissions to year 2016. These steps are described below.

- **Conversion of NEI2014v2 nonpoint C3 to point format**

The NEI2014v2 nonpoint C3 inventory was converted to a point inventory to support plume rise calculations for C3 vessels. The nonpoint emissions were allocated to point sources using a multi-step allocation process because not all of the inventory components had a complete set of county-SCC combinations. In the first step, the county-SCC sources from the nonpoint file were matched to the county-SCC points in the 2011 ECA-IMO C3 inventory. The ECA-IMO inventory contains multiple point locations for each county-SCC. The nonpoint emissions were allocated to those points using the $PM_{2.5}$ emissions at each point as a weighting factor[3].

The cmv_c3 port emissions, which did not have a matching FIPS in the ECA-IMO inventory, were allocated using the 2016 port shapefiles obtained from the EPA Office of Transportation and Air Quality (OTAQ). The contribution fraction of $PM_{2.5}$ from each county that overlapped with the port area polygon was calculated as an initial weighting factor. The port polygons were then drawn with an overlapping 4 km resolution modeling grid on a Lambert Conformal Conic projection. The fraction of the area of each grid cell overlapping the port polygon was calculated as a second weighting factor. The centroids of the grid cells overlapping each port was obtained and grouped by county FIPS. A final area-to-point allocation factor was calculated using the product of the two weighting factors at each centroid point and normalizing the sum of all weighting factors in a county to unity. Any remaining unmatched counties with port emissions from the area inventory were allocated to the centroids of the cells in the 12 km 2014 port area spatial surrogate (surrogate code 801). The emissions for those counties were allocated using the weighting factors in the surrogate.
The cmv_c3 underway emissions that did not have a matching FIPS in the ECA-IMO inventory were allocated using the 12 km 2014 offshore shipping activity spatial surrogate (surrogate code 806). Each county with underway emissions in the area inventory was allocated to the centroids of the cells associated with the respective county in the surrogate. The emissions were allocated using the weighting factors in the surrogate.

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[1] *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C3 Sources*
https://www.epa.gov/sites/production/files/2017-08/documents/2014v7.0_2014_emismod_tsdv1.pdf
[2] *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C3 Sources*
https://www.epa.gov/sites/production/files/2017-08/documents/2014v7.0_2014_emismod_tsdv1.pdf
[3] *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C3 Sources*
https://www.epa.gov/sites/production/files/2017-08/documents/2014v7.0_2014_emismod_tsdv1.pdf

The resulting point emissions were converted to an annual point 2010 flat file format (FF10). Pictures of the emissions are shown in Section 7 of this document. A set of standard stack parameters were assigned to each release point in the cmv_c3 inventory. The assigned stack height was 65.62 ft, the stack diameter was 2.625 ft, the stack temperature was 539.6 °F, and the velocity was 82.02 ft/s[1].

- **Projection of NEI2014v2 point C3 to 2016**

Projections of the NEI2014v2 cmv_c3 emissions to the year 2016 were based on United States Army Corps of Engineers' Entrance and Clearance (E&C) data. Those data were used to estimate the change in commercial shipping activity between 2014 and 2016. E&C data includes records of each entrance and clearance of a port by any vessel involved in international commerce annually. The data do not include information for Jones Act Ships, which are U.S.-owned and U.S.-crewed ships that transit exclusively between U.S. ports. E&C data from 2014 and 2015 were used to determine C3 marine vessel trips by region, engine type, and year built.

In 2014, marine vessels in the North American Emission Control Area (ECA), which extends 200 miles from the shores of North America, Puerto Rico, and the Virgin Islands, met a fuel sulfur standard of 10,000 ppm. On January 1st, 2015, the ECA initiated a fuel sulfur standard which regulated large marine vessels to use fuel with 1,000 ppm sulfur or less. EPA multiplied European Union (EU)[2] C3 emissions factors that include these standards with the E&C calls of the respective years.

The EU emission factors also reflect IMO Tier 3 NOx regulations that apply to engines installed on ships constructed (i.e., keel is laid) on or after January 1st, 2016. However, in allotting time for ship building and engine installation, EPA does not expect Tier 3 vessels to be active by December 31st, 2016. Therefore, the 2016 regional fleet population was assumed to be the same as that of 2015, and the appropriate emission factors were applied. The final growth factors were determined by dividing the 2016 sum of the products of emission factors and calls by that of 2014 per pollutant and region.

The cmv_c3 projection factors are pollutant-specific and region-specific. Most states are mapped to a single region with a few exceptions. Pennsylvania and New York were split between the East Coast and Great Lakes, Florida was split between the Gulf Coast and East Coast, and Alaska was split between Alaska East and Alaska West. The 2014-to-2016 projection factors for C3 sources are listed in Table 5.6.4. The Non-Federal factors listed in this table were applied to sources outside of U.S. federal waters (FIPS 98). Volatile Organic Compound (VOC) Hazardous Air Pollutant (HAP) emissions were projected using the VOC factors. NH3 emissions were held constant at 2014 levels[3].

[1] *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C3 Sources*
https://www.epa.gov/sites/production/files/2017-08/documents/2014v7.0_2014_emismod_tsdv1.pdf

[2] http://ec.europa.eu/environment/air/pdf/chapter1_ship_emissions.pdf

[3] *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C3 Sources*
https://www.epa.gov/sites/production/files/2017-08/documents/2014v7.0_2014_emismod_tsdv1.pdf

Table 5.6.4 2014-to-2016 projection factors for C3 CMV

Region	CO	NOX	PM10	PM2.5	SO2	VOC
Alaska East	-3.67%	-4.28%	-61.02%	-61.93%	-90.42%	-3.72%
Alaska West	17.56%	14.49%	-50.95%	-52.83%	-88.38%	17.42%
East Coast	-0.08%	-0.86%	-58.47%	-59.97%	-90.11%	-0.17%
Gulf Coast	-0.03%	-0.96%	-58.04%	-59.68%	-90.06%	-0.04%
Great Lakes	-4.56%	-4.93%	-60.22%	-61.46%	-90.37%	-4.33%
Hawaii East	-5.95%	-6.44%	-61.37%	-62.62%	-90.73%	-6.12%
North Pacific	-8.32%	-9.18%	-61.42%	-62.94%	-90.87%	-8.31%
Puerto Rico	-0.63%	-1.07%	-58.68%	-59.99%	-90.02%	-0.48%
South Pacific	-10.36%	-11.57%	-62.17%	-63.68%	-91.05%	-10.31%
Virgin Islands	-20.01%	-19.80%	-66.57%	-67.49%	-91.80%	-19.59%
Non-Federal	5.98%	5.98%	5.98%	5.98%	5.98%	5.98%

Spatial Allocation

The 2016beta platform cmv_c3 emissions are point sources and are allocated directly to grid cells within SMOKE, with the conversion of the area source NEI2014v2 cmv_c3 inventory to the 2016beta platform point source format.

Temporal Allocation

Month-of-year temporalization for emissions in the Great Lakes used 2014-based monthly profiles provided by LADCO[1]. For the rest of the sector, month-of-year temporalization used a monthly temporal profile that was first developed for C3 emissions for an earlier EPA emissions modeling platform. As the day-of-week and hour-of-day temporal profiles are flat for all cmv_c3 sources, air quality model-ready emissions were only prepared for one representative day per month. Because day-of-week temporalization is flat for all sources, a single representative day per month is processed. Cmv_c3 sector was processed through SMOKE as point sources and is a 3-D sector in which all emissions are output to an inline point source file to support plume rise calculations within the air quality model. No 2-D gridded emissions were generated for this sector.

The Great Lakes vessels use the profiles that include “GLCMV” in the monthly profile name, used for the 2016beta emissions[2].

[1] Details are available in the workbook TemporalProfiles_byLake_UNC_14Mar2017.xlsx

[2] *Emissions Modeling Platform Collaborative: 2016beta Commercial Marine C3 Sources*
https://www.epa.gov/sites/production/files/2017-08/documents/2014v7.0_2014_emismod_tsdv1.pdf

Table 5.6.5 2016 cmv_c3 emissions by monthly temporal profile (Federal included waters but not non-US sources)

Monthly profile	CO	NH3	NOX	PM10	PM2.5	SO2	VOC
GLCMV1	4	0	44	1	1	1	2
GLCMV10	21	0	173	4	3	6	6
GLCMV11	17	0	145	3	3	5	5
GLCMV12	4	0	37	0	0	1	1
GLCMV5	58	0	610	8	7	15	26
GLCMV8	6	0	51	2	1	2	3
GLCMV9	1	0	4	0	0	0	0

Point Source Adjustments

No point source emissions were subtracted from the area source inventory.

Adjustment for Controls

Controls were applied when applicable to a particular source category.

Spatial and Temporal Allocations

Spatial

National level CMV information was broken down to shapeID# using spatial allocation documented and assigned by EPA.

Temporal

Data for temporal allocation was base on EPA’s annual emissions and were divided by 312 to estimate daily emissions.

6.0 ONROAD MOBILE SOURCES

6.1 INTRODUCTION

This document detailed the methodology, assumptions and results of work performed by MSCP, ARA of MDE to generate the 2017 ozone and the greenhouse gases (GHG) precursor emissions inventories for highway vehicles using the MOVES2014a modeling tools. As detailed in the following sections, the 2017 inventories of highway vehicles had been developed based on daily and annual Highway Performance Monitoring System (HPMS) inventories.

The official 2017 ozone and GHG precursor inventory of highway vehicles for the Baltimore Ozone Nonattainment Area, which comprises Baltimore City, and the counties of Anne Arundel, Baltimore, Carroll, Harford and Howard were the daily and annual HPMS-based inventories. The official 2017 ozone and GHG precursor inventory of highway vehicles for the Maryland portion of the Metropolitan Washington Council of Governments (MWCOG) Nonattainment Area, which comprises the counties of Calvert, Charles, Frederick, Montgomery and Prince George's, were also the daily and annual HPMS-based inventories.

The official 2017 ozone and GHG precursor inventories of highway vehicles for the Maryland portion of the Philadelphia, Pennsylvania Ozone Nonattainment Area, which comprises Cecil County, and the counties of Kent and Queen Anne's Nonattainment Area were also the daily and annual HPMS-based inventories.

The official 2017 ozone and GHG precursor inventory for the remaining portion of the State, which comprises the counties of Allegany, Caroline, Dorchester, Garrett, Saint Mary's, Somerset, Talbot, Washington, Wicomico and Worcester, were also the daily and annual HPMS-based inventories.

6.1.1 Highway Vehicle Emissions Inventory

This inventory documented herein described specifically how United States Environmental Protection Agency's (USEPA's) MOVES2014a (MOVES) was used to estimate the 2017 annual criteria pollutants' and GHG's emissions as well as 2017 daily criteria pollutants from on-road vehicles and total energy consumption in the State. MOVES2014 is the best tool used in developing these criteria pollutants and GHG emission estimates. Moreover, MOVES was used at the County scale to estimate the emissions of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) as these pollutants basically make up the GHG pollutants.

Emissions were estimated based on emission factors and vehicle activity. Consequently, emission factors for vehicles were based on vehicle type such as passenger cars, passenger trucks, vehicle age and the vehicle's operating modes. Operating modes for running, start, and idle emissions are included in MOVES. It should be noted that operating modes for running emissions were based on vehicle speed as well as whether the vehicle was accelerating, decelerating or cruising. In addition, the emission factors from all vehicles varied over the entire range of conditions these vehicles operate such as the ambient air temperature, speed, traffic conditions, road types, road topography, etc. Furthermore, these generated emission factors were then multiplied by the appropriate VMT to estimate the criteria pollutants' and GHG's emissions and energy consumption. Moreover, the inventory must also account for non-exhaust or evaporative emissions. It is also important to look at the fleet, which is composed of several generations, types of vehicles and their emission control technologies, each of which performs differently.

In order to estimate both the rate at which emissions are being generated and to calculate VMT, MDE examined its road network and fleet to estimate vehicle activity. For the annual inventories, this was done for each of the twelve months in 2017 and aggregated for the entire year. The entire process was extremely complex and involved large amounts of various data sets.
Computer models were developed to perform these calculations by simulating the travel of vehicles on the State's roadway system.

These models then generated emission factors for different vehicle types for area-specific conditions and then combined them in summary form. The "area-specific conditions" included fleet characteristics such as vehicle population and vehicle age distribution, roadway and travel characteristics, meteorology, control programs in place, mandated fuel requirements, etc.

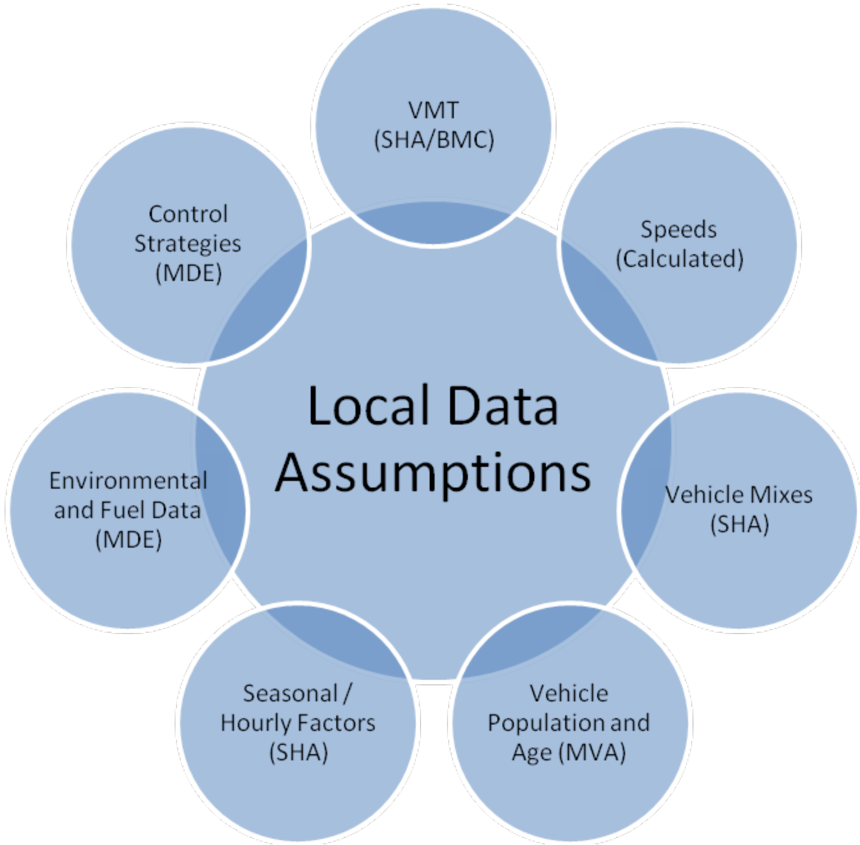
6.1.2 Periodic Inventory Methodology

MSCP used USEPA's Guidance documents to develop the 2017 highway emissions inventory. These documents include inter-alia the following:

Using MOVES for Estimating State and Local Inventories of On-Road Greenhouse Gas Emissions and Energy Consumption, EPA-420-B-12-068, November 2012. *Motor Vehicle Emission Simulator, User Guide for MOVES2014a*, EPA-420-B-14-055, July 2014

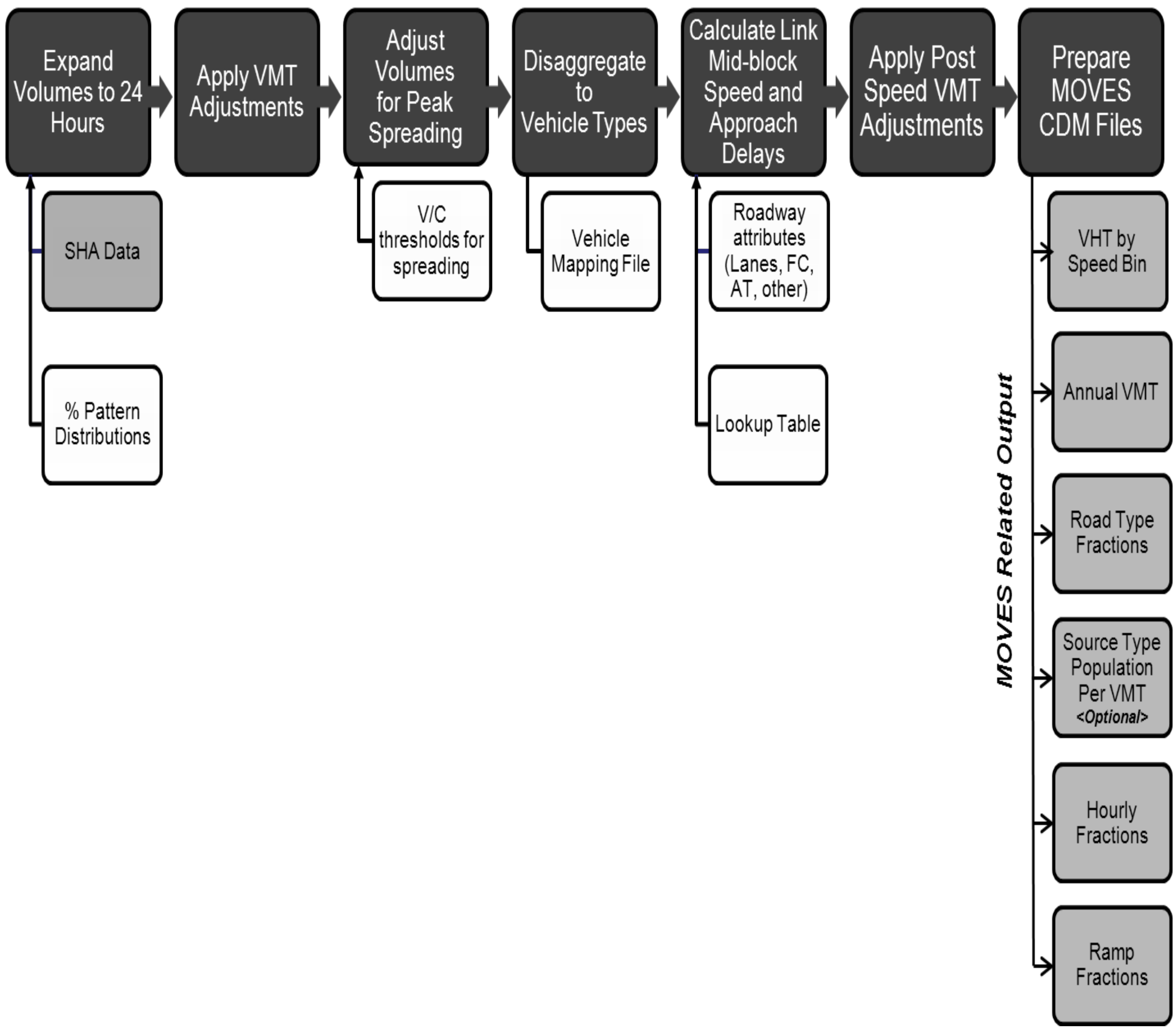
The methodologies used to produce the emission data conform to the recommendations provided in USEPA's Technical Guidance as well as in other documents enumerated above. A mix of local data and national default (internal to MOVES2014a) data had been used for the inventory documented herein. As illustrated in Figure 6.1.2-a, local data had been used for the primary data items, which had a significant impact on emissions. Local data inputs to the inventory process reflected the latest available planning assumptions using data obtained from MDE, MVA, SHA, BMC, MWCOG and other local/national sources. This inventory document herein reflected the 2017 PEI for the Baltimore Ozone Non-Attainment Area and the rest of Maryland using USEPA's latest MOVES2014a emission model.

Figure 6.1.2-a: Local Data Inputs Used for Emissions' Inventory



PPSUITE is a post-processor modeling tool used for estimating speeds and processing emission rates. Section 6.7 describes in detail this modeling tool known as PPSUITE. Figure 6.1.2-b. summarizes the key functions of PPSUITE and the traffic-related input files prepared for MOVES.

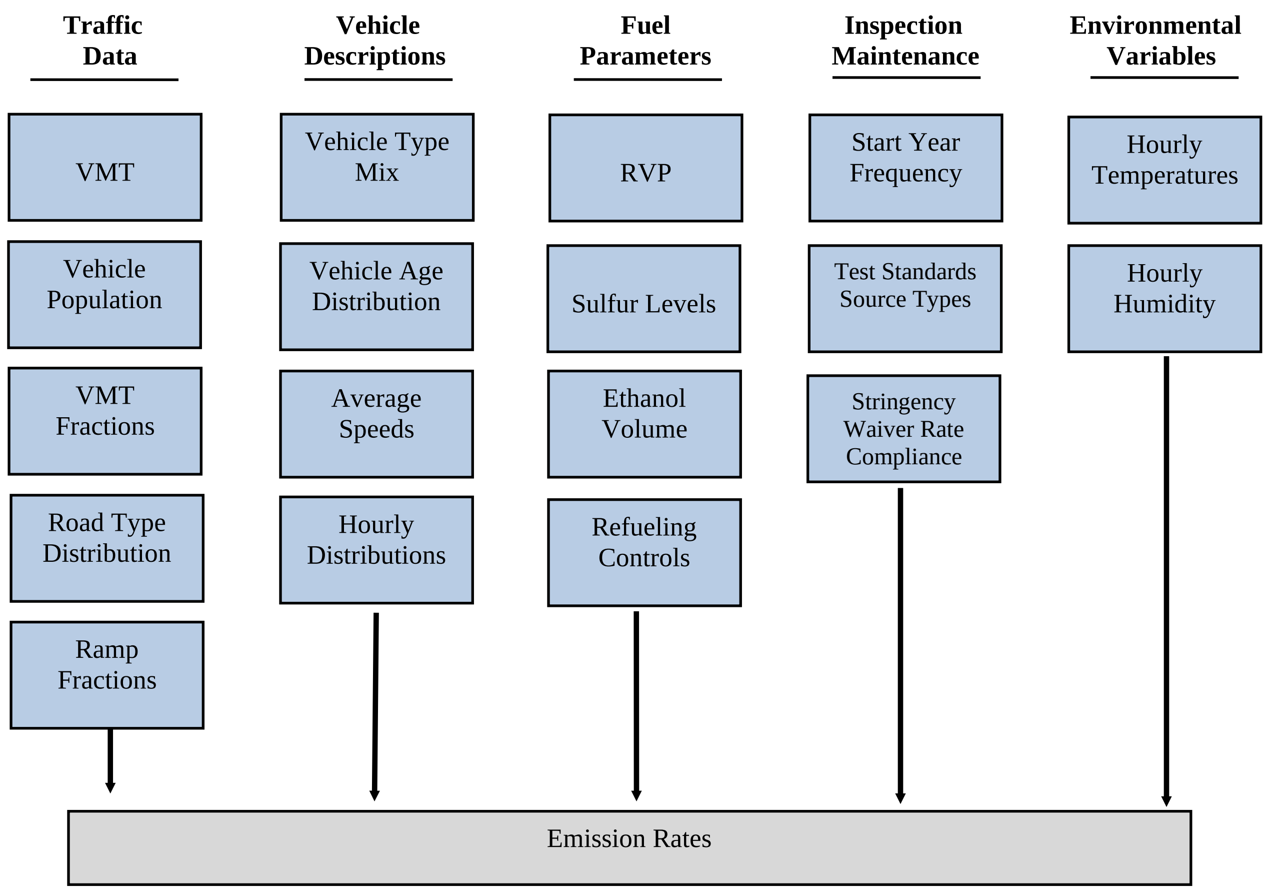
Figure 6.1.2-b: Emission Calculation Process



6.1.3 Data Sources

A large number of inputs to MOVES are needed to fully account for the numerous vehicle and environmental parameters that affect emissions levels. These include traffic flow characteristics, vehicle descriptions, fuel parameters, Inspection/Maintenance (I/M) Program parameters, and environmental variables as shown in Figure 6.1.3.

Figure 6.1.3 : Examples of Key MOVES Input Data



MOVES2014a includes a default national database of meteorology, vehicle fleet, vehicle activity, fuel, and emission control program data for every county, but EPA cannot certify that the default data is the most current or best available information for any specific area. As a result of this, EPA recommended the use of local data for inventory's preparation and SIPs analyses. These data items are discussed in the following sections.

6.2 DESCRIPTION OF INPUT DATA

This section described the data inputs to the emission calculation process. 15 or 14 MOVES data files were required for input to MOVES Graphical User Interface (GUI) through the MOVES' County Data Manager (CDM). These data files were either created by the staff of MSCP or generated by PPSUITE software. These data files were:

- Roadway Data and VMT
- Month VMT Fractions
- Day VMT Fractions
- Hour VMT Fractions
- Average Speed Distribution
- Road Type Distribution
- Ramp Fraction
- Source Types Population
- Source Types Age Distribution
- Fuel Formulation
- Fuel Supply
- Fuel Usage Fraction
- I/M Programs
- Meteorology Data
- Alternate Vehicle Fuel Technology (AVFT)

6.2.1 Roadway Data and VMT

The roadway data input to emissions calculations for this inventory was based on information from the "universal" highway database maintained by the Maryland's State Highway Administration (SHA). SHA obtained this information from periodic visual and electronic traffic counts. The SHA's data is dynamic, since it is continually reviewed and updated from new traffic counts. Information on roadways included in the National Highway System (NHS) is reviewed at least annually, while information on other roadways is reviewed at least biennially.
On a triennial basis, a current "snapshot" of the SHA's database was taken and downloaded to provide an up-to-date record of the State's highway system for estimating emissions. This emissions inventory was based on 2017 data, which is the most current "snapshot" of the SHA's data.
The following information was extracted from the database for emission calculations:

- Lanes and distances
- volumes representing Average Annual Daily Traffic (AADT)
- truck percentages and urban/rural classifications
- functional class codes

The PPSUITE software used the traffic data to prepare key inputs to the MOVES emission model. This software used roadway segment distances and traffic volumes to prepare estimates of VMT that is the primary traffic input that affects emission results. Before the SHA's data could be used by PPSUITE for speed and emission calculations, several adjustments and additions should be made to the roadway data.

The lane values, area type, and functional class were important inputs for determining the congestion and speeds for individual highway segments. Truck percentages were used in the speed determination process and were used to split volumes to individual vehicle types used by the MOVES2014a software.

Maryland classifies its road segments by function, as well as whether it is located in an urban or rural area, as indicated below in Figure 6.2.1. The urban/rural (UR) and functional classes (FC) are important indicators of the type and function of each roadway segment. These values were also used to determine the MOVES Road Type classification, which had an important impact on the emission factors for each roadway segment. Equivalencies between the SHA's and MOVES' indices were discussed in later sections.

Figure 6.2.1: MDOT Urban/Rural and Functional Class Codes

Urban/Rural Code	1=Rural 2=Small Urban 3=Urban	
Functional Class	Rural Functional Classes Used For Rural Areas -------------------------------------	Urban Functional Classes Used For Urban Areas --
	1=Rural Freeway	11=Urban Freeway
	2=Rural Other Principal Arterial	12=Urban Expressway
	6=Rural Minor Arterial	14=Urban Principal Arterial
	7=Rural Major Collector	16=Urban Minor Arterial
	8=Rural Minor Collector	17=Urban Collector
	9=Rural Local	19=Urban Local

The PPSUITE processing software uses other additional variables other than those available in the SHA's database. Using these variables improves the calculation of congested speeds. Such variables include information regarding free-flow speeds and capacities and other physical roadway features (e.g. traffic signals) that could affect a roadway's calculated congested speed.

This data could be determined from lookup tables based on a roadway segment's urban/rural code and functional class. Much of the lookup table data was developed from information contained in the Highway Capacity Manual (HCM).

6.2.2 Other Supporting Traffic Data

Other traffic data were used to adjust and disaggregate traffic volumes. Key sources used in these processes include the following:

6.2.3 HPMS VMT Adjustments

According to EPA's guidance, baseline inventory VMT computed from the SHA's highway segment volumes must be adjusted to be consistent with HPMS VMT totals. Although it has some limitations, the HPMS system is currently in use in all 50 states and is being improved under Federal Highway Administration's (FHWA's) direction. These adjustments were obtained by dividing the HPMS VMT by the analysis run's VMT for each county functional class grouping. These calculated VMT adjustment factors were provided as ASCII input files to PPSUITE, and were applied to each of the roadway segment volumes.

These factors could be applied to any future year runs. The VMT added or subtracted to the SHA's database assumed the speeds calculated using the original volumes for each roadway segment for each hour of the day.

6.2.4 Seasonal Adjustments

The seasonal factors were used to adjust the average annual day traffic (AADT) to represent an average July weekday, an average January weekday, or an average day of any month. Both the seasonal and monthly VMT adjustment factors were developed from the traffic flow data available by day and month from Automatic Traffic Recording (ATR) Station Reports in the Traffic Trends System Report Module, which was obtained from the SHA's website. The report entitled, *Traffic Flow by Day by Month by Group* was used to obtain the monthly variation of traffic flow.

The 4 functional classes for which the seasonal factors were available are: Rural Interstate, Rural other, Urban Interstate and Urban other. This report also contained the AADT's percentage, which was available for the 7 days of the week as well as for the 12 months of the year. An average summer seasonal factor was obtained from the average July weekdays' calculations. In addition, an average winter seasonal factor was obtained from the average January weekdays' calculations. These seasonal factors' calculations were repeated for all the 4 functional classes.

6.2.5 Hourly Patterns

Speeds and emissions vary considerably depending on the time of day as a result of temperature variations and congestion. Therefore, it is important to estimate the pattern by which roadway volume varies by hour of the day. Pattern data is in the form of a percentage of the daily volumes for each hour. In addition, the hourly pattern distributions were a key input file to PPSUITE for hourly congested speeds' estimation. Hourly mixes of vehicles for each area and facility type combination were also input to PPSUITE. These hourly mixes were used to determine the proportion of the daily volume in each hour of the day, so separate hourly speeds could be prepared as input to PPSUITE process.

Consequently, hourly pattern data was obtained from a report entitled, *Traffic Trends System Report Module* from the SHA's website. However, the hourly distribution data could be obtained from the report entitled, *Hour Percent of Traffic by Month-Weekday*. The factors for the 4 functional classes (Rural Interstate, Rural other, Urban Interstate and Urban other) could also be obtained from the aforementioned report. Furthermore, the hourly pattern data for the 4 primary functional classes were used to create the PPSUITE input files that were needed in the emission calculation process. For instance, to obtain an hourly percentage of vehicles for a summer weekday, an average hourly factor was calculated for the months of June, July and August.

6.2.6 Vehicle Mix Inputs

The vehicle distribution file was a key input file that could have a significant impact on emissions. Moreover, the vehicle mixes were input to PPSUITE as hourly distributions of vehicles by vehicle type. These mixes were developed by using the 2017 data, which were available from the SHA's website.

6.2.7 Vehicle Type Processing

Emission rates within MOVES vary significantly by the type of vehicle. The MOVES2014a model produces emissions and rates by thirteen MOVES source types. However, VMT is input to MOVES by 5 HPMS vehicle groups. Figure 6.2.7 below summarizes the distinction between each classification scheme.

Figure 6.2.7: MOVES Source Types and HPMS Vehicle Groups

SOURCE TYPES		HPMS Class Groups	
11	Motorcycle	10	Motorcycle
21	Passenger Car	25	Light Duty Vehicles
31	Passenger Truck	40	Buses
32	Light Commercial Truck	50	Single Unit Trucks
41	Intercity Bus	60	Combination Trucks
42	Transit Bus		
43	School bus		
51	Refuse Truck		
52	Single Unit Short-haul Truck		
53	Single Unit Long-haul Truck		
54	Motor Home		
61	Combination Short-haul Truck		
62	Combination Long-haul Truck		

The PPSUITE process included a method to disaggregate the SHA's traffic volumes to the MOVES2014a thirteen source types and then recombined the estimates to the 5 HPMS vehicle classes. This was done to support the alternative MOVES2014a "rate-based" application method, which could also be handled by the PPSUITE's software. Under the "rate-based" application method, VMT should be estimated for each of the MOVES2014a thirteen source types. PPSUITE used the vehicle type pattern data to divide the hourly roadway segment volumes to the MOVES2014a thirteen source types. This data contained the percentage splits to each source type for every hour of the day, which was similar to the 24-hour pattern data.

6.2.8 VMT Fractions

Month, day and hour VMT fractions were required as inputs to MOVES. Month and day VMT fractions were calculated based on seasonal adjustment factors. It should be noted that the month VMT fractions were used to disaggregate the annual VMT into monthly VMT, while day VMT fractions were used to disaggregate monthly VMT to daily weekdays or weekends VMT. PPSUITE was used to calculate hour VMT fractions, which were based on hourly pattern inputs. These hourly VMT fractions were inputs to MOVES and were responsible to distribute the daily VMT into 24-hourly pattern.

6.2.9 Month VMT Fractions

These are the fractions of annual VMT per source type occurring per month. These fractions must sum to 1 within each source type over a 12-month period. In addition, these fractions were used in MOVES input to disaggregate annual VMT to monthly VMT as stated in the previous section.

6.2.10 Day VMT Fractions

These fractions are the fractions of annual VMT per source type, which occur on either the weekday or weekend. These fractions were also used in MOVES input to disaggregate the monthly VMT to daily VMT per weekdays and weekends as stated in the previous section. These fractions must sum to 1 within each source type, month and road type.

6.2.11 Hour VMT Fractions

These fractions are the fractions of annual VMT per source type, which occur per hour. These fractions were used in MOVES input to distribute the daily VMT by weekdays and weekends into a 24-hourly pattern. These fractions must sum to 1 within each source type, road type and type of day combination. These fractions were applied to all months.

6.2.12 Average Speed Distribution

Emissions for many pollutants such as VOC and NO_x vary significantly with travel speed. Generally, VOC's emissions decrease as speed increases, while NO_x emissions decrease at low speed and increase at higher speeds. The emission process uses the PPSUITE set of programs to obtain the best estimate of vehicle speeds. These PPSUITE sets' primary function was to organize and simplify the handling of large amounts of data, which were needed for the calculations of speeds and preparation of MOVES input files. Furthermore, the PPSUITE's software prepares the MOVES vehicle hours of travel (VHT) by speed bin and summarizes the distribution of speeds across all links into each of 16 MOVES speed bins for each hour of the day.

6.2.13 Road Type Distribution

Typical drive cycles and associated operating conditions vary by the type of roadway in MOVES. MOVES define the following road types:

1. Off-Network,
2. Rural Restricted Access,
3. Rural Unrestricted Access,
4. Urban Restricted Access, and
5. Urban Unrestricted Access.

The off-network road type includes emissions from vehicle starts, extended idle activity and evaporative emissions. Off-network activity is primarily determined by the source type population input. The remaining distribution among road types is determined by associating the Maryland Department of Transportation's (MDOT's) functional class with each MOVES road type:

- MOVES Road Type (2) = MDOT Functional Class (1),
- MOVES Road Type (3) = MDOT functional Class (2, 6, 7, 8, 9),
- MOVES Road Type (4) = MDOT Functional Class (11, 12), and
- MOVES Road Type (5) = MDOT Functional Class (14, 16, 17, 19).

6.2.14 Ramp Fractions

Since ramps are not directly represented within the SHA's database, it is assumed that 8% of the Freeway VHT is Ramp's VHT. This assumption is consistent with the recommendations given in EPA's Technical Guidance. This ramp fractions file was also input to MOVES. The vehicle type percentages are also provided to the capacity analysis section of PPSUITE to adjust the speeds in response to trucks. That is, a given number of larger trucks take up more roadway space than a given number of cars, and this is accounted for in the speed estimation process by adjusting capacity using information from the Highway Capacity Manual.

6.2.15 Source Type Age Distribution

Age distribution could be described as mix of vehicles of different ages. MOVES covers a 31-year range of vehicle ages, while vehicles 30 years and older were grouped together. In MOVES, user could specify the fraction of vehicles in each of the 30 vehicle ages for each 13 source types. It is also known that the age distribution of vehicle fleets could vary extensively from area to area and could affect emissions. As a result of older vehicles to have been driven more miles and experiencing more deterioration in their emission control systems, such vehicles tend to have higher emissions. Therefore, fleets with a higher percentage of older vehicles would have higher emissions. In addition, a higher percentage of older vehicles in the fleet indicate that these vehicles would not be able to meet newer and more stringent emission standards or CAFE standards.

It should be noted that if the user wants to apply rates to multiple counties, the user should use a single age distribution that is appropriate for all those counties. However, if the multiple counties that need to be modeled have different age distributions, it is advisable that the user should model each county separately.

MSCP was able to develop the 2017 source type age distribution from the MVA's motor vehicle registration database. MSCP obtained this MVA’s registration database, which was then VIN-decoded, thereby, making it possible to obtain the 13 MOVES source types by model year. However, same age distribution was used for source types 31 and 32 because of the difficulty to split the data into source types 31and 32. The same age distribution was also used for refuse trucks, single unit short-/long-haul trucks. Furthermore, the same age distribution was also used for combination short-/long-haul trucks. However, for source types 52, 53, 61 and 62, the default age distribution was superimposed on the local age distribution that was obtained from the MVA's processed data.

6.2.16 Source Type Population

MOVES uses source types’ population to calculate evaporative, start and hotelling emissions. It should be noted that start and hotelling emissions depend on how many vehicles are parked and started than on how many miles of these vehicles are driven. As a result of this, source types’ population played a significant role in calculating the aforementioned emissions. If in the absence of any other source of population data, users could still base population estimates on the VMT estimates for a particular source type. This VMT estimates was based on running MOVES at the national scale for a county of interest, but including VMT and population in the output.

Then, the local VMT would be multiplied by the ratio of default population to default VMT by source type to produce an estimate of the local population. This option was used to obtain the source type population for source types 52, 53, 61 and 62.

6.3 METEOROLOGY

In MOVES, ambient temperature and relative humidity data are essential inputs for estimating the on-road criteria and GHG pollutants' emissions. The temperature and relative humidity are significant factors in modeling emissions from motor vehicles as they affect air conditioner use. MOVES need a 24-hour temperature and humidity profile in order to model a full day of emissions based on every hour of the day. It should be noted that the temperature has to be in degrees Fahrenheit, while the relative humidity must be in percentage.

Moreover, EPA urges users to use the average daily temperature and relative humidity profile for each month in case modeling is to be performed for all the 12 months. Latest available information on temperature and relative humidity should also be used for criteria and GHG pollutants emissions' estimates.

MSCP obtained the 2017 local weather data from Air Monitoring Program from all the airports in Maryland. These weather data were then processed to produce the 24-hourly data for each month. For instance, the Thurgood Marshall-Baltimore Washington (BWI) airport data was used for the Baltimore area, which comprises the Baltimore City and the counties of Anne Arundel, Baltimore, Carroll, Harford and Howard. MSCP also used the same procedure to process the weather data for the remaining counties in Maryland. Based on the airport mapping that MSCP developed, the appropriate airport data were allocated to these counties.

6.4 I/M PROGRAM

In Maryland, I/M Program, also known as Vehicle Emissions Inspection Program (VEIP), tests model year 1977 and newer gasoline powered vehicles weighing up to 26,000 pounds. This test is done biennially, or on a change of ownership. There is a two year grace period for new vehicles. However, model year 1996 and newer light-duty vehicles, and model year 2017 and newer vehicles weighing up to 14,000 pounds get the onboard diagnostics' (OBD's) test. All other vehicles get an idle test with a gas cap pressure test and a visual check for the presence of a catalytic converter.

The fields in a typical I/M program are polProcessID, stateID, countyID, yearID, sourceTypeID, fuelTypeID, IMProgramID, inspectFreq, testStandardsID, begModelYearID, endModelYearID, useIMyn and complianceFactor. The field useIMyn allows the user to turn off ("N") or on ("Y").

6.4.1 Pollutant Process ID

MOVES estimate emission reductions from VEIP for CO, hydrocarbons and NO_X. For exhaust emissions, I/M programs affect both running and start emissions. In addition, for evaporative emissions, I/M programs affect hydrocarbon emissions from fuel vapor venting and fuel leaks.

6.4.2 Source Type and Fuel Type IDs

These fields are used to describe the source (vehicle) and fuel types included in I/M program. The staff of the VEIP Division in MSCP when preparing I/M file, made sure that the source and fuel types match I/M programs' parameters for the source types included in the VEIP. It should be noted that MOVES currently calculates I/M program's benefits only for gasoline source types or vehicles.

Furthermore, I/M programs have historically applied to vehicles by regulatory weight class; however, MOVES applies I/M program's benefits by source type. This idea could lead to discrepancies between the number of vehicles covered in the actual I/M program and the number of vehicles that MOVES assumes is covered. For instance, I/M program, which targets trucks less than 8,501 pounds Gross Vehicle Weight Rating (GVWR) such as regulatory classes LDT1, LDT2, LDT3 and LDT4 would include parts of two MOVES source types 31 (passenger trucks) and 32 (light commercial trucks).

Moreover, these source types enumerated in this section also include vehicles with GVWR greater than 8,501 pounds. Whenever I/M program is applied to source types 31 and 32 in MOVES, the benefits of I/M program would be applied to all the vehicles in these source types. Hence, there is a need to adjust the compliance factor to account for the fraction of vehicles within a source type that is actually covered by I/M program.

6.4.3 Inspection Frequency

MOVES allow users to enter either annual or biennial test frequency. In accordance with Maryland's VEIP design, the MSCP utilized the input indicative of a biennial test frequency for all the inventory work that is documented herein.

6.4.4 Test Standards and I/M Program ID

There are 13 exhaust and 7 evaporative emissions tests that MOVES allows users to choose from. In Maryland, MSCP chose for its VEIP four test standards, which are identified by I/M program IDs. The test standards are:

- 11 – This is an Unloaded Idle Test, which is a test performed while vehicle idles in park or neutral.

- 41 – This is an Evaporative Gas Cap Check, which is a test conducted by pressurizing the gas gap so as to identify any leaks in the gas cap.

- 43 – This is an Evaporative System OBD check, which is the test of the evaporative emission related systems and components performed by visual check of the Malfunction Indicator Light (MIL) as well as scan of the OBD computer.

- 51 – This is an Exhaust OBD Check, which is the test of exhaust-related systems and components performed by visual check of MIL and scan of OBD computer for system readiness, MIL status, and troubled codes are then stored. This test covers 1996 and newer OBD-equipped vehicles only.

It should be noted that in MOVES, I/M programs that have both exhaust and evaporative inspection components including OBD programs should be modeled as 2 separate and simultaneous programs. In addition, I/M Program ID numbers are used to identify these programs. MSCP followed this guideline in its VEIP's setup.

6.4.5 Beginning and End Model Years

In I/M Program, MOVES uses these two columns to specify the beginning and ending model years of vehicles covered. In Maryland, there is a grace period of 2 years before new vehicles are tested. The ending model year depends on the year of evaluation and the grace period for vehicles as enumerated above. However, the beginning model year is 1977 for 3 of the 4 test standards, except OBD test that has the beginning model year as 1996.

6.4.6 Compliance Factor

MOVES uses the compliance factor input to account for I/M program compliance rates, waiver rates, and the adjustments needed to account for the fraction of vehicles within a source type that are covered by the I/M program. These adjustments would be referred to as 'regulatory class coverage adjustment'. The compliance factor ranges from 0 to 100, and the number that would be entered in this column depends on the calculation based on the compliance rate, waiver rate and the regulatory class coverage adjustment as illustrated below:

Compliance Factor = (percent compliance rate) * (100-percent waiver rate)* percent regulatory class coverage adjustment.

Furthermore, the compliance factor represents the percentage of vehicles within a source type that actually receive I/M program's benefits. In addition, the compliance factor could also be looked at as reflecting the observed fail and waiver rates in the program, combined with an assumed 96% compliance rate for vehicles showing up for testing. Heavy-duty vehicles have an additional factor, reflecting the fraction of vehicles in the weight range covered by the program.

6.4.7 Compliance Rate

The compliance rate is the percentage of vehicles in the fleet that are covered by I/M program, and which either receive a certificate of compliance or a waiver after taking the test. Moreover, the higher compliance rate for the gas cap check reflects the much higher retest pass rate for this check.

6.4.8 Waiver Rate

The waiver rate is the percentage of vehicles that fail an initial I/M test, as well as retest, but they receive a certificate of compliance. It could also be calculated as follows:

$$\boldsymbol{Waiver\ rate} = \frac{(No.of\ vehicles\ that\ fail\ an\ initial\ test\ and\ do\ not\ pass\ retest)}{(No.of\ vehicles\ that\ fail\ an\ initial\ IM\ test)}$$

6.4.9 Regulatory Class Coverage Adjustment

In MOVES, I/M programs are applied to source types. The association of source types and I/M program could be inconsistent with state I/M program regulations that define I/M program by the vehicle weight classes. It should be noted that MOVES source types comprise several vehicle-weight classes, applying I/M's benefits to the entire MOVES' source types could be inappropriate. Table A.1 on page 61 of EPA's document entitled, *MOVES2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity* could be used to develop adjustments to the compliance factor to account for this discrepancy.

These adjustments are percentages of VMT by the various regulatory weight classes within a source type. After reviewing the table, users should sum the adjustments for weight classes within the source types, which are covered by I/M program. The sum of these adjustments provide users with a multiplicative factor that could be applied along with compliance and waiver rates as already discussed in Section 6.4.6.

6.5 FUELS

The four tables represented under fuel are Fuel Formulation, Fuel Supply, Fuel Usage Fraction and Alternative Vehicle Fuels and Technology (AVFT). These tables interact by defining the fuels used in the area being modeled. In MOVES2014a, the tables are accessed through a single tab in the County Data Manager (CDM). The Fuel Usage Fraction is the only new table that was not available in the previous MOVES versions. MOVES defaults for these tables are available and could be accessed using the Export Default Data button in the Fuel Tab of the CDM.

The MSCP developed the Fuel Formulation and Fuel Supply Tables, while it used the appropriate default Fuel Usage Fraction for the criteria and GHGs pollutants emissions' estimates because no local data were available. MSCP also used the modified AVFT file that EPA developed as part of the input file for MOVES. Moreover, the Fuel Supply Table identified the fuel formulations used in a region as well as its particular market share, while the Fuel Formulation Table itself defined the fuel properties such as RVP, sulfur level, ethanol volume, aromatic and olefin contents, etc. On the other hand, the Fuel Usage Fraction Table defined the frequency at which E-85 capable vehicles also known as flex fuel vehicles use E-85 vs.

conventional gasoline. The AVFT Table was used to enumerate the fraction of fuel types capable of being used by model year and source types.

Furthermore, when modeling an area, fuels should correspond to the temperature profile for a given month. For example, a wintertime diurnal temperature profile using the MonthID = 7 should not use July fuels, but rather such wintertime diurnal temperature profile to be used should be January fuels. If in a run, the user does not choose output that does not distinguish rates by fuel type, the mix of gasoline/diesel/CNG would be determined by the default AVFT (i.e. the fuel type and technology allocations). However, if in a run the user selects output that is distinguished by fuel type, the AVFT values would not be applied, instead an appropriate mix of activity by fuel type would be applied during post-processing.

6.5.1 Regional Fuels

The main goal in the development of the regional fuels approach was to aggregate fuels into larger and more representative areas. By this methodology, eleven general fuel regions were created for the United States and major territories. These fuel regions were initially based on existing Petroleum Administration for Defense Districts' (PADDS') boundaries. These PADDS' boundaries were based on historic division of fuel supply areas, which were originally developed in the 1950s, and were then adjusted to account for broad fuel distribution corridors and the presence of bulk fuel pipelines and terminals. These PADDs are the geographic aggregations of the 50 states and the District of Columbia, which were divided into five districts as follows:

a). PADD1- East Coast.
b). PADD2 – Midwest.
c). PADD3 – Gulf Coast.
d). PADD4 – Rocky Mountain.
e). PADD5 – West Coast.

The MOVES2014a regional fuel areas are defined by the region County table in the MOVES default database. Table 6.5.1-a below illustrates the MOVES2014a Fuel Regions, while Table 6.5.1-b identifies the regionID in MOVES2014a.

TABLE 6.5.1-a MOVES2014a Fuel Regions

Region ID#	Region Name	Description
1	East Coast	East coast states up to Appalachians, Florida, and gulf coast region
2	Midwest	Midwest states up to Appalachians (not including Wisconsin), Tennessee, Kentucky
3	South	Southern states not including gulf coast, Nebraska, Iowa
4	North	North and South Dakota, Minnesota, Wisconsin
5	Rocky Mtns	Pacific northwest, Rocky mountain states, Utah
6	CA/NV/AR	California, Nevada, Arizona, AK, and HI NOT using Reformulated Gasoline (RFG)
11	East Coast RFG	East coast states and regions using RFG fuel or under a controlled fuel program
12	MD/VA	Maryland and Virginia regions using RFG fuel or under a controlled fuel program
13	Texas RFG	Texas regions using RFG fuel or under a controlled fuel program
14	Midwest RFG	Midwest regions using RFG fuel or under a controlled fuel program
15	California	California using California fuel, Nevada and Arizona regions using California Fuel

TABLE 6.5.1-b RegionID in MOVES2014a

RegionID	AA, Base Region ID#	Base Region Name	BB, Maximum summer RVP (psi) or 00 for ASTM	CC, E10 RVP Waiver (00=1 psi waiver, 01=no waiver)	DD, Minimum ethanol volume, %	XX (Reserved for future use)
0	1	East Coast	0.0	0	0	0
100000000			0.0	0	0	0
100010000			0.0	1	0	0
170000000			7.0	0	0	0
178000000			7.8	0	0	0
178010000			7.8	1	0	0
200000000	2	Midwest	0.0	0	0	0
270000000			7.0	0	0	0
278000000			7.8	0	0	0
278010000			7.8	1	0	0
300000000	3	South	0.0	0	0	0
370000000			7.0	0	0	0
370010000			7.0	1	0	0
400000000	4	North	0.0	0	0	0
500000000	5	Rocky Mtns	0.0	0	0	0
578000000			7.8	0	0	0
600000000	6	CA/NV/AR/All Others	0.0	0	0	0
678000000			7.8	0	0	0
1170011000	11	East Coast RFG	7.0	1	10	0
1270011000	12	MD/VA RFG	7.0	1	10	0
1370011000	13	Texas RFG	7.0	1	10	0
1470011000	14	Midwest RFG	7.0	1	10	0
1570011000	15	California	7.0	1	10	0

6.5.2 Fuel Supply

The Fuel Supply Table classifies the fuel formulation that is used in an area, and each formulation's respective market share. Once the fuel formulation for the area being modeled had been modified, the Fuel Supply Table could be populated. The populated table is indicated in Table 6.5.2, and due to its large size, only a portion of the entire table could be shown.

TABLE 6.5.2 Fuel Supply

fuelRegionID	fuelYearID	monthGroupID	fuelFormulationID	marketShare	marketShareCV
1270011000	2017	1	1401	1	0
1270011000	2017	2	1402	1	0
1270011000	2017	3	1403	1	0
1270011000	2017	4	1404	1	0
1270011000	2017	5	1405	1	0
1270011000	2017	6	1406	1	0
1270011000	2017	7	1407	1	0
1270011000	2017	8	1408	1	0
1270011000	2017	9	1409	1	0
1270011000	2017	10	1410	1	0
1270011000	2017	11	1411	1	0
1270011000	2017	12	1412	1	0
1270011000	2017	1	21501	1	0
1270011000	2017	2	21502	1	0
1270011000	2017	3	21503	1	0
1270011000	2017	4	21504	1	0
1270011000	2017	5	21505	1	0
1270011000	2017	6	21506	1	0
1270011000	2017	7	21507	1	0
1270011000	2017	8	21508	1	0
1270011000	2017	9	21509	1	0
1270011000	2017	10	21510	1	0
1270011000	2017	11	21511	1	0
1270011000	2017	12	21512	1	0
1270011000	2017	1	190	1	0
1270011000	2017	2	190	1	0
1270011000	2017	3	190	1	0
1270011000	2017	4	190	1	0
1270011000	2017	5	190	1	0
1270011000	2017	6	190	1	0
1270011000	2017	7	190	1	0
1270011000	2017	8	190	1	0
1270011000	2017	9	190	1	0
1270011000	2017	10	190	1	0
1270011000	2017	11	190	1	0
1270011000	2017	12	190	1	0

The Fuel Supply shown in Table 6.5.2 has six fields which are the fuelregionID, the fuelyearID, the monthgroupID, the fuelformulationID, the marketShare and the marketShareCV. These fields are briefly described as follows:

The fuelregionID field was created based on the new analysis of nationwide fuel use, which prompted a change in how fuels are defined at the county level in the default database. Consequently, the default fuel supply is divided into fuel regions instead of each county having a unique fuel supply. The noticeable impact of this change could be seen in the fuel supply table where the column for countyID has been replaced with the RegionID. MSCP had utilized the RegionIDs 1 and 12 for the inventory of the criteria pollutants and GHGs as contained in this document.

The monthgroupID field is the same as the monthID; for the monthgroupID field was built in to permit the possibility of seasonal fuels, but that option is not functional at present.

The fuelformulationID field identifies the fuel used in the area and this is the number that is entered in the fuel supply table.

The Marketshare field represents the fraction of the volume of each fuel's formulation that is consumed in the area. It is significant that the Marketshare should sum to one within each fuel type.

The MarketshareCV field represents the coefficient of variation for the market share. This field could be used when uncertainty calculations were enabled. In Maryland, the value is not required and a zero was entered.

6.5.3 Fuel Formulation

The Fuel Formulation Table describes the elements such as RVP, sulfur level, ethanol volume, etc. of each fuel. The MSCP prepared the elements of the 2017 Fuel Formulation Table from the Monthly Retail data obtained from the Fuel Tax Division of the Comptroller's Office. A database each was created to enter the values of the gasoline and diesel fuels from these monthly retail data for all the 12 months of 2017. After this, an access program was written to process the average monthly values for all the elements of the gasoline and diesel fuels. For instance, the gasoline fuel is in 3 grades (regular, mid-grade and premium). The weighted average of the gasoline fuel grade was calculated by using EPA's methodology. The diesel fuel is in one grade and access program was also used to calculate the monthly average for all the 12 months of 2017.

These average values represented the elements of the gasoline and diesel in the Fuel Formulation Table. The default values were used for CNG, E-85 and electricity. As a result of the large size of the formulation table, a portion of the fuel formulation table is shown in Table 6.5.3 of this documentation.

The key fields in the fuel formulation table as shown in Table 6.5.3 were briefly described as follows:

Fuel Formulation ID: This field identifies the fuel used in the area and this is the number that is entered in the fuel supply table. In MOVES2014a, the existing fuel formulation ID could be modified or a new formulation ID could also be created.

Fuel Subtype ID: This number provided a small level of detail about the type of fuel the formulation was describing, but in some cases, there could be more than one fuel subtype that also described the fuel formulation. For instance, the fuel reformulation could be gasoline blended with 10% ethanol or the one blended with MTBE that was earlier used in the gasoline mixture. Hence, a different fuel subtype ID is assigned to this different gasoline mixture.

RVP means 'Reid Vapor Pressure', which was measured in pounds per square inch (psi). This field was used to define the volatility of gasoline.

Sulfur Level: The sulfur level was measured in parts per million (ppmw) in terms of weight. Sulfur levels should be entered for all gasoline and diesel fuels. It should be noted that the Tier2 gasoline sulfur rule established a national average of 30 ppmw sulfur and a cap of 80 ppmw. As for diesel fuel, the ultra-low sulfur rule requires that at least 80% of the highway diesel fuel sold should meet the 15 ppm, while the remaining 20% should meet the Low Sulfur Diesel Standard of 500 ppm.

Ethanol Volume: This field represents the percent by volume of ethanol in the gasoline/ethanol mixture.

MTBE Volume: This field represents the percent by volume of methyl tertiary butyl ether (MTBE) in the gasoline/MTBE mixture. The gasoline that is being supplied to Maryland does not contain any significant amount of MTBE because of the MTBE concentrations, which were found in water in some areas. So a zero value was entered in the MTBE Volume column.

ETBE Volume: This field represents the percent by volume of ethyl tertiary butyl ether (ETBE) in the gasoline/ETBE mixture. A value of zero was entered in the ETBE Volume column because there was no trace of ETBE concentrations in the gasoline that is being supplied to Maryland.

TAME Volume: This field represents the percent by volume of tertiary amyl methyl ether (TAME) in the gasoline/TAME mixture. A value of zero was entered in the TAME Volume column because there was no trace of TAME concentrations in the gasoline that is being supplied to Maryland.

Aromatic Content: This field represents the percent by volume of aromatic hydrocarbon compounds in gasoline. A value of zero was entered for diesel fuel, CNG, E-85 and electricity.

Olefin Content: This field represents the percent by volume of olefin hydrocarbon compounds in gasoline. A value of zero was entered for diesel fuel, CNG, E-85 and electricity.

Benzene Content: This field represents the percent by volume of benzene in gasoline. A value of zero was entered for diesel fuel, CNG, E-85 and electricity.

E200: This field represents the percent of gasoline that had evaporated at 200 degrees Fahrenheit. A value of zero was entered for diesel fuel, CNG, E-85 and electricity.

E300: This field represents the percent of gasoline that had evaporated at 300 degrees Fahrenheit. A value of zero was entered for diesel fuel, CNG, E-85 and electricity.

T50: This field represents the temperature at which 50 percent of the gasoline had evaporated. A value of zero was entered for diesel fuel, CNG, E-85 and electricity.

T90: This field represents the temperature at which 90 percent of the gasoline had evaporated. A value of zero was entered for diesel fuel, CNG, E-85 and electricity.

As a result of the large size of the formulation table, a portion of the fuel formulation table is illustrated in Table 6.5.3 of this documentation.

TABLE 6.5.3 Fuel Formulation

fuelFormulationID	fuelSubtypeID	RVP	sulfurLevel	ETOHVol	MTBEVol	ETBEVol	TAMEVol	aromaticC	olefinC	benzeneC	e200	e300	T50	T90
1401	12	12.9	23	10.9	0	0	0	18.8	10.5	0.3	57.5	87.2	157.0	316.4
1402	12	12.9	22	12.2	0	0	0	18.7	10.4	0.3	57.6	87.2	156.7	315.6
1403	12	12.8	22	10.8	0	0	0	19.7	10.2	0.3	57.5	86.9	157.4	316.4
1404	12	11.7	21	10.7	0	0	0	19.9	10.1	0.4	55.8	87.5	165.7	312.8
1405	12	7.5	17	10.5	0	0	0	18.6	8.2	0.4	48.1	87.1	203.7	316.1
1406	12	6.9	22	10.4	0	0	0	19.9	8.6	0.3	47.0	86.2	209.1	320.5
1407	12	7.0	22	10.5	0	0	0	17.0	8.7	0.3	47.2	85.9	207.8	323.3
1408	12	6.9	22	10.4	0	0	0	16.8	8.5	0.3	46.7	85.6	209.3	324.2
1409	12	7.5	23	10.5	0	0	0	17.6	9.9	0.3	48.8	85.8	200.6	323.0
1410	12	10.7	23	10.6	0	0	0	18.2	10.1	0.4	54.5	86.6	173.1	319.1
1411	12	12.3	22	10.8	0	0	0	19.7	9.9	0.4	55.9	87.2	164.4	315.8
1412	12	12.9	23	10.7	0	0	0	18.9	10.1	0.3	57.2	88.4	160.5	309.4
21501	20	0	8	0	0	0	0	0	0	0	0	0	0	0
21502	20	0	8	0	0	0	0	0	0	0	0	0	0	0
21503	20	0	8	0	0	0	0	0	0	0	0	0	0	0
21504	20	0	8	0	0	0	0	0	0	0	0	0	0	0
21505	20	0	7	0	0	0	0	0	0	0	0	0	0	0
21506	20	0	9	0	0	0	0	0	0	0	0	0	0	0
21507	20	0	8	0	0	0	0	0	0	0	0	0	0	0
21508	20	0	7	0	0	0	0	0	0	0	0	0	0	0
21509	20	0	7	0	0	0	0	0	0	0	0	0	0	0
21510	20	0	7	0	0	0	0	0	0	0	0	0	0	0
21511	20	0	7	0	0	0	0	0	0	0	0	0	0	0
21512	20	0	8	0	0	0	0	0	0	0	0	0	0	0
190	90	0	0	0	0	0	0	0	0	0	0	0	0	0
230	30	0	0	0	0	0	0	0	0	0	0	0	0	0
251	51	7.7	8	74	0	0	0	0	0	0	49.9	89.5	200	300

6.5.4 Fuel Usage Fraction

A new table called 'Fuel Usage Fraction' became part of the fuel input files that need to be imported into the MOVES GUI through the CDM. This table contains the countyID, fuelYearID, modelYearGroupID, sourceBinFuelTypeID, fuelSupplyFuelTypeID and usageFraction, and each field is described later in this section. E-85 capable vehicles, which are also known as flex-fuel vehicles, (FFVs) do exist throughout the nation.

These vehicles are capable of using either conventional gasoline or E-85 fuel, which is a blend of 85% ethanol and 15% gasoline by volume. The Fuel Usage table classifies the fraction of E-85 use among E-85 capable vehicles but it is not the fraction of use among all vehicles or the fraction of E-85 capable vehicles in the fleet. It should also be noted that the fuel E-85 should always be selected in the On-road Vehicle Equipment Panel because FFVs are there in the national fleet.

Therefore, the Fuel Usage Fraction inputs turn out to be the appropriate place to account for the amount of actual E-85 usage by the FFVs. Since local data is not available, the MSCP utilized the appropriate default Fuel Usage Fraction Table for the inventory of the 2017 criteria and GHGs pollutants as shown in Table 6.5.4 of this document.

TABLE 6.5.4 Fuel Usage Fraction

countyID	fuelYearID	modelYearGroupID	sourceBinFuelTypeID	fuelSupplyFuelTypeID	usageFraction
24003	2017	0	1	1	1
24003	2017	0	2	2	1
24003	2017	0	3	3	1
24003	2017	0	4	4	1
24003	2017	0	5	1	0.982134
24003	2017	0	5	5	0.017866
24003	2017	0	9	9	1

The fuel usage fraction in Table 6.5.4 of this document contains the following fields:

CountyID: This indentifies the county that is being modeled.

fuelYearID: This indentifies the year of evaluation.

modelYearGroupID: This is sometimes refers to as the engine size. However, a value of zero is entered.

sourceBinFuelTypeID: This indentifies all the available fuels including placeholder's fuels.

fuelSupplyFuelTypeID: This indentifies the fraction of fuel mixtures. For instance, if the fuel is gasoline only, the fuelSupplyFuelTypeID is equal to 1, which means that the fuel is 100% gasoline.

usageFraction: This identifies the fraction of fuel that is being used in the area that is being modeled by capable E-85 vehicles. For example, if the fuel usage fraction was 1.0 in the fuelSupplyFuelTypeID = 5 column, showed that E-85 capable vehicles (FFVs) were using E-85 100% of the time. On the other hand, if the fuel usage fraction was zero in the fuelSupplyFuelTypeID = 5 column, showed that FFVs were using gasoline 100% of the time. It could also indicate that there was no E-85 available in the local fuel supply.

6.5.5 Alternate Vehicle Fuel Technology (AVFT)

This table contains the 13 MOVES source types with the fuel engine fraction of each vehicle using different fuels and technologies in each model year. This table permits the users to modify the fraction of vehicles using different fuels and technologies in each model year. This means that the Fuel Tab allows users to define the split between diesel, gasoline, ethanol, CNG and electricity for each vehicle type and model year. For instance, if in a certain county, it was found that the sales data showed that more diesel vehicles were sold than gasoline vehicles, this tab could be used to make the necessary adjustment to reflect the sales data for this particular county.

The State has adopted both the California Low Emission Vehicle (CALEV) and Zero Emission Vehicle (ZEV) Programs. Moreover, the portion of this table reflects the impact of the modeling of the evaporative portion of the ZEV Program, which affects only source types 21, 31 and 32. It should be noted that each state should make sure that the fuel engine fraction of each fuel should be adjusted in this table according to EPA's Guidance. Based on this information, MSCP appropriately adjusted the AVFT Table for source types 21, 31 and 32 to reflect the implementation of the ZEV Program in the State beginning in model year 2011.

Furthermore, for transit buses, the default table assumed that gasoline, diesel and CNG buses were present in the fleet for most model years. However, if the user has the information about the fuel used by the transit bus fleet in a particular county, the user should make sure that this information is reflected in the AVFT table. For example, if in the modeling area, there are no CNG transit buses, the user needs to allocate zero activity to GNG transit buses in the AVFT Table in order to calculate the correct emission results for transit buses. If this is not done, some VMT would be allocated to CNG transit buses, and the emissions associated with this VMT would not be included in the output, since only gasoline and diesel vehicles were selected in the On-road Vehicle Equipment Panel of the MOVES GUI.

As a result of the enormous size of the AVFT Table, Table 6.5.5 of this document could only show a portion of the AVFT Table. In addition, Table 6-6 specifically showed the fuel engine fraction for source type 21, which was one of the source types that were affected by the implementation of the CALEV and ZEV Programs that began in the State in calendar year 2011, which also coincided with model year 2011.

Other inputs files that were imported into the MOVES GUI include starts, hotelling and retrofit data. MSCP opted for the default values of these input files because local data were not available.

TABLE 6.5.5 AVFT

SourceTypeID	modelYearID	fuelTypeID	engTechID	fuelEngFraction
21	2009	1	1	0.948159
21	2009	2	1	0.007368
21	2009	5	1	0.044473
21	2009	9	30	0
21	2010	1	1	0.935791
21	2010	2	1	0.010123
21	2010	5	1	0.054087
21	2010	9	30	0
21	2011	1	1	0.812126
21	2011	2	1	0.011746
21	2011	5	1	0.066128
21	2011	9	30	0.11
21	2012	1	1	0.786923
21	2012	2	1	0.011746
21	2012	5	1	0.081331
21	2012	9	30	0.12
21	2013	1	1	0.823469
21	2013	2	1	0.011746
21	2013	5	1	0.044785
21	2013	9	30	0.12
21	2014	1	1	0.823632
21	2014	2	1	0.011746
21	2014	5	1	0.044622
21	2014	9	30	0.12
21	2015	1	1	0.804509
21	2015	2	1	0.011746
21	2015	5	1	0.043745
21	2015	9	30	0.14

6.5.6 Fuel Wizard

This is a new feature in MOVES2014a. It is a tool for modifying interrelated properties in a user fuel formulation table when analysis of a change in fuel is desired. For instance, the fuel wizard was used to change the current gasoline sulfur content to 10 ppm to model the effects of gasoline sulfur as required by the Tier3 sulfur content standard, which could also affect other fuel properties. In this case, the Fuel Wizard would appropriately modify related fuel formulation properties, based on refinery modeling, to reflect the change made to sulfur content level.

Once the Wizard is opened, the user could select the desired fuel formulation from the fuelformulation table of the importer database, and from the drop-down field, select the property that needs to be changed, which in this case, is the sulfur content. Then, the Fuel Wizard would automatically adjust related fuel properties in a manner that is consistent with refinery modeling results. As a result of this, the Wizard would display the old and new fuel properties, and the user may accept or reject the change. Furthermore, it is recommended that fuel property changes should be made in ascending order of priority, as the Wizard is only capable of changing one property at a time. In addition, it should be noted that by changing a single fuel property such as sulfur content or RVP, other properties like aromatics or the distillation properties change as well.

Furthermore, the Fuel Wizard contains adjustment factors for three fuel properties (ethanol, sulfur and RVP), which are the most commonly analyzed fuel properties for state and local programs. Moreover, the Fuel Wizard is also currently capable of creating fuels with ethanol variations (E0-E15), sulfur from 5 ppm to 80 ppm and RVP from 5 psi to 14 psi.

6.6 OTHER VEHICLE TECHNOLOGY AND CONTROL STRATEGY DATA

6.6.1 Federal Programs

Current federal vehicle emissions control and fuel programs had been incorporated into the MOVES2014a software. These include the National Program standards covering model year vehicles through 2016. Modifications of default emission rates were required to reflect the early implementation of the National Low Emission Vehicle (NLEV) Program in Maryland.

6.6.2 State Vehicle Technology Programs

MD Clean Car Program*:* Under the Maryland Clean Cars Act of 2007, Maryland adopted the California Low Emission Vehicle (LEV II) Program (CALEV). CALEV was implemented beginning in 2011. CALEV also required all 2011 model year and newer vehicles gross vehicle weight rating (GVWR) to be up to 14,000 lbs. registered in Maryland to meet California emission standards for both criteria and greenhouse gas pollutants. In addition, CALEV also contains a zero emission vehicles' (ZEVs') component that required the manufacturers to produce a certain percentage of zero emission vehicles such as electric, fuel cell, etc., to be purchased in the State. California had just adopted new amendments to the Low-Emission Vehicle regulations entitled, California Low Emission Vehicle III (CALEVIII), which is known as third generation low emission vehicle standards. These amendments created more stringent emission standards for new motor vehicles. These new standards would be phased-in over the 2015-2025 model years in the State.

The impacts of CALEVIII were modeled for all analysis years using USEPA's Guidance document entitled, *Instructions for Using LEV and NLEV Inputs for MOVES2014a*, EPA-420-B-14-060a October 2017. To reflect the impact of both NLEV and CALEVIII programs, USEPA had provided inputs in the form of two databases and one spreadsheet file. The emission rates in these files were to be used only in states other than California, which had adopted the California LEVIII standards, as well as states in the Ozone Transport Commission (OTC), which also received early implementation of NLEV standards. The ZEV file and the CA LEVIII's database were modified according to USEPA's Guidance in the State of Maryland, to reflect the start date that began in 2011.

6.7 POST-PROCESS SUITE (PPSUITE)

PPSUITE is a software tool that is widely used for estimating speeds and processing emission rates. It is a process that is integral to produce key input files to the MOVES emission model. Moreover, PPSUITE utilizes a number of programs and operations, which are assembled into a chain of jobs and steps. Michael Baker Jr. Intl. Inc. has utilized the CENTRAL software to provide MDE with the ability to manage efficiently the emission calculation process.

6.7.1 Other PPSUTE Inputs

The other files required by PPSUITE, which are used for all yearly analysis runs include:

- EQUIV.DBF, which is used for input pattern files and output aggregation.
- NAME.DBF, which is used for the output emission reports. It also relates the coded facility and area type numbers to txt names.
- VEHFC2_14SHA.DAT, which contains the impacts of truck percentages on roadway capacity. Consequently, the amount of trucks could have an impact on calculated congested speeds.
- SPDCAP05.DBF. This file contains the free flow speeds, free flow capacities and BPR parameters , which represents the relationship between speed and congestion for each facility and area types as well as lane combination.

6.7.2 Speed/Capacity Lookup Information

The speed-lookup table has a significant impact on calculated speeds and capacities for each roadway link. This file is used to determine free-flow speeds for links without coded speed limits, link "ideal" capacity, signal densities and characteristics and speed/congestion relationships. The speed capacity fields include inter alia AREATYPE, which is used to indicate area type code, FACTYPE, which represents facility code, LANES, which indicates number of directional lanes, etc.

6.7.3 Running the Air Quality Process in Central

The statewide emission calculation process had been set up to use CENTRAL to assist the user in running the individual program steps. This CENTRAL Program provides a customized windows user-interface with dialog boxes, edit fields and buttons, which are designed specifically for this process. The CENTRAL software had been licensed to MDE, which is always renewed every year and had been used for past regional air quality and conformity analyses as well as the inventories documented herein. This process also requires the PPSUITE software had to be installed in conjunction with MOVES2014a on the computer hard-drive.

6.7.4 Directory and File Structure

The CD-ROM that Michael Baker Jr. Intl. Inc. provided contains the MDMOVES14's directory. This directory contains the input files and program driver files that were needed for producing the emission runs. This directory also contains the following sub-directories:

- ! CENTRAL.
- COMMON.
- DRIVERS.
- MOVESINPUTS.
- OUT.
- OUT_RATETABLE.
- OUT_SUMMARY.
- PROGRAMS.
- TRAFFICINPUTS.

6.7.5 Zone/Area Equivalency

The Zone/Area equivalency file is used to provide equivalency between each link and the fields used for hourly and vehicle mix pattern indexing and output emission indexes. The user is not required to make any adjustments to the file, and even updates to the network and pattern data area.

The fields included in the equivalency file are as follows:
The fields that PPSUITE used in the analysis consist of COUNTY, which defines the county number for pattern and VMT area indexing and NAME that provides the county name.

On the other hand, the fields that are not used in the analysis, but kept for reference include the following:

- ZONE represents traffic zone number, which is linked to the network database field with the same name. This field represents a combination of the county number and the urban-rural code value in the RURURB field. This is calculated as (COUNTY*10) + RURURB.

- UR is related to the RURURB field values.

- FLIPS_CO represents county FIPS code.

- DISTRICT defines the district the county falls under.

- CO_CODE represents county code.

6.7.6 Names Database File

This file is used in generating output emission reports. It transmits the coded facility and area type numbers to text names. This file should only be updated if the area and facility index numbering scheme had been changed from its present values. The NAMES.DBF file contains the emission county totals generated emission reports.

6.7.7 Running the CENTRAL Process

The CENTRAL menu system, which is basically a screen menu system, has been setup to produce emission estimates. This screen menu system comprises the work area directory specified as C:\MDMOVES14, while all output files would be placed in "OUT" subdirectory. It should also be noted that the "Primary Control File" should always be specified as the MDMOVES.CTL file, which could be found in the CENTRAL subdirectory. Furthermore, the user could also select the appropriate directories and files by using the "Select" button on the right side of each input option. After the completion/verification of the "Work Area Directory" and the "Primary Control File", the user could select the "GO" button, which would open other menu screens. This screen allows the user, in this case MSCP to choose between the "Run Emission Process" and the "Run Post Processing Steps". The "Run Post Processing Step" is used to combine emission results for multiple counties.

6.8 ANALYSIS METHODOLOGY

The previous sections summarized the input data used for computing speeds and emission rates for 2017 motor vehicle highway emission estimates' inventories. This section describes how PPSUITE and MOVES used the MOVES input data to produce criteria and GHG emission estimates. Figure 6.6 presents a more detailed overview of the PPSUITE analysis procedure using the available traffic data information described in the previous section.

6.8.1 VMT Preparation

Producing an emissions' inventory with PPSUITE requires a complex process of disaggregation and aggregation of vehicle activities. The data that was available was used on a very small scale -- individual ½ mile roadway segments for each of the 24 hours of the day. This data needed to be processed individually to determine the distribution of vehicle hours of travel (VHT) by speed and then aggregated by vehicle class to determine the input VMT to the MOVES' emission model. The key steps in the preparation of VMT for a summer daily run include:

- *Application of Seasonal Adjustments* - PPSUITE took the input daily volumes from SHA (which represents AADT traffic) and seasonally adjusted the volumes to an average weekday in July. This adjustment utilized factors developed for each functional class and urban/rural code. VMT could then be calculated for each link using the adjusted weekday volumes.

- *Disaggregation to Hours* - After seasonally adjusting the link volumes, the volumes were split to each hour of the day. These seasonal adjustments allowed for more accurate speed calculations factoring in the effects of congested hours, thereby allowing PPSUITE to prepare the hourly VMT and speeds for input to the MOVES model.

- *Peak Spreading* - After dividing the daily volumes to each hour of the day, PPSUITE identified hours that were unreasonably congested. For those hours, PPSUITE then extended a portion of the volume to other hours within the same peak period, thereby approximated the “peak spreading” that normally occurred in such over-capacity conditions.

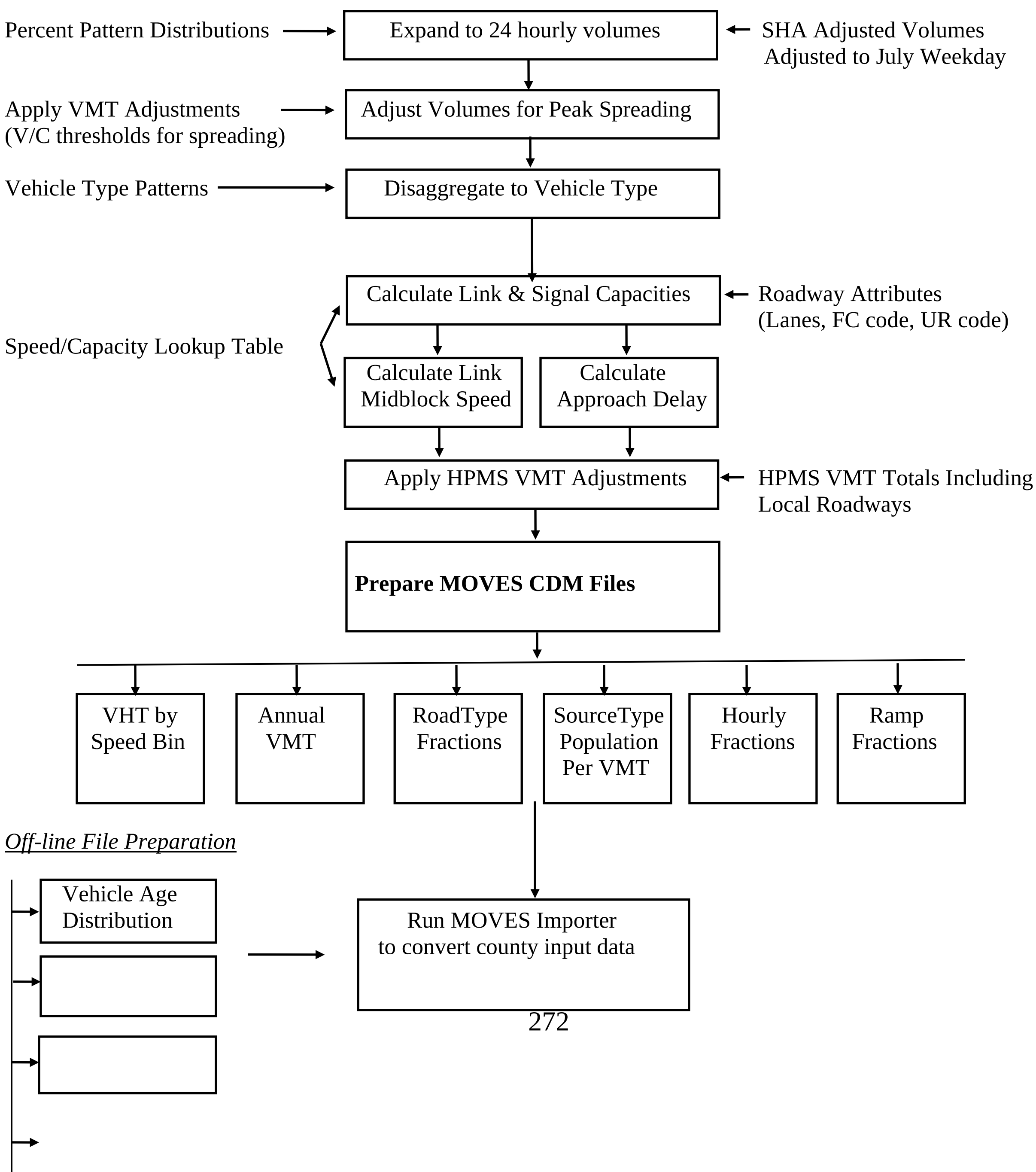
- *Disaggregation to Vehicle Types* - USEPA requires VMT estimates to be prepared by source types, reflecting specific local characteristics. As a result, for Maryland’s emission inventory runs, the hourly volumes were disaggregated to the five HPMS MOVES vehicle grouping based on count data assembled by SHA in combination with MOVES defaults as described in the previous section.

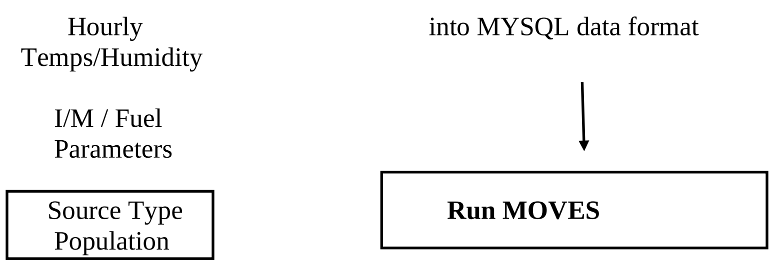
- *Application of HPMS VMT Adjustments* - Volumes must also be adjusted to account for differences with the HPMS VMT totals, as described previously. VMT adjustment factors were provided as input to PPSUITE, and were applied to each of the roadway segment volumes. These factors were developed from the latest HPMS download (conducted triennially); however, they are also applied to any future year runs. The VMT that is added or subtracted to the SHA's database assumed the speeds calculated using the original volumes for each roadway segment for each hour of the day.

Figure 6.8.1: PPSUITE Speed/Emission Estimation Procedure

PPSUITE Analysis Process

(The Following steps are Performed for each SHA's Roadway Segment)

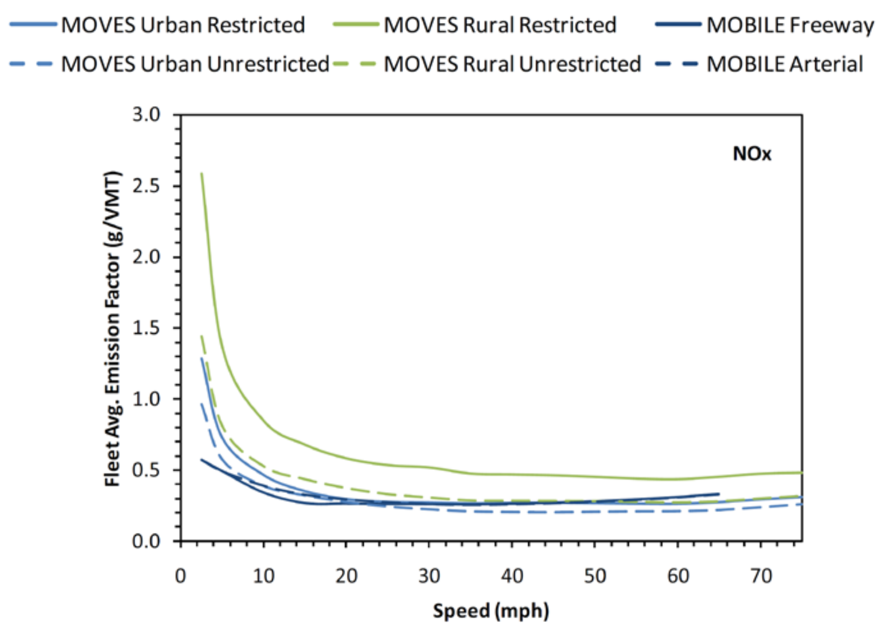




6.8.2 Speed Estimation

Emissions for many pollutants (including both VOC and NOx) vary significantly with travel speed. VOCs generally decrease as speed increases, while NOx decreases at the low speed range and increases at higher speeds, as illustrated in Figure 6.8.2.

Figure 6.8.2: Emission Factor vs. Speed Variances (NO_X)



Source: Figure 3 from Implications of the MOVES2010 Model on Mobile Source Emission Estimates, Air & Waste Management Association, July 2010.

USEPA recognizes that the estimation of vehicle speeds is a difficult and complex process. Moreover, it recommends that special attention should be given to developing reasonable and consistent speed estimates, knowing that emissions are so sensitive to speeds. Furthermore, it also recommends that VMT be disaggregated into subsets that have roughly equal speed, with separate emission factors for each subset. At a minimum, speeds should be estimated separately by road type.

The computational framework used for this analysis met and exceeded that recommendation. Speeds were individually calculated for each roadway segment by hour, and they included the estimated delays encountered at signals. Rather than accumulating the roadway segments into a particular road type and calculating an average speed, each individual link hourly speed was represented in the MOVES vehicle hours of travel (VHT) by speed bin file. This MOVES input file allows the specification of a distribution of hourly speeds. For example, if 5% of a county's arterial VHT operates at 5 mph during the AM peak hour and the remaining 95% operates at 65 mph, this could be represented in the MOVES speed input file. For the motor vehicle highway emissions' inventory, distributions of speeds were input to MOVES by both road type and source type by each hour of the day.

To calculate speeds, PPSUITE first obtained initial capacities (how much volume the roadway could serve before heavy congestion), and free-flow speeds (speeds assuming no congestion) from the speed/capacity lookup data. As described in previous sections, this data contained default roadway information indexed by the urban/rural code and functional class. For areas with known characteristics, values could be directly coded to the SHA's database, and the speed/capacity data could be overwritten.

However, for most areas where known information is not available, the speed/capacity lookups provide valuable default information regarding speeds, capacities, signal characteristics, and other capacity adjustment information used for calculating congested delays and speeds. The result of this process was an estimated average travel time for each hour of the day for each highway segment. The average time multiplied by the volume produced by VHT.

6.8.3 Developing the MOVES Traffic Input Files

The PPSUITE software is responsible for producing the following MOVES input files during any analysis run:

- VMT by HPMS vehicle class
- VHT by speed bin
- Road type distributions
- Ramp fractions

These files are text formatted files with a *.csv extension. The files were provided as inputs to MOVES GUI through the CDM.

VMT Input File: VMT is the primary traffic input that affects emission results. The roadway segment distances and traffic volumes were used to prepare estimates of VMT. PPSUITE performed these calculations and the MOVES annual VMT input file was imported into the MOVES GUI through the CDM.

VHT by Speed Bin File**:** As described in the previous section, the PPSUITE software prepares the MOVES VHT by speed bin file, which summarizes the distribution of speeds across all links into each of 16 MOVES speed bins for each hour of the day by road type. This robust process ensures that MOVES emission rates were used to the fullest extent and was consistent with the methods and recommendations provided in USEPA's Technical Guidance.

Road Type Distributions**:** In MOVES, typical drive cycles and associated operating conditions vary by the type of roadway.

MOVES define five different road types as follows:

1 Off-Network
2 Rural Restricted Access
3 Rural Unrestricted Access
4 Urban Restricted Access
5 Urban Unrestricted Access

For this inventory, the MOVES road type distribution file was automatically generated by PPSUITE using defined equivalencies. The off-network road type included emissions from vehicle starts, extended idle activity, and evaporative emissions. Off-network activity in MOVES is primarily determined by the Source Type Population input.

The remaining distribution among road types is determined by equating the functional class with each MOVES road type as follows:

- MOVES Road Type (2) = SHA Functional Class (1)
- MOVES Road Type (3) = SHA Functional Class (2,6,7,8,9)
- MOVES Road Type (4) = SHA Functional Class (11,12)
- MOVES Road Type (5) = SHA Functional Class (14,16,17,19)

Ramp Fractions**:** Since ramps are not directly represented within the SHA's database information, it is assumed that 8% of the Freeway VHT is ramp VHT. This is consistent with national default values within MOVES and recommendations provided in USEPA's Technical Guidance.

6.8.4 MOVES Runs

After computing speeds and aggregating VMT and VHT, PPSUITE prepared traffic-related inputs needed to run USEPA's MOVES2014a software. Additional required MOVES inputs were prepared external to the processing software, which included temperatures, I/M program parameters, fuel characteristics, vehicle fleet age distributions and source type population.

The MOVES county importer was run in batch mode. This program converted all data files into the MYSQL formats used by the MOVES model. At that point a MOVES run specification file (*.mrs) was created that specified options and key data locations for the run. MOVES was then executed in batch mode.

MOVES could be executed using either the *inventory* or *rate-based* approaches. For this highway emissions inventory, MOVES was applied using the *inventory-based* approach. Under this method, actual VMT and population were provided as inputs to the model, and MOVES was responsible for producing the total emissions for the area being modeled. Under the *rate-based* approach, MOVES would produce emission factors, after which PPSUITE would apply the emission factors to the link data and calculate total emissions for the area being modeled.

6.9 FUEL CONSUMPTION ESTIMATES

The MOVES output energy rates could be converted to fuel consumption values using the conversion rates for gasoline and diesel fuel (See equation 1-1 and 4-12 for the conversion of fuel from kilojoules to gallons).

The estimated 2017 fuel consumption values are shown in Table 6.9 below. The 2017 values were compared to the actual statewide fuel sales as illustrated in the last column.

TABLE 6.9: 2017 Fuel Consumption Estimates

Scenario	Fuel Type	MOVES2014A Output		Actual Statewide Fuel Sales[2] *(Thousand Gallons)*
		Energy Consumption *(Trillion BTU)*	Estimated Fuel Consumption[1] *(Thousand Gallons)*	
2017	Gasoline	291	**2,417, 950**	**2,790,991**
	Diesel	79	**573,989**	**517,250**

[1]Assumes the following conversion rates extracted from the EIA's website:
(120,333 BTU per gallon of gasoline) and (137,381 BTU per gallon of diesel)

[2]Gasoline and diesel values were obtained from Maryland Comptroller's Office for calendar year (CY) 2017.

6.10 RESOURCES

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4. Mobile Sources Control Program, *1990 Inventory of Highway Vehicle Emissions for the Baltimore Ozone Nonattainment Area, the Queen Anne's/Kent County Ozone Nonattainment Area, the Cecil County , Maryland portion of the Philadelphia, Pennsylvania Ozone Nonattainment Area, and the remainder of the State of Maryland*, August 23, 1993.

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16. United States Environmental Protection Agency, *Motor Vehicle Emission Simulator (MOVES), User Guide for MOVES2014*, July 2014.

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6.11 HIGHWAY VEHICLE INVENTORY GLOSSARY

AADT: Average Annual Daily Traffic, average of ALL days.
AWDT: Average Weekday Daily Traffic.

County Data Manager (CDM): User interface developed to simplify importing specific local data for a single county or a user-defined custom domain without requiring direct interaction with the underlying MySQL database.

Emission rate or factor: Expresses the amount of pollution emitted per unit of activity. For highway vehicles, usually in grams of pollutant emitted per mile driven

FC: Functional code, applied in data management to road segments to identify their type (freeway, local, etc.).

Growth factor: Factor used to convert volumes to future years.

HPMS: Highway Performance Monitoring System, MDOT's official source of highway information and a subset of SHA.

I/M: Vehicle emissions inspection/maintenance programs ensure that vehicle emission controls are in good working order throughout the life of the vehicle. The programs require vehicles to be tested for emissions. Most vehicles that do not pass must be repaired.

MOVES: The latest model EPA has developed with which Maryland uses to estimate emissions from highway vehicles.

Pattern data: Extrapolations of traffic patterns (such as how traffic volume on road segment types varies by time of day, or what kinds of vehicles tend to use a road segment type) from segments with observed data to similar segments.

PPSUITE: Post-Processor for Air Quality, a set of programs that estimate speeds and processes MOBILE emission rates.

Road Type: Functional code, applied in data management to road segments to identify their type (rural/urban highways, rural/urban arterials, etc.)
Source Type: vehicle types used in MOVES modeling

UR: Urban/rural cod e, applied in data management to identify whether a road segment is urban, small urban or rural.
VHT: Vehicle hours traveled.
VMT: Vehicle miles traveled. In modeling terms, it is the simulated traffic volumes times the link length.

7.0 BIOGENIC EMISSIONS

7.1 INTRODUCTION

Biogenic sources, a subset of natural sources, include only those sources that result from some sort of biological activity. Biogenic emissions represent a significant portion of the natural source emissions, and VOC, NO_x, and the greenhouse gases can be emitted from biogenic sources.

Vegetation is the predominant biogenic source of VOC and is typically the only source that is used to estimate biogenic VOC emissions. Microbial activity is responsible for the emission of NO_x and the greenhouse gases of CO_2, CH_4, and N_2O. Soil microbial activity is responsible for NO_x and N_2O emissions from agricultural lands and grasslands. CH_4 is emitted through microbial action in waterlogged soils or in other anaerobic microenvironments. CO_2 is released through the aerobic decay of biomass (EPA, 1993; EPA, 1990a).

The Biogenic emissions category can't be controlled directly; therefore, a majority of the resources were directed towards other categories of air pollution where direct control is feasible. For this reason, MDE used the data files created and made available by EPA (2017). These emissions were computed on an hourly basis with a specially-modified version of BEIS3[94] that utilized county land use data from EPA's land use inventory and National Weather Service first-order station data of temperature and cloud cover. However, due to the large size of the hourly data files, only the monthly data files were available when MDE gathered this information.

The data files EPA generated contained county-total estimates of 2002 biogenic emissions based on the BEIS3.12 model. The purpose of this spreadsheet is to provide default 2002 estimates to the states for the purpose of biogenic emissions submittals by county required by the Air

[94] BEIS 3.142 can be downloaded from an EPA website at: https://www.epa.gov/air-emissions-modeling/biogenic-emission-sources

Emissions Reporting Requirements (AERR). These estimates were created using the following data:

1) 2017 annual meteorology
2) BEIS3.14 model via the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system
3) Recently revised BEIS3.14 emission factors file (also provided as a separate file with this spreadsheet)
4) BELD3 land use data (1-km original data aggregated to 36-km grid).
5) Post processing summation of county-total emissions from SMOKE, calculated from 36-km gridded emissions using the "land area" spatial surrogate. This means that when calculating the county-total numbers, the 36-km gridded emissions were assumed to be uniformly distributed over the grid cell for purposes of mapping to the counties.

Monthly emission estimates were given for each county in Maryland for the following pollutants:

- CO: Carbon monoxide (a new species output by BEIS3.14
- NO: Nitrogen oxide
- ALD2: Aldehyde group from CB-IV chemical mechanism
- ETH: Ethane group from CB-IV chemical mechanism
- FORM: Formaldehyde group from CB-IV chemical mechanism
- ISOP: Isoprene
- NR: Nonreactive VOC
- OLE: Olefin group from CB-IV chemical mechanism
- PAR: Parafin group from CB-IV chemical mechanism
- XYL: Xylene group from CB-IV chemical mechanism
- TOL: Toluene group from CB-IV chemical mechanism
- Total VOC: The sum of ALD2, ETH, FORM, ISOP, NR, OLE, PAR, XYL, and TOL
- TERPB: Terpenes (Note that the same mass accounted for by TERPB is also included in VOC

The daily emissions were calculated by summing the monthly emissions from June, July, and August and dividing by the number of days in those three months (92).

WAS RCE