MARYLAND DEPARTMENT OF THE ENVIRONMENT

AIR AND RADIATION MANAGEMENT ADMINISTRATION

State Implementation Plan

2002 Base Year
State Implementation Plan
Emissions Inventory and
Methodologies for
Regional Haze

Prepared for:

U.S. Environmental Protection Agency

Prepared By:

Maryland Department of the Environment

Maryland Department of the Environment
2002 Base Year State Implementation Plan Emissions Inventory and Methodologies for Regional Haze

Table of Contents

1.0 INTRODUCTION

1.1   OVERVIEW AND BACKGROUND

The 2002 Base Year State Implementation Plan Emissions Inventory and Methodologies for Regional Haze 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 Base Year will provide an outline for content and organization review of the inventory. The goal of the Base Year 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 Management Administration (MDE-ARMA), 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, mobile sources, biogenic emissions, non-road mobile sources, and area sources. MDE-ARMA will use the Non-Road Mobile Emissions Model, NONROAD, for small engine emissions. MDE-ARMA will supply emissions for major point sources and area sources, and will accept EPA estimates for biogenic emissions. Mobile source emissions will be estimated by a separate MDE-ARMA work plan with MDOT and MDE-ARMA Mobile Sources Control Program (MSCP) as well as the MWCOG.

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 Base Year is to improve the quality of inventory data collection so that it is a reliable source of information for sound decision-making.

1.2 GEOGRAPHIC AREA

The area that will be inventoried includes the entire State of Maryland. The area can be divided into the distinct Non-attainment areas (NAA). Categories that will be inventoried are point, mobile, biogenic, non-road mobile and area sources.

1.3 TEMPORAL RESOLUTION

Another step of inventory development is the temporal allocation of emissions. Because air quality modeling attempts to represent the actual physical and chemical processes as they occur over a specific duration of time, it is important that the temporal allocation of emissions be as accurate as possible. Temporal allocation can be thought of as an accounting of emissions variation over time. The simplest temporal allocation is for a steady-state emissions source that continually releases emissions at the same rate all the time. Under actual conditions, however, steady-state emission sources are quite rare. Instead, under actual conditions, emissions sources may operate only in the winter not operate on Sundays, or their activity may peak during certain hours of the day.

The planning period for particle matter is based on annual emissions.

1.4 QUALITY ASSURANCE POLICY AND OBJECTIVES

In order to provide data of sufficient quality for maintenance planning needs, quality assurance (QA) and quality control (QC) procedures are implemented as part of the inventory process. The procedures address data quality objectives of accuracy, completeness, comparability and representativeness. A brief discussion of the data quality objectives is given below.

Data quality objectives of accuracy, completeness, comparability, and representativeness are addressed to ensure an inventory of high quality. The target goals for each objective are listed below.

Accuracy: All estimates must be calculated and documented using acceptable methods. Individual source requirements and availability of data and resources will affect the estimation method selection.

Completeness: Completeness is addressed by ensuring that all applicable source categories are included in the inventory, and that all information required to estimate emissions is present. Applicable source categories are listed in Appendix A.

Comparability: Data will be compared to the most recent base year inventories: 1990 for PM_{10} and 1999 for CO. Any discrepancies (data outliers) greater than 20% involving sources that made up greater than 5% of either the 1990 or the 2002 inventories for PM_{10}, or the 1999 and 2002 inventories for CO will be corrected or justified.

Representativeness: Actual 2002 annual and seasonal daily emissions will be calculated for the base year inventory. Local data will be used in inventory calculations wherever possible.

1.5   PLAN INFORMATION SOURCES

This plan draws upon inventory, quality assurance, and emissions projections guidance available from state and federal agencies and partnerships.[1, 2, 3, 4, 5, 6, 7] The effort will also draw upon experience gained with the 1990 Ozone and 1996/1999/ periodic emission inventory reviews and prior SIP inventory efforts in other areas and for other pollutants.

A primary source of emissions inventory data will be the 2002 Consolidated Emissions Reporting Rule (CERR) submittal recently submitted to the U.S. EPA by MDE-ARMA. Another source of information will be EPA's National Emissions Inventory (NEI). The MD DOT and MDE-ARMA-Mobile Department will provide base year and projection year onroad mobile source emissions data and additional activity data to be used in estimating emissions for other source categories (paved and unpaved road dust). Finally, information from local sources, including Maryland Transportation Authority, Maryland Aviation Authority, Maryland Port Authority, university sources, and agricultural experts will be used to develop emission estimates for select source categories (as described in Chapter 6).

1.6   INVENTORY DEVELOPMENT AND QUALITY CONTROL PROCEDURES

An inventory of actual emissions will be developed for base year 2002. Annual and typical VOC, NO_X, SO_2, PM_{10} and CO season day emissions estimates will be made. A list of potential VOC, NO_X, SO_2, PM_{10} and CO sources was developed using the 1990 base year inventory, 1996/1999 periodic emission inventories, local knowledge, categories as defined in references, and the 2002 National Emissions Inventory (NEI) for VOC, NO_X, SO_2, PM_{10} and CO source categories. The source categories are listed in Appendix A.

The inventory development process consists of several steps. A description of each step and the quality control procedures implemented are discussed individually in the following sub-sections:
- Estimation methods and data gathering;
- Emissions calculations and data checking;
- Missing data;
- Application of rule effectiveness and rule penetration;
- Corrective action; and
- Documentation.

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[1] PM-10 Emission Inventory Requirements. Final Report. U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1994.

[2] Emission Inventory Improvement Program, Volume IV: Quality Assurance Procedures. EPA-454/R-97-0041. July 1997.

[3] Procedures Document for National Emissions Inventory, Criteria Air Pollutants 1985-1999. United States Environmental Protection Agency. Office of Air Quality Planning and Standards. Research Triangle Park NC 27711. EPA-454/R-01-006. March 2001.

[4] Procedures for Preparing Emissions Projections. U.S. Environmental Protection Agency, Research Triangle Park, NC, July 1991

[5] Emission Inventory Requirements for Carbon Monoxide State Implementation Plans, EPA-450/4-91-011, March 1991

[6] June 4-6, 1991 EPA manual Workshop for Implementation of Clean Air Act Provisions Relating to Ozone and Carbon Monoxide Emission Inventories, June 4-6, 1991 EPA.

[7] Guidance for the Preparation of Quality Assurance Plans for O3/CO SIP Emission Inventories. EPA-450/4-88-023. December 1988.

1.7 ESTIMATION METHODS AND DATA GATHERING

Guidance listed under Plan Information Sources will be utilized to select estimation methods and gather information necessary to develop the inventory. QC activities during data gathering include thorough documentation of methods and data sources, and checking for reasonableness of data obtained. General estimation methods and data sources anticipated for each source category are listed below.

1.7.1 COMBINED APPROACH FOR O_3, PM_{10} and CO BASE YEAR EMISSIONS

This section of the Base Year document is an overview of MDE-ARMA's proposed approach to preparing the 2002 emission estimates. This is followed by approaches specific to the source categories.

For PM_{10}, the top-emitting PM_{10} categories are point sources, residential wood combustion, open burning, paved and unpaved road fugitive dust. In addition, agricultural tilling and other fugitive dust source categories were not quantified in the 1990 Base Year Emissions Inventory. For agricultural tilling, MDE-ARMA will evaluate the potential importance of this activity during the planning period through contacts with local agricultural experts. If little or no agricultural tilling occurs within the state during the planning period, no effort will be made to quantify these emissions. For windblown dust, emissions are dominated by sources outside of the NAA. MDE-ARMA does not intend to estimate these emissions.

MDE-ARMA plans to focus most of its CO emission inventory and emissions projection effort on the top-emitting source categories in the area. For CO, the priority source categories are onroad mobile sources, point sources, residential wood combustion, open burning, and nonroad engines/vehicles.

1.8 MISSING DATA

Missing data will be identified by the inability to complete the calculations. If data are found to be missing, a reasonable effort will be made to acquire the data. If this is unsuccessful, estimates will be made based on past years' data or default information contained in EPA documents and models. Sources of all data will be documented.

1.9 APPLICATION OF RULE EFFECTIVE AND RULE PENETRATION

Rule effectiveness (RE) reflects the ability of a control device or regulation to achieve all the emission reductions that could be achieved by full compliance at all times. Rule penetration (RP) is a measure of the extent to which a regulation covers emissions from a source category. RE/RP has been the subject of ongoing discussion nationally and is the topic of a draft report by the Emissions Inventory Improvement Program (EPA/STAPPA/ALAPCO).[8] Briefly, the report recognizes that control efficiencies are often based on in-use conditions, and when this is the case, RE has already been taken into account. This is the situation for point sources in the NAAs. Additionally, some point source emissions are estimated through source testing, and therefore do not use control efficiencies and RE/RP to calculate emissions. For area sources, MDE will evaluate each control measure to determine whether EPA default RE and RP estimates (80% and 100%) should be applied or some more representative values.

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[8] "Emissions Inventories and Proper Use of Rule Effectiveness." September 23, 1998. Memorandum from EIIP Point Sources Committee Members to EIIP Steering Committee Members. September 23, 1998.

1.10 CORRECTIVE ACTION

Corrective and follow-up actions identified during the inventory development process will be noted and referred to the appropriate staff. Both the corrective actions identified and results of actions taken in response will be documented and kept on file.

Written documentation specifying inventory methodology and information sources will be provided. Emission summaries will be presented.

2.0 POINT SOURCES

2.1 INTRODUCTION

The Maryland Department of the Environment Air and Radiation Management Administration (ARMA) 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. In order to provide EPA with a written documentation of emissions calculations for major point sources, confidential information was included in the documentation. It is included with the understanding that EPA is also bound to respect the confidentiality of the information, including appropriate storage of the information. Any contractors employed by EPA to review the inventory are also subject to confidentiality provisions, or the EPA must remove the confidential material before submitting the document for review. This information does not appear in copies prepared public review.

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 2002 Periodic Emissions Inventory, point sources are defined as stationary commercial or industrial operations that emit more than 10 tons per year of volatile organic compounds (VOC); 100 tons per year of carbon monoxide (CO), sulfur oxides (SO_x), particulate matter with an aerodynamic diameter less than 10 micrometers (PM_{10}), and total suspended particulates (TSP); or 25 tons per year of oxides of nitrogen (NO_x. In addition, stationary sources included in previous PEI submissions were included herein regardless of the amount of air pollutants emitted. These emissions criteria are more commonly referred to as "emissions thresholds" or simply, "thresholds."

2.2 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 ARMA to ensure the point source inventory is as complete as possible. The primary data source is the Permitting Program, which overseas 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 ARMA. 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.

The Department has established a Small Business Assistance Program as required by the Clean Air Act Amendments to acquaint the owners of potential sources with the State's permitting requirements, including air quality permits. The Department has also published a guidebook, Environmental Regulation: A Business Guide to the Maryland Department of the Environment's Permitting Process as part of its outreach program.

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.

2.2.1   EMISSION CALCULATIONS

The ARMA technical staff uses one of the following methodologies to calculate criteria pollutant emissions:

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

The Compliance Program facility inspectors calculate annual emissions estimates following their annual facility inspections. The results are then entered into ARMA's Registration Files for Facilities and Equipment, which lists facilities by premise numbers and equipment by registration numbers under each facility. The emissions, both stack and fugitive, from all registered equipment at a specific facility are summed to yield the annual facility emissions estimate. This total facility estimate is used to determine whether the facility satisfies the criteria for classification of as a point source.

The estimation of emissions on a facility-wide basis can result in emissions from equipment in some subcategories, such as boilers, being obscured. For example, boiler emissions are included in the Amerada Hess Corporation's total emissions. Therefore, these boiler emissions are included with emissions from gasoline storage and handling operations and included in the Storage, Transportation and Marketing of Petroleum Products and Volatile Organic Liquids source category rather than in External Combustion Sources category.

Emissions from specific subcategories of sources can be extracted from the inventory to estimate possible reductions from various control strategies. However, the emissions from specific equipment subcategories cannot be excluded from the facility-wide emissions because of the limitations of the software used to create the Registration File. Therefore, subcategories of equipment emissions are not included in the inventory as separate line items for to do so would result in the double counting of those emissions.

The estimates prepared by the facility inspectors following the annual inspection of each facility are compared to the annual emissions reported by each facility in its Annual Emissions Certification. A person who owns or operates a major facility as defined in COMAR 26.11.01.05-1 must submit to the Department an emissions statement by April 1 of each year for the previous calendar year. The owner or operator of the facility must further certify that the emissions statement is accurate to the best of the owner/operator's best knowledge. After the certified emissions statements are logged in, they are thoroughly reviewed by the assigned facility inspectors. Each inspector compares their emissions estimate to that prepared by the respective company for consistency of methodology and final emissions estimate results. The facility inspectors resolve any discrepancies between the two estimates with the owner/operator of the facility in question. When all discrepancies are resolved to the satisfaction of MDE, the final emissions estimates are then submitted as an update to ARMA's Registration File for Facilities and Equipment.

2.2.1.1 Seasonal Adjustments

ARMA has not collected extensive data on the temporal allocation of emissions. Typically, companies are required to partition annual emissions by calendar quarter. More specific information to allow allocation of emissions to time of day, peak ozone season, ozone season, or even monthly periods of activity was not collected in 2002. More specific information may be collected in the future.

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 pounds per year were converted into pounds per day emissions by dividing annual emissions by operating days,
2) Pounds 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.

2.2.2 CONSOLIDATED EMISSIONS REPORTING RULE (CERR)

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

3.0 QUASI - POINT SOURCES

3.1 INTRODUCTION

The Maryland Department of the Environment Air and Radiation Management 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.

Sample calculations presented below are for illustrative purposes only and may not reflect actual emissions.

3.2 ABERDEEN PROVING GROUNDS

Description

Aberdeen Proving Ground (APG) occupies more than 72,500 acres in Harford County, Md. Its northernmost point is marked by the confluence of the Susquehanna River and the Chesapeake Bay. On the south the Gunpowder River borders it.

The installation comprises two principal areas, separated by the Bush River. The northern area is known as the Aberdeen Area, and the southern sector, formerly Edgewood Arsenal (established in November, 1917 - as a chemical weapons research, development and testing facility), is the Edgewood Area. The two areas were administratively combined in 1971.

Aberdeen Proving Ground is home to 66 tenants and a host of satellite activities. Among the major tenants are the U.S. Research, Development and Engineering (RDECOM), U.S. Army Ordnance Center and Schools, U.S. Army Developmental Test Command, U.S. Army Aberdeen Test Center, U.S. Army Center for Health Promotion and Preventive Medicine, Northeast Region Civilian Personnel Operations Center, U.S. Army Medical Research Institute of Chemical Defense, Program Manager for Chemical Demilitarization and major elements of the Army Research Laboratory.

As a center for Army materiel testing, laboratory research and military training, the post is a key element in the nation's defense. All tanks and wheeled vehicles which have served U.S. forces for the past 50 years have been tested for performance and durability at APG - from the M4 Sherman tank of World War II to the M1 tank and High Mobility Multipurpose Wheeled Vehicle and Family of Stryker Vehicles of today.

Known as the "Home of Ordnance," APG has been training Army ordnance personnel since 1918. The Army's ordnance training was consolidated at the proving ground during World War II, and today the U.S. Army Ordnance Center and School provides mechanical maintenance training for more than 20,000 U.S. and foreign personnel each year. APG is the regimental headquarters for the Army's Chief of Ordnance.

APG's Edgewood Area has been a center for chemical warfare research and development since it was established. From the trenches of France and Belgium in World War I to the desert battlefields of Iraq nearly 80 years later, the work done at APG has contributed to the defense and safety of American forces threatened by chemical weapons.

More than 7,500 civilians work at Aberdeen Proving Ground, and more than 5,000 military personnel are assigned there. In addition, there are nearly 3,000 contractors and private business employees working on the proving ground.

There are 2,148 military family members living on the post and another 155 off post. The post supports more than 16,000 military retirees and retiree family members. The post is Harford County's largest employer and one of the largest employers in the state of Maryland.

U.S. Army Garrison, Aberdeen Proving Ground, provides general, administrative and logistical support to the post's tenants and satellite activities, and is responsible for the management and operation of the entire installation, which in many ways is like a small city.

Environmental stewardship is an essential component of all activity at APG. The installation and its tenants are actively involved in a wide variety of environmental compliance, pollution prevention, conservation, and restoration programs. In FY 2004 APG spent a total of $31 million on environmental programs, installation programs and installation restoration activities.

Pollutants

VOC, NOx, CO, PM, Toxics

Emission Source Categories

MDE staff reviewed emission estimates prepared for Aberdeen Proving Grounds by a private contractor. These emission estimates included data for the following source categories:

- Mobile On-Road Source Emissions
    - Mobile - LDGV Emissions
    - Mobile - LDGT 1&2 Emissions
    - Mobile - LDGT 3&4 Emissions
    - Mobile - HDGV
    - Mobile - LDDT 1-4
    - Mobile - HDDV
    - Mobile - HDDV Exhaust
    - Mobile – HDDB
    - Mobile - HD CNG Trucks
    - Mobile - LD CNG Trucks

- Mobile Nonroad Source Emissions
    - 2-Stroke Gas Eng; Lawn & Garden Equip; Other Equipment
    - 4-Stroke Gas Eng; Recreational Equip; Golf Carts
    - 4-Stroke Gas Eng; Recreational Equip; Specialty Vehicles/Carts
    - 4-Stroke Gas Eng; Construction & Mining Equip; Off-Highway Trucks
    - 4-Stroke Gas Eng; Industrial Equip; Forklifts
    - 4-Stroke Gas Eng; Lawn & Garden Equip; Chain Saws
    - 4-Stroke Gas Eng; Lawn & Garden Equip; Leaf blowers/Vacuums
    - 4-Stroke Gas Eng; Lawn & Garden Equip; Rear Eng Riding Mowers

- o 4-Stroke Gas Eng; Lawn & Garden Equip; Front Mowers
- o 4-Stroke Gas Eng; Lawn & Garden Equip; Other Lawn & Garden Equip
- o 4-Stroke Gas Eng; Commercial Equip; Generator Sets
- o LPG Eng; Construction & Mining Equip; Off-Highway Trucks
- o Diesel Eng; Construction & Mining Equip; Rollers
- o Diesel Eng; Construction & Mining Equip; Cranes
- o Diesel Eng; Construction & Mining Equip; Graders
- o Diesel Eng; Construction & Mining Equip; Off-highway Trucks
- o Diesel Eng; Construction & Mining Equip; Tractors/Loaders/Backhoes
- o Diesel Eng; Construction & Mining Equip; Other Construction Equip
- o Diesel Eng; Industrial Equip; Forklifts
- o Diesel Eng; Industrial Equip; Sweepers/Scrubbers
- o Diesel Eng; Lawn & Garden Equip; Front Mowers
- o Diesel Eng; Agricultural Equip; Agricultural Tractors
- o Diesel Eng; Commercial Equip; Generator Sets
- o Recreational marine 4-stroke gasoline equipment
- o Recreational marine diesel compression ignition equipment
- o Aircraft

- Area Source Emissions
    - o Emissions from aircraft refueling.
    - o Construction Welding
    - o Solvent-based architectural surface coatings.
    - o Water-based architectural surface coatings.
    - o Cold cleaning solvents.
    - o Solvent Utilization - Miscellaneous
    - o Commercial/consumer solvents.
    - o Open Burning Detonation
    - o Landfills - All Categories
    - o Munitions Detonation
    - o Firefighting Training
    - o Industrial Process - Miscellaneous
    - o Commercial/institutional distillate oil combustion.
    - o Commercial/institutional natural gas combustion.

- Point Source Emissions
    - o MDE staff also reviewed and included emission estimates from emission certification reports prepared by Aberdeen Proving Grounds and submitted on an annual basis to MDE's Compliance and Enforcement Program. These emission estimates include major sources.

Emission Estimation Methodologies

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

Mobile On-Road Source Emissions

Information on the privately owned vehicles for APG was estimated from a 2001 traffic study conducted for all gates at both Aberdeen and Edgewood.

Emissions for the on-road vehicles were calculated only for the estimated miles and hours of on-base vehicle operation. Miles traveled off the base were not included in the emission calculations. *AP-42, Volume 11, Fifth Edition* includes the emission factors for NOx, CO, and VOC, which were calculated using EPA's MOBILE 5 model for gasoline and diesel operated vehicles. AP-42 has not been updated with NOx, CO, and VOC emission factors from the latest version of EPA's MOBILE 6.2.03 model, released in October 2002, which also includes emission factors for PM-10, PM-25, S02, and HAPS. Therefore, the emission factors for on-road vehicles were obtained by running the MOBILE 6.2.03 model.

APG government-owned vehicles were grouped into vehicle categories according to vehicle type, gross vehicle weight (GVW), and fuel type. The CY 2002 mileage for each vehicle, if available, was provided by each organization, as were estimates of on-base mileage or a percentage of the total miles per vehicle that were driven on the base. If the mileage data was not available, it was estimated based on mileage for similar types of vehicles from other organizations or from estimates provided by organization personnel.

Emission estimates for privately owned vehicles (POVs) are based on traffic studies for CY 2000 and CY 2001. Each traffic study tracked incoming vehicles at all gates at both Aberdeen and Edgewood over a three-week period. The average number of vehicles counted at each gate over both years was used to estimate the number of POVs entering each day. The average values were 7,680 POVs per day at Aberdeen and 5,277 per day at Edgewood.

POV miles traveled were determined by using the distance from each gate to a central location at both Aberdeen and Edgewood. Each POV that entered a specific gate was assumed to drive that distance each day. The daily on-base mileage was determined by multiplying the number of POVs by the round-trip distance to a specific gate. The POV vehicles from the traffic study were conservatively estimated to be in the above-referenced vehicle categories.

Emissions of NOx, CO, VOC, PM-10, PM-2.5, and SO2 from daily employee POVs were estimated by multiplying the annual on-base mileage of each vehicle category with the emission factors obtained from the MOBILE 6.2.03. Since the model years of POVs traveling on the base would vary greatly, it is impractical to estimate the emissions from each vehicle in that model year range. Instead the year 2000 was considered the average vehicle model year, and the emission factors for the 2000 model year vehicles were used. The emission factors were used in the following equation to estimate annual emissions:

$$1.1.1.1.1.1.1 \quad E = V * F * C$$

Where:
E = Annual emissions of particular pollutant from each vehicle category (lb/yr)
V = 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 = Conversion factor (2.205 x 10 lb/g)

The information on the vehicles tested and miles driven on unpaved test tracks at APG was obtained from 2002 logs for each track. The test vehicles were divided equally into the HDDV and HDGV vehicle classes.

Mobile Nonroad Mobile Source Emissions

APG gathered information about the number of vehicles, model year, horsepower rating, fuel type, engine cycle type, and estimated operating hours for CY 2002. In the majority of instances, horsepower ratings and operating hours were not readily available and have been assumed based on the typical horsepower of similar types equipment. If data was not available for CY 2002, then data was obtained for the closest available year.

Criteria pollutant emission factors were obtained from *Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations, United States Air Force Institute for Environment, Safety* & *Occupational Health Risk Analysis (IERA), January 2002,* which includes the emission factors used in EPA's NON-ROAD 2002 model. Emission factors to estimate PM-2.5 from PM-10 emissions were obtained from EPA's NON-ROAD 2002a model. The Non-road model incorporates research results from *U.S. EPA 's Non-road Engine and Vehicle Emission Study (NEVES), November* 1991, as well as from the California Air Resources Board's off-road model, test results, and regulatory emission standards. These factors were used to estimate the emissions from non-road vehicles and equipment.

Emission factors for stationary internal combustion engines were used to estimate criteria pollutant emissions for the non-mobile equipment. These factors are found in *Table* 3.3-1, *AP-42 Section* 3.3, *Gasoline and Diesel Industrial Engines.* Emissions were calculated by multiplying the power output by the emission factors applicable to the type of fuel used by the non-mobile equipment, either gasoline or diesel. The power output was calculated by multiplying the power of the equipment in horsepower times the estimated hours of operation. Net workdays were derived from the equipment rental records. It was assumed that the light towers were used 8 hours per day and that all other equipment was used 10 hours per day.

The total emissions for all non-road vehicles and equipment were separated into emissions for Aberdeen and Edgewood. In cases were vehicles were used at both Aberdeen and Edgewood the total emissions were divided equally.

Aircraft operations are conducted at Phillips Airfield at Aberdeen and Weide Heliport at Edgewood. These operations include landings and takeoffs (LTOs), touch and go's (T&Gs), low approaches (LAs), and trim and power checks (T&Ps). Emissions from aircraft operations were estimated using the EDMS (version 4.4) model.

Emissions of criteria pollutants for watercraft were calculated using factors provided in *AP-42, Volume 11.* Inboard emissions were calculated based on fuel consumption or operating time. Outboard emissions were calculated using factors related to fuel consumption. Fuel consumption was rarely known, so a generic fuel usage of 3 gallons per hour was used to calculate consumption from operating time.

17

The inventory of watercraft includes APG vessels, privately owned boats, and rental boats. The inventory included the size of vessels, whether the boat has an inboard or outboard motor, whether the boat uses gasoline or diesel, on-site fuel usage, and on-site estimated usage.

Many assumptions were necessary to calculate emissions from the limited information known about many of the watercraft. The number of memberships to the private boat clubs located at APG and number of permits to launch boats at APG was known, but no information as to the size and type of boats was, nor the time or distance they traveled within the boundaries of APG. All privately owned boats launched in the Aberdeen Area were considered outside of the APG boundary once in the water, so no emissions were counted from these boats. For privately owned watercraft it was assumed that 80% have outboard motors and 20% have inboard and that all are gasoline fueled. An assumption was made that privately owned watercraft were used 5 times per year and spent 2 hours on site each usage for a total of 10 hours each. For rental outboards it was assumed that they were used 3 hours on-site per rental weekend and that there were 40 rentals in 2002.

Area Source Emissions

Emissions from the various area source categories were estimated using a variety of methods, including population based, fuel consumption, and mass balance. Emission factors were derived from the EPA document titled 'Emission Inventory Improvement Program', and AP-42. Landfill losses as VOC were calculated for Michaelsville landfill using *Landfill Gas Emissions Model (LandGEM) version 3.02* available through the EPA. LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of waste in municipal solid waste landfills.

Activity

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

Emission Factors

Emission factors were derived from the Emission Inventory Improvement Program (EIIP); AP-42, Volume 11, Fifth Edition; EPA's NON-ROAD 2002 model; EPA's MOBILE 5 model; and the Landfill Gas Emissions Model (LandGEM) version 3.02.

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 APG is not available.

Temporal
Data for temporal allocation is not available for this source.

3.3 ANDREWS AIR FORCE BASE

Description

Andrews Air Force Base (ICAO code KADW) is a United States Air Force base near Washington, DC and the home base of the U.S. presidential aircraft, Air Force One.

The base is located a few miles southeast of Washington, in Prince George's County, Maryland near the town of Morningside. According to the United States Census Bureau, the town has a total land area of 6.8 mi² and none of it is covered by water. There are two runways on the base; the western runway is 3,440 meters in length, and the eastern runway is 3,570 meters in length.

The host unit for Andrews AFB is the 89th Airlift Wing which falls under Air Mobility Command. The primary mission at Andrews AFB is to transport the President of the United States. The base is also tasked, under what is known as "SAM FOX", to provide worldwide airlift for the vice president, the president's Cabinet, members of Congress, military leaders and other high ranking dignitaries. At one time, "SAM FOX", was used as a prefix to an aircraft tail number, during radio transmissions to identify Air Force aircraft that were transporting high-ranking VIPs, typically on foreign flights. The call sign prefix was constructed from the acronym SAM (Special Air Mission) and the initial F (Foreign), which at the time was represented by the phonetic word "Fox."

Andrews is also the home of the 89th Communication Group, a unit that provides communications to military installations all over the world. The technical control facility is one of the largest in the world, and hosts a myriad of sophisticated telecommunications equipment. One of the squadrons within the 89th Communications Group is the 789th Communications Squadron, whose CNCS remotely operates 15 HF Global radio stations from around the Globe. Other major tenants include the District of Columbia Air National Guard (DC-ANG), Naval Air Facility (NAF), and the Maryland State Police.

Pollutants

VOC, NOx, CO, PM, Toxics

**Emission
Source
Categories**

MDE staff reviewed emission estimates prepared for Andrews Air Force Base by a private contractor. These emission estimates included data for the following source categories:

- Mobile On-Road Source Emissions
  - Mobile - LDGV
  - Mobile - LDGT12

- o Mobile - LDGT34
- o Mobile - HDGV / Buses
- o Mobile - MC
- o Mobile - LDDV
- o Mobile - LDDT
- o Mobile - HDDBT
- o Mobile - HDDV
- o Mobile - HDDBS
- o Mobile - Heavy Duty Trucks
- o Mobile - Light Duty Vehicles

- Mobile Nonroad Source Emissions
  - o Nonroad Mobile - Recreational
  - o Nonroad Mobile - Construction
  - o Nonroad Mobile - Industrial
  - o Nonroad Mobile - Lawn and Garden
  - o Nonroad Mobile – Agricultural
  - o Gas-Fired Non-road vehicle-4-stroke gasoline engine
  - o Gas-Fired Non-road vehicle-2-stroke gasoline engine
  - o Aircraft - All Aircraft Types and Operations
  - o Emissions from military aviation aircraft landing and takeoff.
  - o Emissions from commercial aviation aircraft landing and takeoff.
  - o Diesel Generators
  - o Off-highway Vehicle Gasoline, 2-Stroke Total without APUs
  - o Off-highway Vehicle Gasoline, 4-Stroke Total without APUs
  - o Off-highway Vehicle Gasoline, 4-Stroke APU emissions
  - o Off-highway Vehicle Diesel APU emissions
  - o Nonroad Mobile Aircraft Ground Equipment - All Gasoline Engines
  - o Nonroad Mobile Aircraft Ground Equipment - All JP-8 Engines

- Point Source Emissions
  - o MDE staff also reviewed and included emission estimates from emission certification reports prepared by Andrews Air Force Base and submitted on an annual basis to MDE's Compliance and Enforcement Program. These emission estimates include major sources.

**Emission
Estimation
Methodologies**

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

Mobile On-Road Source Emissions

The Andrews AFB on-road vehicle inventory consists of a mix of light- and heavy-duty gasoline-, diesel-, and natural gas-powered government-, and privately owned vehicles (POVs). POVs include vehicles owned by both daily employees and weekend personnel. The inventory contains the vehicle type, model year, number of vehicles, and annual on-base mileage. To distinguish leased General Services Administration (GSA) government-owned vehicles (GOVs) from the regular fleet, vehicle tag numbers are provided in cases where they are known.

On the basis of inventory data provided by vehicle maintenance personnel, government-owned vehicles (GOVs) were grouped into eight vehicle categories according to vehicle type, gross vehicle weight (GVW), and fuel type. The 2002 mileage for each vehicle was provided by vehicle maintenance personnel, as were estimates of on-base mileage or a percentage of the total miles per vehicle that were driven on the base.

Emissions were calculated only for the estimated miles and hours of on-base vehicle and equipment operation. Miles traveled off the base were not included in the emission calculations. The Fifth Edition of AP-42, Volume II includes the emission factors for NOx, CO, and VOC, which were calculated using EPA's MOBILE 5 model for gasoline and diesel operated vehicles. AP-42 has not been updated with NOx, CO, and VOC emission factors from the latest version of EPA's MOBILE 6.2.03 model, released in October 2002, which also includes emission factors for PM-10, PM-2.5, SO2, and HAPs. Therefore, the emission factors for on-road vehicles were obtained by running the MOBILE 6.2.03 model. The MOBILE model does not address compressed natural gas vehicles, so emission factors for these vehicles have been obtained from 40CFR86.1708-99, 40CFR88.105-94, and 40CFR88.104.94.

Emission estimates for privately owned vehicles (POVs) are based on traffic studies supplied by base personnel (89th AW Civil Engineering, July 2004). Andrews AFB has approximately 61, 738 vehicles traveling on base each workday. This number assumes a working schedule of employees of 40 hours per week. In addition, 25% of the daily personnel are assumed to be on the base on the weekends.

The emission factors were used in the following equation to estimate annual emissions:

$$E = V * F * C$$

Where:
E = Annual emissions of particular pollutant from each vehicle category (lb/yr)
V = 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 = Conversion factor (2.205 x 10 lb/g)

Mobile Nonroad Mobile Source Emissions

The Andrews AFB non-road vehicle inventory consists of various equipment including forklifts, loaders, riding lawn care equipment, and towing equipment. The inventory contains the equipment name, model year, horsepower rating, number of vehicles, fuel type, engine cycle type, and operating hours for CY 2002. The inventory specifies whether the operating hours are a total operating time for CY 2002 for the number of units listed or an operating time for each unit.

Criteria pollutant and HAP emission factors were obtained from *Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations, United States Air Force Institute for Environment, Safety & Occupational Health Risk Analysis (IERA),* January 2002, which includes the emission factors used in EPA's NONROAD 2002a model. Emission factors to estimate PM-2.5 from PM-10 emissions were obtained from EPA's NONROAD 2002a model.

The Andrews AFB aircraft operations inventory consists of information related to landings and takeoffs (LTOs), touch and go's (T&Gs), low approaches (LAs), and trim and power checks (T&PCs). Calendar year 2002 was used for the calculations of the baseline emissions inventory because 2002 is the baseline year selected by the MDE for use in the revision of its SIP. The inventory contains the aircraft type and manufacturer, engine model and manufacturer, the number of LTOs, T&Gs, LAs, and T&PCs. The calendar year 2002 inventory was generated using information compiled from the Aerial Port Squadron, the Andrews AFB Federal Aviation Administration (FAA) Liason, and Allan Holtzman, Andrews AFB Air Quality Program Manager. This inventory will also be submitted to MDE for incorporation into EDMS (version 4.4).

Activity

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

Emission Factors
Emission factors were derived from the EDMS Airport Emission Model, Version 4.4; EPA's NON-ROAD 2002 model; and EPA's MOBILE 6.02.03 model.

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 Andrews Air Force Base is not available.

Temporal
Data for temporal allocation is not available for this source.

3.4 BALTIMORE-WASHINGTON INTERNATIONAL AIRPORT (BWI)

Description

Baltimore-Washington International Airport (BWI) is located in Anne Arundel County, Maryland, approximately 9 miles south of the City of Baltimore and approximately 30 miles northeast of Washington, D.C. BWI Airport is generally bounded on the north, east, and west by Aviation Boulevard (MD Route 170 and MD Route 162) and on the south by Dorsey Road (MD Route 176). Interstate 195 (I-195) is a four-lane divided highway that serves as the primary access point to the airport terminal area. Elm Road and Aviation Boulevard provide secondary access to the terminal and cargo facilities.

BWI is operated by the Maryland Aviation Administration, Maryland Department of Transportation. BWI Airport encompasses 3,596 acres of land. The passenger terminal contains 1.4 million square feet; 4 concourses (3 domestic, 1 international/swing); 69 jet gates with 12 gates dedicated to commuter aircraft.

The emission sources at BWI include aircraft, aircraft ground support service equipment, motor vehicles (on roadways, in parking facilities, and at terminal curbsides), the heating plant, fuel storage and handling, and training fires.

Pollutants

VOC, NOx, CO, PM, Toxics

**Emission
Source
Categories**

MDE staff reviewed emission estimates prepared for BWI Airport by a private contractor. These emission estimates included data for the following source categories:

- Mobile Onroad Source Emissions
    - Mobile - LDGV Emissions
    - Mobile - Parking Facility Emissions
    - Mobile - LDGT 1&2 Emissions
    - Mobile - LDDT 1-4
    - Mobile – HDDV

- Mobile Nonroad Source Emissions
    - Emissions from airport service diesel compression ignition equipment
    - Emissions from military aircraft LTOs
    - Emissions from commercial aircraft LTOs
    - Emissions from general aviation aircraft LTOs
    - Emissions from aircraft auxiliary power units

- Mobile Nonroad Source Construction Equipment Emissions
  - 2-Stroke Gas Eng; Construction & Mining Equip; Paving Equip
  - 4-Stroke Gas Eng; Construction & Mining Equip; Plate Compactors
  - 4-Stroke Gas Eng; Construction & Mining Equip; Concrete/Industrial Saws
  - Diesel Eng; Construction & Mining Equip; Pavers
  - Diesel Eng; Construction & Mining Equip; Rollers
  - Diesel Eng; Construction & Mining Equip; Scrapers
  - Diesel Eng; Construction & Mining Equip; Signal Boards/Light Plants
  - Diesel Eng; Construction & Mining Equip; Trenchers
  - Diesel Eng; Construction & Mining Equip; Excavators
  - Diesel Eng; Construction & Mining Equip; Cranes
  - Diesel Eng; Construction & Mining Equip; Graders
  - Diesel Eng; Construction & Mining Equip; Off-highway Trucks
  - Diesel Eng; Construction & Mining Equip; Rubber Tire Loaders
  - Diesel Eng; Construction & Mining Equip; Tractors/Loaders/Backhoes
  - Diesel Eng; Construction & Mining Equip; Crawler Tractor/Dozers
  - Diesel Eng; Industrial Equip; Aerial Lifts
  - Diesel Eng; Industrial Equip; Forklifts
  - Diesel Eng; Industrial Equip; Sweepers/Scrubbers
  - Diesel Eng; Commercial Equip; Generator Sets
  - Diesel Eng; Commercial Equip; Air Compressors
  - Diesel Eng; Commercial Equip; Welders

- Mobile Onroad Source Emissions
  - Firefighting Training

- Point Source Emissions
  - MDE staff also reviewed and included emission estimates from emission certification reports prepared by BWI and submitted on an annual basis to MDE's Compliance and Enforcement Program. These emission estimates include major sources.

**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 4.4

- **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.

- **Roadways**

FAA's EDMS computer program uses EPA's MOBILE 6.2 model to estimate on-road mobile vehicle emissions.

- **Parking Facilities**

FAA's EDMS computer program uses EPA's MOBILE 6.2 model to estimate on-road mobile vehicle emissions from parking facilities.

- **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.

Nonroad Mobile Source Emissions

- **Construction Equipment**

Emissions from construction activities were estimated based on the construction activity schedule, including the number and types of construction vehicles and equipment units and their utilization rates. Emission rates were taken from EPA's NONROAD program and MOBILE6.2. Emissions from several components of construction activities were calculated, specifically: onsite construction equipment (backhoes, bull dozers, graders, etc.), haul vehicles idling onsite (cement trucks, dump trucks, etc.), and haul vehicles and construction worker vehicles accessing the site. An industry-wide, representative mix of the number and types of construction equipment, average power rating (horse power), and equipment load factors was used in the analysis. Construction-related motor vehicles (dump trucks, pick-up

trucks, etc.) were assumed to travel a round trip on-site distance of 5 miles while on the Airport construction site.

Activity

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

Emission Factors

Emission factors were derived from FAA's EDMS computer program (Version 4.4). Vehicular emission factors contained in EDMS are obtained from the EPA's MOBILE 6.2 model. Construction emission factors were derived from EPA's NONROAD Model.

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 Baltimore Washington International Airport 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

Sample calculations presented below are for illustrative purposes only and may not reflect actual emissions.

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 MOBILE6 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

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

**Method and
Data Sources:**

The method used to calculate emissions (all VOC), is presented in EIIP[9], 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.

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 2002. 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 recent 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/ARMA 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

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[9] Emission Inventory Improvement Program

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.

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

Activity Days per Year	365

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[10]:

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

where:

L_L   =   loading loss, pounds per 1000 gallons (lb/10₃ gal) of liquid loaded
(The loading loss is equivalent to an emission factor)

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

P   =   true vapor pressure of liquid loaded, pounds per square inch absolute (psia)
(see Figure 7.1-5, Figure 7.1-6, and Table 7.1-2)

M   =   molecular weight of vapors, pounds per pound-mole (lb/lb-mole)
(see Table 7.1-2)

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.

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

Proportioning the loading factors yields

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

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

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

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

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

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

Spatial and Temporal Allocations

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

Temporal
Data for temporal allocation is not available for this source.

**Emissions
Calculation**

The equation for estimating emissions from tank truck unloading is:

$$E_{fj} = \frac{(G_i \times F_{i\,(fm)} \times EF_{fm}) + (G_i \times F_{i\,(fm)} \times EF_{fm})}{2000 \times 365} \quad \text{Where:}$$

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 2002

$F_{i\,(fm)}$ = Fraction of gasoline dispensed per county i per filling method (balanced submerged or submerged) during 2002

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 (Carroll County)

To calculate fuel usage for Carroll County:

Filling Method	Carroll County Adjusted Emission Factor Lb. $_{VOC}$ per 1,000 gallon
Balanced Submerged	0.2453
Submerged	5.9691
Diesel Fuel Unloading	0.014

Total fuel sold in Maryland in 2002[11] = 2,570,356,195 gallons

Allocate gallons of fuel sold to the county level by the 2002 county vehicle registration proportion:

$$\frac{\text{Carroll County vehicle registration}^{12}}{\text{Total MD vehicle registration}} = \frac{138,645}{4,100,225} = 0.0338$$

2,570,356,195 **x** 0.0338 = 86,914,019.269 gallons sold in Carroll County

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

[86,914,019.269 gallons of gasoline sold in Carroll County in 2002 **x** 91 percent[13] filled by balanced submerged filling method **x** 0.2453 lbs.. $_{VOC}$ per 1000 gallons of gasoline[14]] + [86,914,019.269 gallons of gasoline sold in Carroll County in 2002 **x** 9 percent filled by submerged filling method **x** 5.9691 lbs.. $_{VOC}$ per 1000 gallons of gasoline[15]] = 66,093.07 lbs.. $_{VOC}$ emitted.

Convert to tons per day:
66,093.07 lbs. $_{VOC}$ **/** (365 days per year **x** 2000 lbs. per ton) = 0.09 tons $_{VOC}$ per day

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[13] A rule effectiveness of 91% was determined from a study of Stage I compliance performed in Regions III and IV by the MDE/ARMA enforcement program in 1991. In the attainment counties outside of Regions III and IV, a default rule effectiveness of 80 % was used.
[14] Emission factor for balanced submerged filling from AP-42 Volume I, Table 5.2-7.
[15] Emission factor for submerged filling from AP-42 Volume I, Table 5.2-7.

4.1.1.2   Stage II Refueling

SCC: 25 01 060 100

Description

Emissions from Stage II refueling are substantially less than those from Stage I because gasoline vapors that ordinarily might have escaped during vehicle fueling are recirculated by a special nozzle back into the pump. The start year for Stage II refueling in all Maryland ozone nonattainment areas was 1993. Gasoline stations were required to have Stage II nozzles installed by November of that year. Calculations were based on the filling method used and gallons sold.

Pollutants

VOC

**Method and
Data Sources**

EPA recommends that the MOBILE6 model be used to generate refueling (Stage II) emission factors for highway vehicle emission inventories (EPA, 1992b). 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. A detailed discussion of using this model is available from EPA (EPA, 1994).

Activity
The MOBILE6 model produces estimates of refueling emissions in units of grams per mile. These values are multiplied by fuel economy (in units of miles per gallon) and total gasoline sales (in units of gallons purchased/sold) in the study area resulting in refueling emissions in terms of grams. It should be noted that MOBILE makes use of improved predictive equations to calculate refueling emission factors, including sensitivity to temperature and Reid vapor pressure (RVP), and these have not yet been incorporated into published AP-42 factors for refueling. Additionally, the user may provide information on local Stage II emission controls to develop an emission factor for controlled emissions.

Refueling emissions have two mechanisms of introducing emissions to the environment: (1) vapor displacement from the vehicle fuel tank during refilling; and (2) gasoline spillage during refueling. The MOBILE user may request either a single emission factor that combines the two mechanisms or separate emission factors for displacement and spillage. Because both mechanisms should be taken into account when estimating refueling emissions, the preferred approach is to request the combined emission factor.

Emission Factors
ARMA mobile sources staff ran the MOBILE6 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 subtration of emissions from point sources is necessary.

**Adjustment for
Controls**

Controls for this source category include Stage II Vapor Recovery Systems and Onboard Refueling Vapor Recovery (ORVR) systems. The controls are reflected in the emission estimates produced by the MOBILE6 model.

**Spatial and
Temporal
Allocations**

Spatial
The MOBILE6 model uses user-supplied county-level gasoline sales data to spatially allocate emission estimates.

Temporal
Data for temporal allocation is not available for this source.

**Emissions
Calculation**

The equation for estimating emissions from tank truck unloading is:

$$E_{StII} = \frac{(G_i \times EF_{StII} \times MPG \times SAF)}{2000 \times 365} \qquad \text{Where:}$$

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

G_i = gallons of gasoline sold in county i during 2002

EF_{StII} = emission factor for stage II refueling from the MOBILE6 model (grams/mile)

MPG = average fuel economy (miles/gallon)

SAF = seasonal adjustment factor to reflect summer weekday emissions

Stage II Refueling Sample Calculation

Since all calculations are included in the MOBILE6 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

**Method and
Data Sources:**

The method used to calculate emissions (all VOC), is presented in EIIP[16], 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.

An activity level of 7 days per week was used.

Activity Days per Year   365

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.

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

---

[16] Emission Inventory Improvement Program

**Point Source
Adjustments**

No subtration of emissions from point sources is necessary.

**Adjustment for
Controls**

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

**Spatial and
Temporal
Allocations**

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

Temporal
Data for temporal allocation is not available for this source.

**Emissions
Calculation**

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

$$E_{utb} = \frac{(G_i \times EF_{utb})}{2000 \times 365} \qquad \text{Where:}$$

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 2002

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

Underground Tank Breathing Sample Calculation (Carroll County)

To calculate fuel usage for Carroll County:

Total fuel sold in Maryland in 2002[17] = 2,570,356,195 gallons

Allocate gallons of fuel sold to the county level by the 2002 county vehicle registration proportion:

---

[17] Annual sales of gasoline from Maryland Comptroller of the Treasury, Gasoline Tax Division

$$\frac{\text{Carroll County vehicle registration}[18]}{\text{Total MD vehicle registration}} = \frac{138,645}{4,100,225} = 0.0338$$

2,570,356,195 **x** 0.0338 = 86,914,019.269 gallons sold in Carroll County in 2002.

22,376,721 **=** gallons of gasoline sold in Carroll County during the summer of 2002.

[22,376,721 gallons of gasoline sold in Carroll County in 2002 **x** 0.000818 lbs. $_{VOC}$ per gallons of gasoline[19]] = 18,304.16 lbs. VOC emitted.

Convert to tons per summer day: 18,304.16 **/** (92 days per year **x** 2000 lbs. per ton) = 0.0994 tons $_{VOC}$ per day emitted from underground tank breathing in Carroll County.

---

[18] State of Maryland Motor Vehicle Administration and MDE Mobile Sources Control Program.
[19] Emission factor from AP-42 Volume I, Table 5.2-7.

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. Emissons 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[20], Chapter 11, Gasoline Marketing (Stage I & Stage II), 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 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

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

MDE used the emission factors from EIIP, Volume I, 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 $_{VOC}$

---

[20] Emission Inventory Improvement Program

/1000 gallon empty tank return). MDE also used a bulk facility throughput adjustment factor of 1.25 and calculated throughput by a ratio of county retail sales and state retail sales times state fuel sales. MDE used the same sources for gasoline sales and car registration as in tank truck unloading.

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: 1.25
Activity Days Per Year: 312

Equation:

$$E_{tt} = \frac{(G_i \times 1.25 \times EF_{tt})}{2000 \times 312} \quad \text{Where:}$$

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

2002 Gasoline Tank Trucks in Transit Sample Calculation (Carroll County)

To calculate fuel usage for Carroll County:

Total fuel sold in Maryland in 2002[21] = 2,570,356,195 gallons

Allocate gallons of fuel sold to the county level by the 2002 county vehicle registration proportion:

$$\frac{\text{Carroll County vehicle registration[22]}}{\text{Total MD vehicle registration}} = \frac{138,645}{4,100,225} = 0.0338$$

2,570,356,195 **x** 0.0338 = 86,914,019.269 gallons

[86,914,019.269 gallons of gasoline sold in Carroll County in 2002 **x** 1.25 x 0.06 lbs. $_{VOC}$ per 1000 gallons of gasoline[23]] = 6,518.55 lbs. $_{VOC}$ emitted.

---

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

Convert to tons per day: 6,518.55 **/** (312 days per year **x** 2000 lbs. per ton) = 0.010446 tons $_{VOC}$ per day emitted from tank trucks in transit in Carroll County.

---

[23] Emission factor from AP-42 Volume I, Table 5.2-7.

4.1.1.5 Aircraft Refueling

SCC: 22 75 900 000

Description

Jet kerosene (used primarily by commercial turbojet and turboprop aircraft), jet naphtha (used primarily by military aircraft) and aviation gasoline (used by aviation reciprocating engines) are the three most common types of aircraft fuels used in the United States. Emissions occur when vapor-laden air in a partially empty fuel tank is displaced to the atmosphere when the tank is refilled.

Pollutants

VOC

Method and
Data Sources

MDE staff apportioned state level fuel sales to aircraft activity as suggested in Procedures, Section 4.2.3.

Activity
MDE used selected data from the Department of Energy's State Energy Data System, to obtain fuel consumption data.   MDE used airport survey data and the Maryland Aviation Administration's 2002 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 Barrels)
Jet Kerosene	3,938.000
Aviation Gasoline	38.877
Jet Naphtha	39.380

Emission Factors
Emission factors, splash loading factor and physical properties of aviation fuel are taken from AP-42, Tables 5.2-1, 5.2-5, 7.1-2, and are summarized below. Note the relatively high emission factor for aviation gasoline which contributes to high emissions at airports with large amounts of general aviation (piston engine aircraft).

Fuel Type	Vapor Pressure (60 ° F)	Molecular Weight (at 60 ° F)
Jet Kerosene	0.0085	130
Aviation Gasoline	6.9	62
Jet Naphtha	1.3	80

Splash loading saturation factor: 1.45

43

Units conversion factor   42 gals/barrel
Activity days per period   365 days/year
Study Temperature   520 deg. R (unit used in <u>Procedures</u>)

Emission Factor Equation:

$$\text{Refueling EF} = 12.46 \times \begin{array}{c}\text{splash}\\\text{loading}\\\text{factor}\end{array} \times \begin{array}{c}\text{true}\\\text{vapor}\\\text{pressure}\end{array} \times \begin{array}{c}\text{molecular weight}\\\text{at the study}\\\text{temperature}\end{array}$$

Fuel Type	Refueling EF (RE_i) (lbs. VOC/kgal)
Jet Kerosene	0.03839
Aviation Gasoline	14.86358
Jet Naphtha	3.61340

<u>Emission Estimate Equation:</u>

$$E_{ar} = \frac{S_i \times \dfrac{CA_I}{SA_i} \times RE_i}{2000 \times 365}$$

where:

S_i = State aircraft fuel sales for fuel type i
CA_i = County aircraft activity (LTO) for fuel type i
SA_i = State aircraft activity (LTO) for fuel type i
RE_i = Refueling emission factor for fuel type i
E_{ar} = Emissions from aircraft refueling in tons $_{VOC}$ per day

<u>2002 Sample Calculation for Aircraft Refueling- General Aviation (Allegany County)</u>

Maryland aviation gasoline fuel sales=   105,000 barrels[24]   =   1,632,826.86 gallons

$$\frac{\text{Allegany County General Aviation LTOs}}{\text{Maryland general aviation LTOs}} = \frac{7650.5}{723,256} = 0.010578$$

Gallons of AvGas used $_{Allegany}$ = 1,632,826.86 **x** 0.010578 = 17,271.81

Emissions-GA Refueling $_{Allegany}$ = 17,271.81 ÷ 1,000 **x** 14.86358[25] = 256.721 lbs. $_{VOC}$ /year
Emissions-GA Refueling $_{Allegany}$ = 256.721 ÷ (2000 x 365)   = 0.0004 tons $_{VOC}$ /day

---

[24] From Department of Energy State Energy Data Report
[25] Emission factors, splash loading factor and physical properties of aviation fuel are taken from <u>AP-42</u>, Tables 5.2-1, 5.2-5, 7.1-2,

4.1.1.6   Petroleum Vessel Unloading Losses

SCC: 25 05 020 000

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 naptha, 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

Activity

The method used to calculate emissions (all VOC) is presented in EIIP[26], 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, Waterborne Commerce of the United States, Atlantic Region Freight Tables, Part 1, 1998, and AP-42, Table 7.1-2 and Section 5.2. Waterborne Commerce supplied tonnage and type of petroleum products delivered to the various ports in Maryland for the year 2001. Tonnages of petroleum delivered were converted into Kgal.s (1000 gallons) and then used to calculate emissions.

Factors

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

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 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:

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[26] Emission Inventory Improvement Program

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

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[27] (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 (%)

Equation:

$$PV_P = \frac{[(SOEF_P \times PP_{S,P}) + (BREF_P \times PP_{B,P}) + (BLEF_{P,U} \times 0.30 \times PP_{BL,P}) + (TREF_P \times PP_{T,P})]}{2000}$$

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)

---

[27] AP-42, Table 7.1-2

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)

2002 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 Harbor	**0.00**	**1690.14**	**33214.29**	**625**	**56202.53**	**0.00**

Tonnage of distillate oil shipped in Baltimore Harbor (from Waterborne Commerce of the U.S., 2001) were converted in thousands of gallons (Kgal.s) 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 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.

Vessel Loading (gasoline) emissions are calculated:
PV $_{GAS}$ = [(1.8 lbs $_{VOC}$/Kgal) x (31785.71 Kgal/yr) x {0.10 + [0.9 (1 − 95/100)]}÷ 2,000 lb/ton
PV $_{GAS}$ = **4.1480** tons/year

Barge Loading emissions are calculated:
PV $_{GAS}$ = [(3.4 lbs $_{VOC}$/Kgal) x (113928.57 Kgal/yr)] ÷ 2,000 lb/ton
PV $_{GAS}$ = **193.6786** tons/year

Ballasting emissions are calculated:
PV $_{GAS}$ = [(0.8 lbs $_{VOC}$/Kgal) x (477857.14 Kgal/yr) x (0.20)] ÷ 2,000 lbs/ton
PV $_{GAS}$ = **38.2286** 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:
PV_{GAS} = (2.7 lbs $_{VOC}$/Kgal) x (1271071.43 Kgal/yr) x (2/7wk) ÷ 2,000 lbs/ton
PV_{GAS} = **490.2704** tons/year

Total VOC emissions are calculated as follows:
Total $_{VOC}$ = **4.1480** tons/year + **193.6786** tons/year + **38.2286** tons/year + **490.2704** tons/year
Total $_{VOC}$ = **726.3256** tons/yr

There are 260 activity days per year
Total Daily $_{VOC}$ = (726.3256 tons/yr ÷ 260 days/yr = **2.7936** tons/day for Baltimore City.

True vapor pressure of distillate oil at 60 deg. F: 0.0074

4.1.1.7 Portable Fuel Containers

<div align="right">

SCC: 25 01 011 011 (Residential – Permeation)
25 01 011 012 (Residential – Diurnal)
25 01 011 016 (Residential – Transport)
25 01 012 011 (Commercial – Permeation)
25 01 012 012 (Commercial – Diurnal)
25 01 012 016 (Commercial – Transport)

</div>

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.
- *Equipment Refueling Emissions* results when fuel escapes (e.g., spillage, vapor displacement) during the refueling of nonroad equipment; however these emissions are handled by EPA's NONROAD model. Activity data from the NONROAD model were used to estimate these emissions (described below).

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

Pollutants

VOC

**Method and
Data Sources**

The method used to calculate emissions (all VOC), is adoped from a CARB[28] survey and methodology adopted by OTC[29].

Portable fuel container emission 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

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

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

(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. Number of residential housing units in 2002 by county, N
2. Number of commercial businesses[30] 2002 expected to have at least one gas can by county, NAICS 11, 23, 31-33, 441, 45299, 447, 484, 488, 493, 53131, 5321, 532291, 5323, 5324, 54132, 54162, 54169, 56173, 71391, 71393, 7212, 811, 81293
3. Weekly activity, WAF = 7 days/week
4. Seasonal adjustment factors, SAF = 1

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

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

No controls are available for this source category.

Spatial and
Temporal
Allocations

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
For the residential PFC SCCs, the emissions were allocated based on the monthly and weekday/weekend day temporal profiles for residential lawn and garden equipment in the

---

[30] Total 2002 employment and business establishments by 6 digit NAICS code and by county, County Business Patterns

NONROAD model. For the commercial PFC SCCs, these emissions were allocated based on temporal profiles for the NONROAD model engines used in commercial applications.

**Emissions
Calculation**

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

Equation:

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

$$\text{Pop}_R = (N)*(A)*(\text{Count}_R) \quad \text{(Eq. 1)}$$

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:

$$\text{HC}_{PR} = \Sigma (\text{Pop}_R)*(S)*(EF_P)*(B_R)*(\text{Size}_R)*(\text{Level})/CF \quad \text{(Eq. 2)}$$

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	=	908,105 g/ton

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

$$\text{HC}_{DR} = (\text{Pop}_R)*(S)*(EF_D)*(B_R)*(\text{Size}_R)*(\text{Level}) \quad \text{(Eq. 3)}$$

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 = 908,105 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 = 908,105 g/ton

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 = 908,105 g/ton

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

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

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	=	908,105 g/ton

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

$$REFILL_c = \left[\frac{\left(\sum Fuel \right)}{(SIZE_c)*(POP_{NON})*(S)} \right] \qquad \text{(Eq. 8)}$$

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	=	908,105 g/ton

The commercial-transport-spillage emissions are determined as:

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

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 = 908,105 g/ton

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

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

$$E_{PFC\text{-}SD} = E_{PFC\text{-}A} * SAF//ADDF$$

Where:
E$_{PFC\text{-}A}$ = (tons/yr) for an annual emission of pollutant by county
E$_{PFC\text{-}SD}$ = (tons/day) for a typical summer day emission of pollutant
AADF = Annual activity day factor (WAF * 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

Since perchloroethylene has been removed from the EPA list of reactive VOCs, it has been removed from the inventory total. Table 4.3-3 in <u>Procedures</u> lists three compounds under halogenated solvents for dry cleaning: 1,1,1 trichloroethane, trifluorotrichloroethane and perchloroethylene. None of these solvents is on the VOC list. The latest Emission Inventory Improvement Program guidance on dry cleaning (Vol. III, Chapter 4, *Dry Cleaning Final Report*, May 2002), also states that the synthetic solvents used in dry cleaning are not photochemically reactive and should not be included in a VOC inventory of ozone precursors. Therefore this category has been eliminated from the 2002 periodic inventory.

4.1.2.2　Surface Cleaning (Cold Cleaning Degreasing)

SCC:　24 15 300 000

Description

Cold cleaning 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.

Cold cleaners 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

**Method and
Data Source**

MDE staff used an alternative per capita emission estimation method documented in EIIP[31],
Chapter 6, Solvent Cleaning, dated September 1997.

Activity
The U.S. Census Bureau reports population statistics for the counties of Maryland.
Population statistics for 2002 for the counties of Maryland were collected from the U.S.
Census Bureau Internet address (http://www.census.gov).

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 such as Safety
Kleen are included in the point source inventory. The U.S. Census Bureau reports
population statistics for the counties of Maryland. Population statistics for 2002 for the
counties of Maryland were collected from the U.S. Census Bureau Internet address
(http://www.census.gov).   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 6.5-4 of the EIIP document lists a total emission factor of 4.3 lbs. VOC per capita
per year for solvent cleaning operations. The emission factor is a composed of a total from
four categories; including automobile repair (2.5 lbs. $_{VOC}$ per capita), manufacturing (1.1
lbs. $_{VOC}$ per capita), electronics and electrical (0.21 lbs. $_{VOC}$ per capita), and other (0.49 lbs.
$_{VOC}$ per capita).

Factors

E_{cc} =   4.3 lbs $_{VOC}$ per capita per year for cold cleaning degreasers
CE_{cc} =   67%
RE_{cc} =   80%
RP_{cc} =   100%

Note:

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[31] Emission Inventory Improvement Program

Emissions from this source category have increased because of a change in the emission factor and emission estimation methodology. In previous emission inventories, only cold cleaning degreasing operations were considered an area source and open top and conveyor degreasing operations were considered point sources that were listed in the MDE/ARMA registration files. No point source emissions were then subtracted from the area source inventory. MDE previously used an emission factor from AP-42, Section 4.6 – Solvent Degreasing, Table 4.6-1[32]. This table reports a 4.0 lbs. VOC per capita emission factor that includes 25 percent non-reactive VOCs, yielding an effective emission factor of 3.0 lbs. VOC per capita. A 1996 reduction factor of 0.70 was applied to the calculated emissions (rule effectiveness was not applied). This factor combines reductions from technology rules and good housekeeping practices. In effect, MDE increased the emission factor from 3.0 to 4.3.

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
Data for spatial allocation is not available for this source.

Temporal
Data for temporal allocation is not available for this source.

Emissions Calculation

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

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[32] Nonmethane VOC Emissions from small cold cleaning degreasing operations

Equation:

$$E_{CC} = \left\{ \frac{POP_j * EF_{cc}}{2000 * 312} * \left[1 - (CE_{CC} * RE_{CC} * RP_{CC}) \right] \right\} - E_{PtSourceCC}$$

Where:

E_{cc} = Emissions of VOC in tons/day from cold cleaners
POP_j = 2002 population 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

2002 Sample Calculation for Cold Cleaning Degreasing (Anne Arundel County)

(503,388[33] people x 4.3 lb/capita/year)/(2000 lbs./ton x 312 operating days/year) = 3.469 tons/day.
503,388 x 4.3 lbs. VOC/ person/year[34] = 2,164,568 lbs. per person VOC emitted.

Converting to tons per day: 2,164,568 **/** (312 operating days per year[35] **x** 2000 pounds per ton) = 3.469tons $_{VOC}$ per day emitted (there is no seasonal adjustment[36]).

To adjust for controls
3.469 **x** [1 – (0.67 x 0.80 x 1.00)] = 1.610 tons $_{VOC}$ / day emitted with 2002 controls applied

To adjust for point sources
1.610 tons $_{VOC}$ / day – 0.076 tons $_{VOC}$ / day = 1.534 tons $_{VOC}$ / day

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[33] Population data from the U.S. Bureau of Census, Population Estimates Branch
[34] Emission factor from EIIP
[35] 6 days per week operation from EIIP
[36] No seasonal adjustment from EIIP

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 01 001 000

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[37], 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 and an emission factor to calculated a VOC emission estimate.

Activity
Determine the per capita usage factor by dividing the national total architectural surface coating quantities[38] for solvent- and water-based coatings by the U.S. population[39] for that year.

Per Capita Usage Factor Development

The table below shows a portion of Table 2 from the U.S. Bureau of Census MA28F - Paint and Allied Products. This section of the table summarizes the market information available on architectural coatings for the year of 2002. 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 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:

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[37] Emission Inventory Improvement Program
[38] Total national coating usage is compiled by the Bureau of the Census, Report MA28F—Paint and Allied Products, available on the Census Bureau Bulletin Board, (301)457-2310.
[39] Population data from the U.S. Bureau of the Census, Population Estimates Branch .

$$\text{Solvent-Based Paints} = 70,967 + 48,947 + 5,808 + 1,981$$
$$= 127,703 \text{ thousand gallons of paints}$$

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

$$\text{Water-Based Paints} = 182,423 + 407,104$$
$$= 589,527 \text{ thousand gallons of paints}$$

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.

$$\text{Per Capita Solvent Based Usage Factor} = \frac{\text{Gallons of Solvent Based Paints}}{\text{U. S. Population}}$$
$$= \frac{127,703,000}{288,368,698}$$
$$= 0.442846$$

$$\text{Per Capita Water Based Usage Factor} = \frac{\text{Gallons of Water Based Paints}}{\text{U. S. Population}}$$
$$= \frac{589,527,000}{288,368,698}$$
$$= 2.044352$$

Product code	Product description	2002 Quantity
	Table 2. Quantity and Value of Shipments of Paint and Allied Products: 2002	
325510	Paint and allied products 1/	1,448,755
3255101	Architectural coatings	717,230
	Exterior solvent-type	70,967
3255101111	Solvent thinned paints and tinting bases, including barn	
	and roof paints	19,874
3255101115	Solvent thinned enamels and tinting bases, including	
	exterior-interior floor enamels	11,444
3255101119	Solvent thinned undercoaters and primers	9,184
3255101121	Solvent thinned clear finishes and sealers	5,701
3255101125	Solvent thinned stains, including shingle and shake	14,665
3255101129	Other exterior solvent thinned coatings, including	
	bituminous paints	10,099
	Exterior water-type	182,423
3255101131	Water thinned paints and tinting bases, including barn	
	and roof paints	118,492
3255101135	Water thinned exterior-interior deck and floor enamels	4,186
3255101139	Water thinned undercoaters and primers	13,786
3255101141	Water thinned stains and sealers	16,773
3255101145	Other exterior water thinned coatings	29,186
	Interior solvent-type	48,947
3255101211	Flat solvent thinned wall paint and tinting bases, including	
	mill white paints	6,288
3255101215	Gloss and quick drying enamels and other gloss solvent	
	thinned paints and enamels	4,164
3255101219	Semigloss, eggshell, satin solvent thinned paints and	
	tinting bases	9,674
3255101221	Solvent thinned undercoaters and primers	11,602
3255101225	Solvent thinned clear finishes and sealers	7,429
3255101229	Solvent thinned stains	1,892
3255101231	Other interior solvent thinned coatings	7,898
	Interior water-type	407,104
3255101235	Flat water thinned paints and tinting bases	162,810
3255101239	Semigloss, eggshell, satin, and other water thinned paints	
	and tinting bases	164,419
3255101241	Water thinned undercoaters and primers	43,051
3255101245	Other interior water thinned coatings, stains, and sealers	36,824
3255101249	Architectural lacquers	5,808
3255101YWV	Architectural coatings, n.s.k.	1,981
3255104	Product finishes for original equipment manufacturers (OEM),	
	excluding marine coatings	414,943
3255104111	Automobile, light truck, van, and sport utility vehicle finishes	47,994

3255104121	Automobile parts finishes	5,636
3255104131	Heavy duty truck, bus, and recreational vehicle finishes	12,481
3255104141	Other transportation equipment finishes, including aircraft	
	and railroad	11,558
3255104211	Appliance, heating equipment, and air-conditioner finishes	7,329
3255104215	Wood furniture, cabinet, and fixture finishes	43,725
3255104219	Wood and composition board flat stock finishes	10,060
3255104221	Metal building product finishes (including coatings for	
	aluminum extrusions and siding)	35,855
3255104225	Container and closure finishes	43,393
3255104229	Machinery and equipment finishes, including road building	
	equipment and farm implement	18,865
3255104231	Nonwood furniture and fixture finishes, including business	38,842
	equipment finishes	
3255104235	Paper, paper board, film, and foil finishes, excluding pigment	14,241
	binders	4,447
3255104239	Electrical insulating coatings	77,567
3255104241	Appliance powder coatings 2/	11,889
3255104245	Automotive powder coatings 2/	8,903
3255104249	Architectural powder coatings (such as aluminum	
	extrusions) 2/	2,062
3255104251	Lawn and garden powder coatings 2/	2,434
3255104255	General metal finishing powder coatings 2/	22,203
3255104259	Thermoset functional powder coatings (for pipe, rebar,	
	electrical insulation, etc.) 2/	(D)
3255104261	Thermoplastic powder coatings (all) 2/	(D)
3255104265	Other industrial product finishes	38,485
3255104YWV	Product finishes for original equipment manufacturers (OEM),	
	excluding marine coatings, n.s.k.	4,465
3255107	Special purpose coatings, including all marine coatings	174,114
	Industrial new construction and maintenance paints	
	(especially formulated coatings for special conditions of	
	industrial plants and/or facilities requiring protection against	
	extreme temperatures, funge, chemicals, fumes, etc.):	
3255107011	Interior	23,370
3255107015	Exterior	34,207
3255107021	Traffic marking paints (all types; shelf goods and highway	
	department)	39,397
3255107031	Automotive, other transportation and machinery refinish	
	paints and enamels, including primers	45,979
3255107041	Marine paints, ship and off-shore facilities and shelf goods for	
	both new construction and marine refinish and	
	maintenance. Excludes spar varnish	13,565
3255107051	Marine paints for yacht and pleasure craft, new construction,	
	refinish and maintenance	(D)
3255107061	Aerosol - Paint concentrates produced for packaging in	

	aerosol containers	(D)
3255107YWV	Special purpose coatings, n.s.k.	4,233
325510A	Miscellaneous allied paint products	142,468
325510A011	Paint and varnish removers	6,433
325510A021	Thinners for lacquers and other solvent based paint products	31,386
325510A031	Pigment dispersions	25,151
325510A041	Other miscellaneous allied paint products, including brush	
	cleaners, ink vehicles, putty and glazing compounds, etc.	78,512
325510AYWV	Miscellaneous allied paint products, n.s.k.	986
	Total Solvent-Based	**127,703**
	Total Water-Based	**589,527**

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 <u>Procedures</u>). 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 provides a 20 percent reduction.

Spatial and Temporal Allocations

Spatial

Data for spatial allocation is not available for this source.

Temporal

Data for temporal allocation is not available for this source.

**Emissions
Calculation**

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

Equation to calculate solvent-based emissions is:

$$E_{ASC-SB} = \frac{POP_i \times UF_{ASC-SB} \times EF_{ASC-SB} \times SAF_{ASC} \times [(1 - (CE_{ASC} \times RE_{ASC} \times RP_{ASC}))]}{2000 \times 365}$$

Where:

E_{ASC-SB} = VOC emissions in tons per day from solvent-based architectural surface coatings
POP_i = 2002 population of county i
UF_{ASC-SB} = Usage factor for solvent-based architectural surface coatings
EF_{ASC-SB} = VOC emission factor for solvent-based architectural surface coatings
SAF_{ASC} = Seasonal adjustment factor for architectural surface coatings
CE_{ASC} = Control efficiency[40] for architectural surface coatings
RE_{ASC} = Rule effectiveness[41] for architectural surface coatings
RP_{ASC} = Rule penetration for architectural surface coatings

Equation to calculate water-based emissions is:

$$E_{ASC-WB} = \frac{POP_i \times UF_{ASC-WB} \times EF_{ASC-WB} \times SAF_{ASC} \times [(1 - (CE_{ASC} \times RE_{ASC} \times RP_{ASC}))]}{2000 \times 365}$$

Where:

E_{ASC-WB} = VOC emissions in tons per day from water-based architectural surface coatings
POP_i = 2002 population of county i
UF_{ASC-WB} = Usage factor for water-based architectural surface coatings
EF_{ASC-WB} = VOC emission factor for water-based architectural surface coatings
SAF_{ASC} = Seasonal adjustment factor for 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

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[40] A 20% reduction in emissions is due to EPA's AIM regulation
[41] EPA's AIM regulation is a federal rule applying to architectural surface coatings

2002 Example Calculation Architectural Surface Coating (Anne Arundel County)

Solvent-Based
$503,388^1$ **x** 0.442846 gal/capita **x** 3.87 lbs. $_{VOC}$/gal/year^2 = 862,713.4 lbs. $_{VOC}$ per person per yr

To adjust for controls
862,713.4 **x** [1 – (0.20 x 1.00 x 1.00)] = 690170.7 lbs. $_{VOC}$ / year with 2002 controls
Converting to tons per day:
690,170.7 **/** (365 days per year **x** 2000 lbs. per ton) = 0.945439 tons $_{VOC}$ per average day

To seasonally adjust:
0.945439 **x** 1.3^3 = **1.229** tons $_{VOC}$ per ozone season day emitted from solvent-based architectural
surface coating

Water-Based
$503,388^1$ **x** 2.044352 gal/capita **x** 0.74 lbs. $_{VOC}$/gal/year^2 = 761,535.7 lbs. $_{VOC}$ per person per yr

To adjust for controls
761,535.7 **x** [1 – (0.20 x 1.00 x 1.00)] = 609,228.6 lbs. $_{VOC}$ / year with controls applied

Converting to tons per day:
609,228.6 **/** (365 days per year **x** 2000 lbs. per ton) = 0.83456 tons $_{VOC}$ per average day

To seasonally adjust:
0.83456 **x** 1.3^3 = **1.085** tons $_{VOC}$ per ozone season day emitted from water-based architectural
surface coating

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[42], 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 0.3858 tons $_{VOC}$ per employee per year by utilizing the national VOC emission estimate found in the EIIP document (79,429.39 tons) and totaling all of the reported state employment totals within SIC 7532 for the entire U. S. The national VOC emission estimate of 79,429.39 tons per year has been developed using 1997 activity and 1998 and 1999 emission rate information and are thus controlled emissions. An EPA memo on auto body refinishing allows a 37% reduction for the federal rule. Maryland's auto body regulation is more stringent than the national rule, which allowed MDE to take an additional 8% reduction.
>
> County Business Patterns lists employee data by Standard Industry Code (SIC). Many values are based on actual data. However, some county SICs 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 SIC matched the sum of the number of employees reported per county.

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[42] Emission Inventory Improvement Program

The autobody refinishing category does not include new car coating. Applicable point source emissions (those within the same SIC) taken from the MDE/ARMA registration files have been subtracted from the calculated emissions, and their emissions are separated from the totals presented below. Table 5.8-1 in Procedures shows that there is no seasonal variation in this category and the activity level is 5 days a week.

Emission Factor:

MDE calculated an emission factor of 0.3858 tons $_{VOC}$ per employee per year by utilizing the national VOC emission estimate found in the EIIP document (79,429.39 tons) and totaling all of the reported state employment totals within SIC 7532 for the entire U. S.

0.3858 tons $_{VOC}$ per employee per year

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

The national VOC emission estimate of 79,429.39 tons per year has been developed using 1997 activity and 1998 and 1999 emission rate information and are thus controlled emissions. An EPA memo on auto body refinishing allows a 37% reduction for the federal rule. Maryland's auto body regulation is more stringent than the national rule, which allowed MDE to take an additional 8% reduction.

Spatial and Temporal Allocations

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

Temporal
Data for temporal allocation is not available for this source.

Emissions Calculation

The equation used to estimate emissions from automobile refinishing is:

$$E_{AR} = \frac{EMP_J \ x \ EF_{AR} \ x \ [\ 1- (RE \ x \ RP \ x \ CE)]}{260} - E_{Point \ Source \ AR}$$

Where:

E_{AR} = VOC emissions in tons per day from auto refinishing

EMP_J = Number of employees in county j for SIC 7532 (auto refinishing), from County Business Patterns

EF_{AR} = VOC emission factor for auto refinishing

$E_{Point\ Source\ AR}$ = Point source emissions from auto body refinishing

2002 Example Calculation Auto Refinishing (Baltimore County)

$$E_{AR} = \frac{594^{43} \times 0.3858^{44} \times [\ 1 - (1.0 \times 1.0 \times .08)]}{260} - 0.00$$

$$E_{AR} = \frac{210.832}{260} - 0.00$$

$$E_{AR} = 0.811 \quad \text{Tons }_{VOC}\text{ / day}$$

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[43] Employee data from County Business Patterns - Maryland
[44] Emission factor from EIIP Chapter 13 – Auto Body Refinishing

4.1.2.5 Traffic Markings

SCC: 24 01 008 000 - Traffic paints
SCC: 24 01 008 999 - Traffic paint solvents

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 staff were not able to utilize EPA's recommended "pounds per lane-mile painted" emission factor due to the fact that several jurisdictions did not keep records on lane-miles painted. Instead MDE surveyed 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 county. 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 Addministration (MAA) and the Mass Transit Addministation (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.

70

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

Gallons of yellow traffic paint and solvent used in 2002.
Gallons of white traffic paint and solvent used in 2002.

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

Point Source Adjustments

No subtraction of emissions from point sources is necessary.

Adjustment for Controls

MDE surveyed the various state agenicies that apply coatings to road surfaces and transportation projects. MDE collected data on the gallons of paint applied and the VOC content of the paint. MDE made emission estimates based on this data and therefore no controls are available for this source category.

Spatial and Temporal Allocations

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

Temporal
Data for temporal allocation is not available for this source.

Emissions Calculation

Traffic Paint Sample Calculation (Caroline County)

(1)   Calculate VOC emissions from yellow and white traffic paints for ozone season

a. State Highway Administration (SHA) Traffic Paint Use

Total yellow gallons used April - October[45]   =   4,671 gallons
Total VOC per gallon of yellow paint used[46]   =   0.78 lbs. $_{VOC}$ /gallon
Total white gallons used April – October[47]   =   6,481 gallons
Total VOC per gallon of white paint used[48]   =   0.77 lbs. $_{VOC}$ /gallon

$$E_{\text{Yellow Paint}} = \frac{(4{,}671 \text{ gallons}) \times (0.78 \text{ lbs. }_{VOC}\text{ /gallon})}{(2{,}000 \text{ lbs./ton}) \times (214 \text{ days / ozone season})}$$

$E_{\text{Yellow Paint}} =$ **0.0085** tons / ozone day

$$E_{\text{White Paint}} = \frac{(6{,}481 \text{ gallons}) \times (0.77 \text{ lbs. }_{VOC}\text{ /gallon})}{(2{,}000 \text{ lbs./ton}) \times (214 \text{ days / ozone season})}$$

$E_{\text{White Paint}} =$ **0.0117** tons / ozone day

$E_{\text{Local Paint Total}} =$ $E_{\text{Yellow Paint}} + E_{\text{White Paint}}$

$E_{\text{Local Paint Total}} =$ $0.0085 + 0.0117$

$E_{\text{Local Paint Total}} =$ **0.0202** tons / ozone day

b. Maryland Aviation Administration (MAA) Traffic Paint Use

The MAA did not apply any paint in Caroline County.

c. Maryland Transportation Administration (MTA) Traffic Paint Use

The MTA did not apply any paint in Caroline County.

d. Local Jurisdiction Traffic Paint Use

The Local Jurisdictions did not apply any paint in Caroline County.

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[45] Reported by Caroline County's Department of Public Works, Division of Highways
[46] MSDS from Caroline County's Department of Public Works, Division of Highways
[47] Reported by Caroline County's Department of Public Works, Division of Highways
[48] MSDS from Caroline County's Department of Public Works, Division of Highways

(2)   Calculate VOC emissions from paint cleaning solvent use for ozone season

    a.   <u>Local Jurisdiction Traffic Paint Use</u>

The Local Jurisdictions did not use any paint cleaning solvents in Caroline County.

    b.   <u>State Highway Administration (SHA) Solvent Use</u> - None

The SHA did not use any paint cleaning solvents in Caroline County.

    c.   <u>Maryland Aviation Administration (MAA) Solvent Use</u> - None

The MAA did not use any paint cleaning solvents in Caroline County.

    d.   <u>Maryland Transportation Administration (MTA) Solvent Use</u> - None

The MTA did not use any paint cleaning solvents in Caroline County.

(3)   Total VOC emissions from traffic paint use and paint cleaning solvent use for ozone season

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

$$E_{\text{Paint Total}} = 0.0202 + 0.0 + 0.0 + 0.0 + 0.0$$

$$E_{\text{Paint Total}} = \mathbf{0.0202}$$

4.1.2.6 Industrial Surface Coating

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

**Method and
Data Sources**

MDE used the methods and procedures documented in EIIP[49], Chapter 8, Industrial Surface Coatings, dated September 1997. Applicable point source emissions (those within the same NAICS) taken from the MDE/ARMA 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 and per employee factors in categories where a choice of factors was offered was made based on the quality of data. County Business Patterns 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 Maryland. Population statistics for 2002 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 2001 was the last year employment data was available per NAICS, MDE used the 2001 County Business Patterns as the source for employment figures.

Emission Factor
Per employee factors were used for the following SIC and 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.

---

[49] Emission Inventory Improvement Program

Industry	SCC	SIC	NAICS
Factory Finished Wood	24 01 015 000	2426, 2427, 2428, 2429, 2430, 2440, 2450, 2493, 2499	32121
Metal Furniture and Fixtures	24 01 025 000	2500	33636, 33791, 33792, 337121, 337122, 337124, 337125, 337127, 337129, 337211, 337212, 337214, 337215, 339111, 339942
Machinery and Equipment	24 01 055 000	3500	33272
Other Transportation Equipment	24 01 990 000	3700 except 3711 and 3730	333924
Marine Coatings	24 01 080 000	3730	48839, 81149, 336611, 336612

NAICS were used that best corresponded 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. Emission factors are listed in Table 8.5-1 in the EIIP Industrial Surface Coating document and below. As an example, MDE has chosen finished wood for presentation of an equation and emissions by county. The EIIP document lists no seasonal adjustment factor and 5 days per week activity. For counties with no employees listed in County Business Patterns 2001- Maryland, MDE assumed no emissions were generated because these processes were not located in those counties.

Appliances (SIC 363), and **Electrical Insulation (SIC 3357,3612)**, had no employees listed in County Business Patterns in Maryland, thus no emissions were calculated. Emissions from **New Motor Vehicles (SIC 3711)**, were assigned to the point source section of the inventory since they are all from the General Motors Truck and Bus Group in Baltimore City.

Industry	VOC Emission Factor (lbs. $_{VOC}$/employee/year)
Factory Finished Wood	131
Metal Furniture and Fixtures	944
Machinery and Equipment	77
Other Transportation Equipment	35
Marine Coatings	308
Appliances	463
Electrical Insulation	290
New Motor Vehicles	794

Point Source
Adjustments

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

Adjustment for
Controls

MDE surveyed the various state agenicies that apply coatings to road surfaces and transportation projects. MDE collected data on the gallons of paint applied and the VOC content of the paint. MDE made emission estimates based on this data and therefore no controls are available for this source category.

Spatial and
Temporal
Allocations

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

Temporal
Data for temporal allocation is not available for this source.

Emissions
Calculation

Equation:

$$E_{FW} = \frac{EMP_i \ \mathbf{x} \ EF_{FW}}{2000 \ \mathbf{x} \ 260}$$

Where:
E_{FW} = VOC emissions in tons per day from finished wood
EMP_i = employees in county i employed in NAICS 32121.
EF_{FW} = VOC emission factor for finished wood which is 131 lbs. $_{VOC}$ per employee per year

To adjust for control efficiency, etc.:

E_{FWA} = $(E_{FW} \mathbf{-} E_{FWR}) \ \mathbf{x} \ [1 \mathbf{-} (CE \ x \ RE \ x \ RP)]$ where:

E_{FWA} = finished wood adjusted emissions

E_{FWR} =   emissions from factory finished wood sources in ARMA registration files that emit more than 10 tons per year VOC

CE = Control Efficiency
RE = Rule Effectiveness
RP = Rule Penetration

2002 Example Calculation Industrial Surface Coating – Machinery Coating (Baltimore County)

Number of employees in NAICS 33272 in Baltimore County
(2001 County Business Patterns):   4543

Emission factor for other transportation equipment (lbs. VOC/employee/year): 77[50]

5 days per week activity level, no seasonal adjustment factor

$$E_{MC-Baltimore} = \frac{(4543 \times 77) \times [1 - (0 * 1.00 * 1.00)]}{(260 \times 2000)}$$

$E_{MC-Baltimore}$ = 0.6727 tons $_{VOC}$ per day

Adjusting for registered point sources:

$E_{MC-ADJ-Baltimore}$ = $E_{MC-Baltimore}$ - $E_{MC\ Pt.\ Sources\ -\ Baltimore}$[51]
$E_{MC-ADJ-Baltimore}$ =   0.6727 – 0.00
$E_{MC-ADJ-Baltimore}$ =   0.6635 tons $_{VOC}$ per day

---

[50] Table 8.5-1, EIIP Chapter 8 Industrial Surface Coatings
[51] Point Source Reduction from JCB Incorporated (SIC 3531)

<u>Industrial Surface Coating- per Capita Emissions</u>

The following sources had their emissions calculated by per capita emission factors because employment data was not definitive.

Industry	VOC Emission Factor (lbs. $_{VOC}$/person/year)
Metal Cans	1.3
Misc. Manufacturing	0.6
Industrial Maintenance	0.8
Other Special Purpose Coatings	0.8
Misc. Finished Metals	0.5

<u>Equation:</u>

$$E_{MFM} = \frac{POP_i \times EF_{MFM}}{2000 \times 260} \times [1 - (CE \times RE \times RP)]$$

where:

E_{MFM} = VOC emissions in tons per day from miscellaneous finished metals
POP_i = 2002 population of county i
EF_{MFM} = VOC emission factor for misc. finished metals (0.5 lbs. $_{VOC}$ per person per year)
CE = Control Efficiency
RE = Rule Effectiveness
RP = Rule Penetration

To adjust for Point Sources:

E_{MFMA} = (E_{MFM} - E_{mfmar})

Where:

E_{MFMA} = adjusted emissions from miscellaneous finished metals

E_{MFMAR} = emissions from miscellaneous finished metal coating facilities in ARMA registered premise files

<u>2002 Per Capital Sample Calculation for Misc. Manufacturing Coating in Anne Arundel County</u>

503,388[52] **x** 0.6 lbs. VOC/capita/year[53] x [1 – (0.0 x 1.0 x 1.0)] = 302,032.8 lbs. $_{VOC}$ per person

Converting to tons per day: 302,032.8 **/** (260 days per year **x** 2000 lbs. per ton) = 0.5808 tons $_{VOC}$ per day

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[52] 2002 estimated population from U.S. Bureau of the Census, Population Estimation Branch .
[53] Emission factor from EIIP Industrial Surface Coating

4.1.2.7 Industrial Adhesives and Sealants

<div align="right">SCC: 2440020000</div>

Description

Industrial adhesive and sealant surface coating is 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

**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

EPA used the Freedonia[54] market research report on nonpoint solvents to obtain solvent utilization data for this source category. Some solvent usage estimates came from a National Paint and Coating Association (NP&CA)[55]. A brakedown of the methods used to derive the data for painting and coating sources are described in the report and is attached as section **3.4.1 Industrail Adhesives and Sealants**. VOC emission estimates were then allocated to the state and county levels and adopted by MDE for this source category.

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[54] Data were estimated from Freedonia Group, Inc. - Freedonia Reports from 1999 and 2004

[55] National Paint and Coating Association (NP&CA) "Paints and Coatings '2000': Review and Forecast"

4.1.2.8 Graphic Arts

Description

Graphic arts includes 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. 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[56], 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. An activity level of 5 days per week was used with no seasonal adjustment factor as recommended in Table 5.8-1 in Procedures. Any point source graphic arts facility (SIC 275) in the ARMA registration files that had 2002 emissions of between 10 and 100 tons VOC per year had its emissions 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	Estimated Percentage of Product Market Share
Rotogravure	18
Flexography	18
Offset Lithography	47
Letterpress	8
Screen	3
Plateless	3

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

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[56] Emission Inventory Improvement Program

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.

	Lithographic	Rotogravure	Flexographic	Screen
Rule Effectiveness (RE)	0.800	0.800	0.800	0.800
Rule Penetration (RP)	0.640	0.180	0.180	0.050
Control Efficiency (CE)	0.750	0.630	0.540	0.350
Reduction factor (RE x RP x CE)	0.3840	0.0907	0.0778	0.0140

Spatial and Temporal Allocations

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

Temporal
Data for temporal allocation is not available for this source.

Emissions Calculation

The equation used to estimate emissions from graphic arts is:

Equation:

$$E_{GA} = \frac{POP_i \times EF_{GA}}{2000 \times 260} \times [\, 1 - RF_L - RF_R - RF_F - RF_S \,]$$

Where:

E_{GA} = VOC emissions in tons per day from graphic arts
POP_i = 2002 population of county i
EF_{GA} = VOC emission factor for graphic arts (1.3 lbs. $_{VOC}$ per person per year)

RF_L = Reduction Factor for Lithographic Printing
RF_R = Reduction Factor for Rotogravure Printing
RF_F = Reduction Factor for Flexographic Printing
RF_S = Reduction Factor for Screen Printing

To adjust for point sources emitting below 100 tons per years:

$$E_{GAA} = (E_{GA} - E_{GAR})$$

Where:

E_{GAA} = adjusted emissions
E_{GAR} = emissions from printers in MDE/ARMA registered premise files that emit more than 10 tons $_{VOC}$/year

2002 Example Calculation Graphic Arts (Anne Arundel County)

E_{GA} = 503,388[57] **x** 1.3 lbs. $_{VOC}$/capita/year[58] x [1 – 0.384 – 0.0907 – 0.0778 – 0.014]
E_{GA} = 283684.3 lbs. $_{VOC}$ per person

Converting to tons per day:
  E_{GA} = 283684.3 **/** (260 days per year **x** 2000 lbs. per ton)
  E_{GA} = 0.5455 tons $_{VOC}$ per day

Adjusting for registered point sources emitting between 10 and 100 tons per year:
  E_{GAA} = (E_{GA} **-** E_{GAR})
  E_{GAA} = 0.5455 – 0.1035
  E_{GAA} = **0.4420** tons $_{VOC}$ per day

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[57] 2002 estimated population from U.S. Bureau of the Census, Population Estimation Branch .

[58] Emission factor from EIIP Chapter 7 Graphic Arts

4.1.2.9   Asphalt Paving

SCC: 24 61 022 000

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. 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.

Pollutants

VOC

Method and Data Sources

MDE calculated emissions from this category based on a per capita emission factor of 0.004 pounds VOC per person per year for emulsified asphalt from the Short List of AMS SCCs and Emission Factors prepared by EPA's National Air Data Branch. All emissions from this source are reactive VOC. An activity level of 5 days a week and no seasonal variation were assumed. 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. Emulsified asphalt is asphalt cement mixed with a blend of water and an emulsifier, usually soap. The equations for calculating VOC emissions from emulsified asphalt paving are presented below.

> *Activity*
> The U.S. Census Bureau reports population statistics for the counties of Maryland. Population statistics for 2002 for the counties of Maryland were collected from the U.S. Census Bureau Internet address (http://www.census.gov).

> *Emission Factors:*
> Emulsified Asphalt   0.004 pounds VOC per person per year

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. 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

Data for temporal allocation is not available for this source.

Emissions Calculation

The per capita equation used to estimate emissions from asphalt paving is:

$$E_{EA} = \frac{POP_i \text{ x } EF_{EA}}{2000 \text{ x } 260} \qquad \text{Where:}$$

E_{EA} = VOC emissions in tons per day from emulsified asphalt
POP_i = 2002 population of county i
EF_{EA} = VOC emission factor for emulsified asphalt which is 0.004 lbs. $_{VOC}$ per person per yr

2002 Emulsified Asphalt Sample Calculations: Anne Arundel County

- No seasonal variation assumed
- Activity of five days per week
- Emission factor of 0.004 lbs. VOC/person/year

$$\frac{503,388 \text{ (2002 County Population) x } 0.004}{2000 \text{ lbs. per ton x } 260 \text{ days per year}} = \mathbf{0.0039} \text{ tons VOC per day}$$

503,388[59] **x** 0.004 lbs. VOC/capita/year[60] = 2,013.552 pounds per person VOC emitted

Converting to tons per day: 2,013.552 / (260 days per year **x** 2000 lbs. per ton) = **0.0039** tons $_{VOC}$ per day emitted

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[59] Population data from U.S. Bureau of the Census, Population Estimates Branch
[60] Emission factor from the Short List of AMS SCCs and Emission Factors from EPA National Air Data Branch.

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 61 800 000

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.

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

**Method and
Data Source:**

 Maryland Agricultural Statistics service in cooperation with the Pesticide Regulation Section of the Maryland Department of Agriculture compiled information for Maryland's 2000 pesticide statistics document. The document, Maryland Pesticide Statistics for 2000, reported pesticide usage in pounds used in a year by active ingredient for each Maryland county. Along with the pounds of AI applied, the document also listed the form of many pesticides and the formulation of some selected pesticides. From this, MDE used the EIIP's emission inventory reference document titled Pesticides – Agricultural and Nonagricultural, December 1997, Section 9.2.2 to generate the VOC emissions for the active ingredient and inert carrier of the pesticide. This required assumptions and other references to collect the best information used in the calculations.

The EPA method for estimating pesticide emissions uses a six-step procedure, as follows:
    1. Determine both the application method and the quantity of pesticide product applied.
    2. Determine the type of formulation used.
    3. Determine the specific AI(s) in the formulation and their vapor pressure(s).
    4. Determine the percentage of the AI (or each AI) present.
    5. Determine the VOC content of the formulation.
    6. Calculate the emissions.

MDE slightly deviated from this method, since information was presented to MDE in pounds of active ingredient. With the active ingredient, the vapor pressure and general application method (surface application or soil incorporation) was determined from the EPA's AP-42 document or The SCS/ARS/CES Pesticide Properties Database For Environmental Decision-Making, by R. D. Wauchope, et al. Then the form (i.e. wettable powder, emulsified concentrate, granule, etc.) of the most likely pesticide was determined from a list in the Maryland Pesticide Statistics for 2000. Also, the statistics listed some formulations, for example 80% inert, 20% AI. Most of the formulations were assumptions based on the information provided with the form of the pesticide in the Maryland Pesticide Statistics for 2000.

The table below lists the EIIP emissions factors taken from AP-42 (Table 9.2.2-4) used to calculate this category.

Uncontrolled Emission Factors for Pesticide Active Ingredients

Vapor Pressure Range (mm Hg at 20° to 25° C)	Emission Factor	
	kg/Mg	lbs./ton
Surface Application		
1×10^{-4} to 1×10^{-6}	350	700
$> 1 \times 10^{-4}$	580	1160
Soil Incorporation		
$< 1 \times 10^{-6}$	2.7	5.4
1×10^{-4} to 1×10^{-6}	21	42
$> 1 \times 10^{-4}$	52	104

Equations:

E_{pest} = VOC Emissions from Active Ingredient (AI)   +   VOC Emissions from the Inert Ingredients (Inert).

VOC Emissions Active Ingredients (AI)   =   (lbs $_{AI}$ / year)   x   (lbs $_{VOC}$ / lb $_{AI}$)

VOC Emissions Inert Ingredients   =   [(lbs $_{AI}$ / year) / % AI] x % Inert Ingredients x % VOC $_{INERT\ INGREDIENTS}$

$$E_{pest} = \frac{(\text{lbs AI/year}) \times EF_{AI}\ \text{in lbs VOC/ton AI}}{2000\ \text{lbs. Per ton}} + \frac{(\text{lbs AI/year})}{(1 - \%\ \text{Inert})} \times (\%\ \text{Inert}) \times (\%\ \text{VOC in Inert})$$

$$\text{Daily Emissions} = \frac{\text{Annual Emissions}}{312\ \text{days / year}} \times \text{Seasonal Adjustment Factor}$$

where:

AI = Active Ingredient (lbs. / yr.)

EF_{AI} = Emission Factor (lbs. VOC / ton AI)

% inert = percentage of formulation that contains the Inert Carrier

% VOC in the inert = percentage of VOCs in the Inert Carrier portion of the pesticide

SAF = seasonal adjustment factor of 1.3 to adjust for the summer ozone season

MDE assumed six working days per week and 100% volatilization of the VOC portion of the inert carrier.

Sample Calculations:

The following information was compiled from The Maryland Pesticide Statistics for 2000 and The SCS/ARS/CES Pesticide Properties Database for Environmental Decision-Making:

Table 3-26
Allegany County Pesticide Information

Pesticide	V. Press mm Hg	Application	Formulation Type	Formula (% Inert)	% VOC Inert	EF lbs. VOC/ lbs. A.I.	Alleg. lbs of A.I.	VOC Alleg. Lbs/yr
2,4-D	8E-06	foliar spray	gas	0.8	0.29	0.35	2,058	3107.580
Acephate	1.7E-06	crop spray	gas	0.8	0.29	0.35	62	93.620
Alachlor	1.4E-05	soil spray	gas	0.15	0.29	0.35	19	7.622
Amitrole	4.40E-07	foliar spray	gas	0.784	0.29	0.35	6	8.416
Atrazine	2.89E-07	soil surface	wp	0.8	0.25	0.35	478	645.300
Azinphos-Methyl	2E-07	crop spray	ec	0.35	0.56	0.35	33	21.501
Azoxystrobin		crop spray	gas	0.77	0.29	0.35	1	1.321
Bacillus thuringiensis	neg	crop spray	gr	0.96	0.25	0.35	107	679.450
Benomyl	1E-10	crop spray	wp	0.8	0.25	0.35	9	12.150
Bifenthrin	1.8E-07	crop spray	gas	0.1	0.29	0.35	2	0.764
Boric Acid	0.0001	spray	wp	0.1	0.25	0.35	4	1.511
Captan	8E-08	crop spray	gas	0.5	0.29	0.35	727	465.280
Carbaryl	1.2E-06	crop spray	gas	0.5	0.29	0.35	93	59.520
Carbofuran	6E-07	foliar spray	fog	0.56	0.39	0.35	1	0.846
Chloroneb	0.003	spray	wp	0.35	0.25	0.58	17	12.148
Chlorothalonil	1E-03	crop spray	gas	0.8	0.29	0.58	368	640.320
Chlorpyrifos	1.7E-05	soil incorporation	gas	0.15	0.29	0.021	36	2.598
Clomazone	1.4E-04	soil incorporation	ec	0.3	0.56	0.052	3	0.876
Clopyralid	0	foliar spray	gas	0.8	0.29	0.35	1	1.510
Cyanazine	1.6E-09	crop spray	dust	0.8	0.21	0.35	31	36.890
Cyfluthrin	1.6E-08	crop spray	wp	0.3	0.25	0.35	153	69.943
Cypermethrin	1.4E-09	crop spray	wp	0.3	0.25	0.35	5	2.286
Diazinon	6E-05	crop spray	pellet	0.143	0.27	0.35	21	8.296
Dicamba	0	spray	gas	0.8	0.29	0.35	126	190.260
Dichlobenil	1E-03	crop spray	wp	0.8	0.25	0.58	3	4.740
Dicofol	4E-07	crop spray	wp	0.3	0.25	0.35	25	11.429

	VOC							
	V. Press		**Formulation**	**Formula**	**% VOC**	**EF**	**Alleg.**	**Alleg.**
Pesticide	**mm Hg**	**Application**	**Type**	**(% Inert)**	**Inert**	**lbs. VOC/ lbs. A.I.**	**lbs of A.I.**	**Lbs/yr**
Diflubenzuron	9E-10	crop spray	wp	0.25	0.25	0.35	80	34.667
Dimethenamid	> 1.0	soil spray	gas	0.468	0.29	0.35	5	3.026
Diuron	6.9E-08	soil surface	wp	0.8	0.25	0.35	310	418.500
Endosulfan	1.7E-07	crop spray	gas	0.5	0.29	0.35	2	1.280
Esfenvalerate	1.1E-08	crop spray	dust	0.3	0.21	0.35	7	3.080
Fenarimol	2.2E-07	crop spray	wp	0.3	0.25	0.35	1	0.457
Flumetsulam	ND	spray	aq	0.18	0.21	0.35	12	4.753
Fluvalinate	1E-07	crop spray	rtu	0.8	0.2	0.35	69	79.350
Fosamine Ammonium	4E-06	foliar spray	aq	0.8	0.21	0.35	8	9.520
Glyphosate	0	foliar spray	aq	0.8	0.21	0.35	2,610	3105.900
Hydroprene	?	?	gr	0.09	0.25		2	0.049
Imidacloprid	1.50E-09	spray	aq	0.786	0.21	0.35	1,426	1598.986
Iprodione	1E-07	crop spray	wp	0.8	0.25	0.35	24	32.400
Lambda-cyhalothrin	1.50E-09	spray	ec	0.87	0.56	0.35	8	32.782
MCPP	0	foliar spray	aq	0.5	0.21	0.35	49	27.440
Malathion	8E-06	contact spray	ec	0.3	0.56	0.35	7	4.130
Mancozeb	0	crop spray	Fl aq conc	0.8	0.21	0.35	165	196.350
Maneb	0	crop spray	wp	0.8	0.25	0.35	26	35.100
Metalaxyl	5.62E-06	soil spray	wp	0.25	0.25	0.35	7	3.033
Metam-Sodium	20	soil spray	aq	0.8	0.21	0.58	334	474.280
Methoprene	17.5	spray	aq	0.8	0.21	0.58	26	36.920
Methoxychlor	0	spray	wp		0.25	0.35	3	1.050
Methyl Bromide	1824	release of gas	Fl aq conc	0.8	0.21	0.58	58	82.360
Metolachlor	3.135E-05	soil spray	ec	0.3	0.56	0.35	488	287.920
Metribuzin	1E-05	soil surface	Fl aq conc	0.75	0.21	0.35	3	2.940
Metsulfuron Methyl	2.5E-12	foliar spray	gr	0.2	0.25	0.35	1	0.413
Nicosulfuron	1.20E-16	grass spray	gr	0.162	0.25	0.35	2	0.797
Oryzalin	1E-08	soil spray	wp	0.75	0.25	0.35	77	84.700
PCNB	1.1E-04	soil spray	wp	0.6	0.25	0.58	88	84.040
Paclobutrazol	6.00E-10	spray	wp	0.5	0.25	0.35	13	7.800
Paraquat	0	target spray	aq	0.8	0.21	0.35	124	147.560
Pendimethalin	9.4E-06	soil spray	ec	0.6	0.56	0.35	1,257	1495.830
Permethrin	1.3E-08	crop spray	ec	0.3	0.56	0.35	9,455	5578.450
Petroleum Oils	1.0E-03	spray	ec		0.56	0.58	1,503	871.740
Phosmet	4.9E-07	crop spray	wp	0.5	0.25	0.35	26	15.600
Picloram	Neg	foliar spray	aq	0.8	0.21	0.35	252	299.880
Primisulfuron-methyl	1.50E-05	crop spray	gr	0.49	0.25	0.35	2	1.180
Propachlor	7.90E-05	spray	gr	0.35	0.25	0.35	2	0.969
Propoxur	9.7E-06	crop spray	ec	0.3	0.56	0.35	2	1.180
Quizalofop-ethyl	3E-07	foliar spray	ec	0.2	0.56	0.35	1	0.490
Sethoxydim	1.6E-07	foliar spray	ec	0.3	0.56	0.35	1	0.590
Simazine	2.21E-08	soil spray	wp	0.8	0.25	0.35	776	1047.600
Sulfentrazone		spray	gr	0.25	0.25	0.56	1	0.643
Sulfometuron Methyl	6E-16	soil spray	gr	0.2	0.25	0.35	7	2.888
Sulfur	0	dust	dust	0.2	0.21	0	96	5.040
Terbacil	3.1E-07	soil spray	wp	0.8	0.25	0.35	4	5.400
Thifensulfuron methyl	1.3E-10	foliar spray	gr	0.2	0.25	0.35	1	0.413
Thiophanate-methyl	1E-07	crop spray	wp	0.5	0.25	0.35	37	22.200
Triadimefon	1.5E-08	crop spray	wp	0.8	0.25	0.35	7	9.450

Pesticide	V. Press mm Hg	Application	Formulation Type	Formula (% Inert)	% VOC Inert	EF lbs. VOC/ lbs. A.I.	Alleg. lbs of A.I.	VOC Alleg. Lbs/yr
Trichlorfon	2E-06	crop spray	sp	0.8	0.12	0.35	36	29.880
Triclopyr	1.26E-06	foliar spray	ec	0.8	0.56	0.35	454	1175.860
Trifluralin	1.1E-04	soil incorporation	ec	0.015	0.56	0.052	3	0.182
Vinclozolin	120.0099	spray	ec	0.5	0.56	0.58	16	18.240
Zinc Phosphide	0	powder	pellet	0.8	0.27	0	1	1.080
County Total							24529	23472.544

Emissions are calculated for each pesticide active ingredient per county and then summed.

Example calculation for the emissions from Pendimethalin pesticide use in Allegany county.

$$\text{Emis}_{\text{Pendimethalin}} = 1257 \; \frac{\text{Lbs}}{\text{year}} \times \left(0 \; \frac{\text{lbs.}_{\text{VOC}}}{\text{lbs.}_{\text{AI}}} + \frac{1257}{(1-0.6)} \times 0.6 \times 0.56 \right)$$

$$\text{Emis}_{\text{Pendimethalin}} = 1495.83 \; \text{lbs.}_{\text{VOC}} / \text{year}$$

$$\text{Emis}_{\text{Pendimethalin}} = 1495.83 \, / \, 2000 = 0.7479 \; \text{tons}_{\text{VOC}} / \text{year}$$

$$\text{Emis}_{\text{Pendimethalin}} = (0.7479 \; \text{tons}_{\text{VOC}} / \text{year}) * (1 \; \text{year} / 312 \; \text{days}) * (1.3)$$

$$\text{Emis}_{\text{Pendimethalin}} = \mathbf{0.0031} \; \text{tons}_{\text{VOC}} / \text{day}$$

The remaining pesticides used in Allegany county are calculated in a similar manner.

Results:
Since the EPA has released new guidance on the calculation of agricultural pesticide application, the new methodology vastly differs from the method used in 1990. In the Maryland Ozone Precursor Inventory for 1990, Air and Radiation Management, MDE, September 1993, pesticide application for the state totaled 42 tons per day. This method assumed 90% volatilization of the AI. The method also assumed the inert carrier content to be 145% by weight of the AI. Another major assumption is 100% volatilization of the inert carrier.

Since publication, the accuracy of the old pesticide methodology has been debated by different groups. General thoughts from scholars and private industry is the old methodology overpredicts the volatility of the organics in the pesticide. The new methodology, presented here, requires many assumptions and uses data that takes account for the different vapor pressures of individual active ingredients. This method, along with some general assumptions, estimated pesticide emissions at 8.7 tons per day for the state. The decrease is due to the change in method, along with a decline in pounds of pesticides applied in the state.

4.1.2.12 Commercial/Consumer Solvent Use

SCC: 24 65 000 000

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

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 population statistics for the counties of Maryland. Population statistics for 2002 for the counties of Maryland were collected from the U.S. Census Bureau Internet address (http://www.census.gov).

> *Emission Factors:*
> Commercial and Consumer Products (All)   7.84 lbs. $_{VOC}$/person/year

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.

Spatial and Temporal Allocations

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

Temporal

Data for temporal allocation is not available for this source.

**Emissions
Calculation**

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

$$E_{CC} = \frac{[\, POP_i \times EF_{CC} \,] - [\, (POP_i \times CS_{CC}) \times CE_{CC} \,]}{2000 \times 365}$$

Where:

E_{CC} = VOC emissions in tons per day from commercial and consumer solvents
POP_i = 2002 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%)

2002 Sample Calculation Commercial/Consumer Solvent Use (Anne Arundel County)

$$E_{CC} = \frac{[\, (503,388^{[61]}) \times (7.84^{[62]}) \,] - [\, (503,388 \times 3.9^{[63]}) \times (0.20)^{[64]} \,]}{2000 \times 365}$$

E_{CC} = **4.868** tons $_{VOC}$ per day

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[61] Population data from U.S. Bureau of Census, Population Estimates Branch
[62] Emission factor from EIIP Chapter 5 Commercial and Consumer Solvent Use
[63] EPA memo from John Sietz
[64] EPA memo from John Sietz

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. The 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.

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 and an emission factor of 0.11 tons $_{VOC}$ per employee cited in an April 24, 1992 Technical Memorandum prepared by Radian Corporation for EPA. Applicable point source emissions (those within the same NAICS) taken from the MDE/ARMA registration files have been subtracted from the emissions calculated on a per employee basis that are presented below.

Activity
Employee numbers were taken from County Business Patterns 2001 - Maryland, NAICS 311812, Bakery Products and 311811, Retail Bakeries. Some county employment data is represented by a letter code indicating a range for the number of employees for that SIC. In this case the arithmetic average number of employees per letter code per county was adjusted so that the state total employment in a SIC matched the sum of the number of employees reported per county

Emission Factor

An emission factor of 0.11 tons $_{VOC}$ per employee cited in an April 24, 1992 Technical Memorandum prepared by Radian Corporation for EPA 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
Data for temporal allocation is not available for this source.

Emissions Calculation

The equation used to estimate emissions from bakeries is:

Equation:

$$E_{BAK} = \frac{EF_{BAK} \textbf{ x } EMPj}{260}$$

Where:

E_{BAK} =   VOC emissions from small bakeries in tons per day
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

$$E_{BAK\text{-}ADJ} = E_{BAK} - E_{BAK-Pt.\ Sources}[65]$$

Where:

$E_{BAK\text{-}ADJ}$	Point source adjusted bakery emissions
E_{BAK}	Calculated area source bakery emissions
$E_{BAK-Pt.\ Sources}$	Point source emissions from MDE ARMA registration files

2002 Sample Calculation for Bakery VOC Emissions (Prince George's County):

Employees in NAICS 311811 in Prince George's County: 256

$$E_{BAK} = \frac{0.11 \times 256}{260}$$

$$E_{BAK} = 0.108 \text{ tons}_{VOC} \text{ per day}$$

Point Source Adjustment

$E_{BAK-Pt.\ Sources}$ (Prince George's County) = 0.0728 tons$_{VOC}$ per day

$E_{BAK\text{-}ADJ}$	=	$E_{BAK} - E_{BAK-Pt.\ Sources}$
$E_{BAK\text{-}ADJ}$	=	0.1083 – 0.0728
$E_{BAK\text{-}ADJ}$	=	0.0355 tons$_{VOC}$ per day

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[65] Point Source Reduction from MDE ARMA registration files

4.1.3.2 Breweries

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/ARMA staff surveyed small brewpubs and microbreweries in Maryland.

Activity
The survey questionnaire asked the brewing facilities to provide MDE/ARMA with the amount of barrels brewed per month for the calendar year 2002. 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.

**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.

98

Data for temporal allocation is not available for this source.

**Emissions
Calculation**

The equation used to estimate emissions from bakeries is:

$$E_{BREW} = \frac{EF_{BREW} \textbf{ x } BPj}{2000 \textbf{ x } 260}$$

Where:

E_{BREW}	=	VOC emissions from small bakeries in tons per day
EF_{BREW}	=	emission factor for small breweries
BPj	=	2002 beer production in barrels
260	=	5 days/week activity level

2002 Sample Calculation for Small Brewery VOC Emissions (Anne Arundel County):

Number barrels produced by microbreweries in Anne Arundel County: 1470.25

$$E_{BREW} = \frac{0.05674 \textbf{ x } 1506.40}{2000 \textbf{ x } 260}$$

E_{BREW} =   0.000164 lbs. $_{VOC}$ per day

4.1.3.3 Wineries

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[66], Chapter 12, Beverages, Section 2, Wines and Brandies dated September 1995. AP42 Chapter 9.12.2

> *Activity*
> State of Maryland Comptrollers Office and the State of Maryland Department of Agriculture informed MDE staff that in 2002 Maryland wineries produced approximately 99,701 gallons of wine. An informal survey of wineries in the area suggests that 64,233 gallons of white and 57,303 gallons of red wine yielding approximately 121,536 gallons of wine was 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**

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

Spatial

Data for spatial allocation is not available for this source.

Temporal

Data for temporal allocation is not available for this source.

Emissions
Calculation

Using the above figures, the production of wine by all Maryland wineries in 2002 resulted in the production of 379.2 pounds of ethanol. MDE has decided not to include this source in the periodic inventory due to the insignificance of the 2002 emissions.

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 2002. 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 SO2, CO, CO2, 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 Hazardous Waste Emergency Response Department. They provided MDE/ARMA staff a monthly list of all oil spills that occurred in Maryland during 1999, by county. Gallons of oil spilled per ozone season were summed by county for the ozone season period of April 1 through October 31 (214 days).

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 (over 10 million gallons of oil). Based on this study, a range of evaporation estimates for reactive organic gases was found to be between 5,500 and 13,000 tons. Using this information, an average emission factor was calculated to be 0.0000925 tons VOC per gallon of oil spilled. below.

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
Data for temporal allocation is not available for this source.

Emissions Calculation

The equation used to estimate emissions from oil spills:

$$E_{\text{Oil Spills}} = \frac{EF_{\text{Oil Spills}} \textbf{ x } GOSj}{2000 \textbf{ x } 365}$$

Where:

$E_{\text{Oil Spills}}$	=	VOC emissions from oil spills in tons $_{\text{VOC}}$ per day
$EF_{\text{Oil Spills}}$	=	emission factor for small breweries
GOSi	=	gallons of oil spilled in county I

<u>2002 Sample Calculation for Oil Spill VOC Emissions (Baltimore County)</u>:

Annual Emissions:
Number gallons oil spilled in Baltimore County, 2002:

$$E_{\text{Oil Spills}} = \frac{(0.0000925) \textbf{ x } (Gal)}{2000}$$

$$E_{\text{Oil Spills}} = \text{tons }_{\text{VOC}} \text{ per year}$$

Number gallons oil spilled in Baltimore County, April-October, 2002

$$E_{\text{Oil Spills}} = \frac{(0.0000925) \textbf{ x } (Gal)}{2000 \text{ x } 214}$$

$$E_{\text{Oil Spills}} = \text{tons }_{\text{VOC}} \text{ per ozone season day}$$

103

4.1.4.2 Leaking Underground Storage Tanks

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 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
As suggested in section 4.8.6 of Procedures, MDE staff used emissions from soil and groundwater remediation to estimate VOC emissions from leaking underground storage tanks. From the MDE/ARMA registration files, inventory staff obtained location of soil and groundwater remediation sites and obtained fugitive VOC emissions from each site in pounds per day. No seasonal variation was assumed.

Emission Factor
VOC emissions are those allowable in each remediation permit- there are different allowable emissions for each permit.

**Point Source
Adjustments**

No point source adjustments were made.

**Adjustment for
Controls**

No controls are available for this source category. Because MDE staff used maximum allowable emissions from permit information, MDE believes that Rule Effectiveness, Control Efficiency, and Rule Penetration are not applicable to this source.

Spatial and Temporal Allocations

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

Temporal
Data for temporal allocation is not available for this source.

Emissions Calculation

$$E_{UST} = \frac{RS1_j + RS2_j + RS3_j \ldots .}{2000}$$

where:

E_{UST} = VOC emissions in tons per day from leaking underground storage tanks

$RS1_j, RS2_j$ = pounds $_{VOC}$ per day allowed from remediation site(s) in county j

2002 Sample Calculation for Leaking Underground Storage Tanks (Anne Arundel County)

No seasonal variation assumed

Annual VOC emissions in pounds per day: (from soil and groundwater remediation)
Activity level: 7 days/week (see text)

VOC emissions in tons per day:
pounds/day total from registration data:
pounds/day/ 2000 =   tons $_{VOC}$ per day from leaking underground storage tanks in Anne Arundel County

4.1.5   SOLID WASTE DISPOSAL, TREATMENT, AND RECOVERY

4.1.5.1   On-site Incineration

SCC: 26 01 000 000

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, and PM_{10}

**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/ARMA 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

EPA Procedures mentions that research into VOC emissions from POTWs has found that in the event of "heavy chemical loading", 85% of volatile pollutants discharged to these facilities "are stripped to the ambient air" (Section 3.5.1). Also, VOC concentration in POTW influent is directly proportional to the industrial contribution to POTWs as stated in Procedures, Page 3-14.

Pollutants

VOC, NH_3

**Method and
Data Sources**

The emissions from these facilities were calculated based on the method described in Procedures, Section 3.5.1.

Activity
The percent industrial flow for each POTW in Maryland was supplied by the Maryland Water Management Administration. MDE staff multiplied this amount by the emission factor listed above to get VOC emissions from each POTW. The individual POTW emissions were then totaled by county. Some counties are not listed in this table because their industrial effluent is discharged to a POTW in another county.

Emission Factor
This method uses an emission factor of 1.1×10^{-4} pounds $_{VOC}$ emitted per gallon of industrial wastewater discharged to a POTW.

**Point Source
Adjustments**

VOC stack emissions in the Air Management registration files from the Patapsco Wastewater Treatment Plant in Baltimore City were subtracted from the totals below.

**Adjustment for
Controls**

No controls are available for this source category.

107

Spatial and Temporal Allocations

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

Temporal
Data for temporal allocation is not available for this source.

Emissions Calculation

The equation used to estimate emissions from POTWs is:

$$E_{POTW} = \frac{DF_{IJ} \times PIF_{IJ} \times EF_{POTW} \times SAF_{POTW}}{2000}$$

Where:

E_{POTW}	=	VOC emissions in tons $_{VOC}$ per day from POTWs
DF_{IJ}	=	Daily flow into POTW i in county j
PIF_{IJ}	=	Percent industrial flow from POTW i in county j
EF_{POTW}	=	VOC emission factor[67] for POTWs
SAF_{POTW}	=	Seasonal adjustment factor[68] for peak ozone season which is 1.4

2002 Sample Calculation for POTW VOC Emissions (Anne Arundel County):

Back River Sewage Treatment Plant statistics[69]:
    Average daily flow (MGD)[70]: 152.0
    Percent industrial flow: 4.2%

$$E_{POTW} = \frac{(843,800) \times (4.2\%) \times (1.1 \times 10^{-4} \text{ lbs.}_{VOC} / \text{gal}) \times 1.4}{2000}$$

E_{POTW} =   0.0639 tons $_{VOC}$ / day

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[67] Emission factor taken from Procedures, Section 3.5.1
[68] Seasonal adjustment factor taken from Procedures, Table 5.8.1
[69] Supplied by the Maryland Water Management Administration
[70] 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 <u>EIIP</u>[71], 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.

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[71] Emission Inventory Improvement Program

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 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	99	148.5
Softwood	57	85.5
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 [72]

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	13	Lbs. $_{VOC}$/ ton
SOx	1.0	Lbs. $_{SOx}$/ ton
CO	85	Lbs. $_{CO}$/ ton
PM_{10}	16	Lbs. $_{PM10}$/ ton
$PM_{2.5}$	17	Lbs. $_{PM2.5}$/ ton

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

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

**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
Data for temporal allocation is not available for this source.

**Emissions
Calculation**

Annual Emissions

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

$E_{OB-LCD-Ann}$ = 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
$EF_{OB\,i}$ = Open burning emission factor for pollutant i in lbs. / ton

Ozone Season Daily Emissions

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

$E_{OB-LCD-Day}$ = 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

111

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 Toxics

**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."[73]

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.

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 espondents. The respondents for this survey were typically local fire wardens or chiefs. Rule

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

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 subcounty, 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[74] are listed below:

Pollutant	Emission Factor Lb/ton total mass burned
VOC	8.556
NOx	6
CO	85
PM_{10}	38
$PM_{2.5}$	34.8
SO_2	1.0

Point Source Adjustments

No subtration 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:

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

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[74] EPA. 1997. Evaluation of Emissions from the Open Burning Of Household Waste in Barrels. EPA-600/R-97-134a. U.S. Enivironmental 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/100
RP	=	% Rule penetration/100
RE	=	% Rule effectiveness/100

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 was 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 statespecific 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 and 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 affect 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)

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)

	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)

	Weekend Day 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

	Weekend Day 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

**Emissions
Calculation**

Emissions were caculated 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:

PUT EQUATION HERE

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

4.1.5.5 Open Burning – Residential Yard Waste

<div align="right">

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

</div>

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 Toxics

**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."[75]

> *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.
>
> 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

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

respondents or jurisdictions, while yard waste surveys were conducted for 181 respondents. The respondents for this survey were typically local fire wardens or chiefs. 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 subcounty, 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[76] are listed below:

Pollutant	Emission Factor Lb/ton total mass burned
VOC	8.556
NOx	6
CO	85
PM_{10}	38
$PM_{2.5}$	34.8
SO_2	1.0

Point Source Adjustments

No subtration of emissions from point sources is necessary.

Adjustments for Controls

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

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

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

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

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 was 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 statespecific 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 and 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 affect 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)

SCC	Month											
	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 caculated 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:

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: 31 502 102

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 thelate 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 preheat 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. Cooldown follows for 45 minutes to 1.5 hours.

Pollutants

Air Toxics (Criteria Pollutants were not calculated)

Method and
Data Sources

The method used to calculate emissions, is presented in "Documentation for the 1996 Base Year National Toxics Inventory for Area Sources" prepared by Eastern Research Group, Inc. (May 31, 2001) and distributed by U.S. EPA Emissions, Monitoring and Analysis Division, Emission Factor and Inventory Group.

> *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 an crematory must obtain certification from MDE and renew the certification annually.
>
> MDE/ARMA 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.

Emission Factors

Emission factors these hazardous air pollutants, except formaldehyde, were taken from the State of California Air Resources Board Test Report No. C-90-004[77]. The emission factor used for formaldehyde was reported in the USEPA FIRE[78] system database.

Emission factors were converted to a pound per ton basis using the procedure provided by the Emission Standards Division[79]. National activity was provided by the Emissions Standards Division based on an assumed body weight of 150 pounds and information reported by the Cremation Association of North America[80] that 21.13 percent of bodies were cremated and that there were 2,322,265 deaths in the United States in 1996[81].

Pollutant	Animal and Human Cremation Emission Factor Lbs. $_{pollutant}$ / ton cremated
arsenic	4.00E-04
beryllium	1.84E-05
cadmium	1.48E-04
chromium	3.99E-04
formaldehyde	2.89E-09
nickel	5.09E-04
POM as 16-PAH	9.63E-04
POM as 7-PAH	1.03E-09
Mercury	4.39E-02

Point Source Adjustments

No subtration of emissions from point sources is necessary.

Adjustments for Controls

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[77] State of California Air Resources Board, Engineering Evaluation Branch, Monitoring and Laboratory Division. "Evaluation Test on Two Propane Fired Crematories at Camellia Lawn Cemetary." Test Report No. C-90-004. October 29, 1992

[78] U.S. EPA. Factor Information Retrieval (FIRE) System Database, Version 5.1a. Research Triangle Park, NC. September 1995.

[79] Crume, Richard, U.S. EPA, Emission Standards Division. Note to Anne Pope, U.S. EPA/Emissions Monitoring and Analysis Division. Comments on Human and Animal Cremation information in the "Baseline Emission Inventory of HAP Emissions from MACT Sources – Interim Final Report," September 18, 1998. October 30, 1998.

[80] Cremation Association of North America. 1996 Statistics as found on the Internet Cremation Society, Cremation Stats Nationwide webpage: www.cremation.org/stats.htm

[81] Ventura, S. et al. "Births and Deaths: United States, 1996." Monthly Vital Statistics Report, Vol. 64, No. 1, Supplement 2. Setpember 11, 1997. U.S. Department of Health and Human Services, Centers for Dieseas Control and Prevention, National Center for Health and Statistics.

No controls are available for this source category.

**Spatial and
Temporal
Allocations**

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

Temporal
Data for temporal allocation is not available for this source.

**Emissions
Calculation**

The equation for estimating emissions from crematories is:

where:

E_{CREM}	=	Annual emissions from crematories
TON_{cty}	=	Tons cremated per year in county
EF	=	Emission Factor per pollutant (lbs/ton)

2002 Sample Calculation (Harford County)

Arsenic Annual Emissions:

TON_{cty}	=	26
EF	=	0.0004 lbs Arsenic/Ton Cremated

$$E_{CREM} = \frac{(26) \times (0.0004)}{(2000 \text{ lbs/ton})}$$

$$E_{CREM} = 5.20E\text{-}06 \text{ tons Arsenic per Year}$$

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 landfilled 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[82], 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 uncontrolled emissions of the various compounds present in landfill gas, total landfill gas emissions must first be estimated. Emissions of landfill gas depend on several factors including: (1) the size, configuration, and operating conditions of the landfill; and (2) the characteristics of the refuse such as moisture content, age, and composition. Uncontrolled CH_4 emissions may be estimated for individual landfills by using a theoretical first-order kinetic model of methane production developed by the EPA. A computer program that uses this model is known as the Landfill Gas Emissions Model (LandGEM). The model equation is as follows:

$$Q_{CH4} \quad = \quad L_O \, R \, (e^{-kc} - e^{-kt}) \qquad (1)$$

Where:

Q_{CH4} = Methane generation rate at time t, m^3/yr;

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[82] Emission Inventory Improvement Program

L_O = Methane generation potential, m^3 CH_4 / Mg (megagrams) refuse;

R = Average annual refuse acceptance rate during active life, Mg/yr;

e = Base log, unitless;

k = Methane generation rate constant, yr^{-1};

c = Time since landfill closure, years (c = 0 for active landfills); and

t = Time since the initial refuse placement, yrs.

Site-specific landfill information is generally available for variables R, c, and t. When refuse acceptance rate information is scant or unknown, R can be estimated by dividing the refuse in place by the age of the landfill. Also, nondegradable refuse should be subtracted from the refuse in place to prevent over estimation of CH_4 generation. The average annual acceptance rate should only be estimated by this method when there is inadequate information available on the actual annual acceptance rate.

The following LandGEM parameters are needed to estimate emissions from a landfill:

- The methane generation rate (k),
- The potential methane generation capacity (Lo),
- The number of years past closure that the model will estimate emissions,
- The estimated percentage composition of methane and carbon dioxide in the gas (the default value is a 50/50 split),
- The concentration of nonmethane organic compounds (NMOC) found in the landfill gas,
- The concentrations of toxic air pollutants found in the landfill gas, and whether the landfill has been used for disposal of hazardous waste (co-disposal).
- The years the landfill has been in operation (including the closure year),
- The design capacity of the landfill,

The Landfill Gas Emissions Model has several different default values for k, Lo and NMOC concentration. The EIIP document recommends using AP-42 default values for k, Lo and NMOC concentration when site-specific information is not known. The AP-42 default value for k (0.04/yr) was used for Maryland since it has normal or above normal precipitation, rather than the default value. This recommendation is based on a comparison of gas-yield forecasts with landfill gas recovery data. The LandGEM contains a proposed regulatory default value for total VOCs of 595 ppmv expressed as hexane for non-codisposal and 2,420 ppmv for codisposal. However, there is a wide range for total VOC values from landfills. The proposed regulatory default value for VOC concentration was developed for regulatory compliance purposes and to provide the most cost-effective default values on a national basis for the regulation. Therefore, if the landfill is known to contain only municipal solid waste or have very little organic commercial/industrial wastes, then the mean value of all VOC concentrations, 595 ppmv as hexane should be used. This was done for Maryland. The AP-42 default values used in the LandGEM to develop Maryland's landfill inventory are shown in the table below:

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 facilites directly.

Emission Factors
All factors are incorparted into the LandGEM itself.

**Point Source
Adjustments**

The Brown Station Sites A & B, Sandy Hill Landfill, Montgomery County RRF, and Newland Park Landfill are considered Point Sources. LandGEM model runs for these landfills are not included in the area source emission estimates for landfills.

**Adjustments for
Controls**
Emission reductions were calculated for landfills that used control technology to reduce emissions. 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**

Data for spatial and temporal allocation is not available for this source.

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 <u>Inventory of Power Plants in the United States</u>, 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)
SCC: 21 03 011 000 (commercial/institutional kerosene)
SCC: 21 04 004 000 (residential distillate oil)
SCC: 21 03 004 000 (commercial/institutional distillate oil)
SCC: 21 02 004 000 (industrial distillate oil)
SCC: 21 03 005 000 (commercial/institutional residual oil)
SCC: 21 02 005 000 (industrial 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, 2002, published by Energy Information Administration, U.S. Department of Energy[83].

Emission Factors
Emission factors were obtained from AP-42[84], Tables 1.3-1 and 1.3-3 (hand-fed units).

Uncontrollled Emission Factors – AP-42 Tables 1.3-1 and 1.3-3						
Residential Distillate	Commercial Distillate	Commercial Residual	Industrial Distillate	Industrial Residual	Commercial Residual 1% S	Industrial Residual 1% S

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[83] Total residential distillate oil use in the State of Maryland in 2002 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, 2002".
[84] Emission Factors from AP-42 Tables 1.3-1 and 1.3-3

	lbs/Kgal	lbs/Kgal	lbs/Kgal	lbs/Kgal	lbs/Kgal	lbs/Kgal	lbs/Kgal
PM10	1.080	1.080	13.494	1.000	18.714	7.703	10.683
PM2.5	0.830	0.830	5.011	0.250	12.189	2.861	6.958
SOx	43.200	43.200	318.000	43.200	318.000	159.000	159.000
NOx	18.000	20.000	55.000	20.000	55.000	55.000	55.000
CO	5.000	5.000	5.000	5.000	5.000	5.000	5.000
VOC	0.713	0.340	1.130	0.200	0.280	1.130	0.280

**Point Source
Adjustments**

No subtration 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[85] 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).[86]

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[85] Emissions Inventory Improvement Program (EIIP) Area Source Method Abstract – Residential and
Commercial/Institutional Fuel Oil and Kerosene Combustion, dated April 2002

[86] http://www.noaa.gov (home page) or http://www.ncdc.noaa.gov/ol/climate/climateproducts.html#PUBS (for a list
of available data)

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 2002 was obtained from 1990 Census Profile Series, Social and Economic Characteristics of Population and Housing. The number of new housing units authorized for construction between 1990 and 2002 was obtained from the Maryland Office of Planning – New Residential Units Authorized for Construction by Building Permits (http://www.op.state.md.us). MDE estimated that no new housing units would be equipped to burn coal as a home 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.

(ii) Residential Coal Activity Consumption Data

The State Energy Data Report, Consumption Estimates, by the Energy Information Administration, provided information on estimated coal consumption. The report indicates that in Maryland mostly bituminous coal was used in 2002. It was assumed, therefore, that bituminous coal was consumed by most of the hand-fired residential coal sources in the State of Maryland.

Emission Factors

Emission factors were obtained from AP-42, Tables 1.1-3 and 1.1-19 (hand-fed units).

Coal Emission Factors					
	NOx **(lbs./kgal)**	**CO** **(lbs./kgal)**	**VOC** **(lbs./kgal)**	**PM 10** **(lbs./kgal)**	**SOx** [87] **(lbs./kgal)**
Residential	9.10	275.00	10.00	6.20	62.00

Point Source
Adjustments

No subtration 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[88] 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).[89]

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[87] MDE assumed an average sulfur content in coal of 2%
[88] Emissions Inventory Improvement Program (EIIP) Area Source Method Abstract – Natural Gas and LPG Combustion, dated April 2002
[89] http://www.noaa.gov (home page) or http://www.ncdc.noaa.gov/ol/climate/climateproducts.html#PUBS (for a list of available data)

$$SAF_{InventoryCounty} = \frac{HDD_{InventoryCounty} * CHU_{InventoryCounty}}{\displaystyle\sum_{AllCountiesInState}(HDD_{County} * CHU_{County})}$$

Where:

SAF $_{\text{INVENTORY COUNTY}}$	=	Spatial apportioning factor for inventory county
HDD $_{\text{INVENTORY COUNTY}}$	=	Annual heating degree days for inventory county
CHU $_{\text{INVENTORY COUNTY}}$	=	Housing units using coal in inventory county
HDD $_{\text{COUNTY}}$	=	Annual heating degree days for each county in the state
CHU $_{\text{COUNTY}}$	=	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 $_{\text{INVENTORY COUNTY}}$ = SAF $_{\text{INVENTORY COUNTY}}$ x Coal $_{\text{TOTAL STATE}}$

Where:

Coal $_{\text{INVENTORY COUNTY}}$	=	Total Coal fuel consumed in the inventory county
Coal $_{\text{TOTAL STATE}}$	=	Total Coal fuel consumed in the inventory county

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.

$$\text{Residential Fuel}_{\text{MONTH}} \quad = \quad \text{Residential Fuel}_{\text{ANNUAL}} \quad \text{x} \quad \frac{\text{HDD}_{\text{MONTH}}}{\text{HDD}_{\text{ANNUAL}}}$$

where:

Residential Fuel $_{\text{MONTH}}$ =		Space heating fuel use for inventory month
Residential Fuel $_{\text{ANNUAL}}$ =		Space heating fuel use for inventory year
HDD $_{\text{MONTH}}$	=	Heating degree days for inventory month
HDD $_{\text{ANNUAL}}$	=	Heating degree days for inventory year

Emissions Calculation

Ozone Season Daily Emissions
<u>Equation:</u>

$$E_{\text{COAL}} = \frac{\dfrac{(\text{EF}_{\text{COAL i}} \text{ x } \text{Coal}_{\text{Space Heat - J}})}{2000} \text{ x } \dfrac{\text{HDD}_{\text{Co Oz Season}}}{\text{HDD}_{\text{Co Annual}}}}{\text{Ozone}_{\text{DAYS}}}$$

136

E_{COALG}	=	Ozone Season Daily emissions from residential coal combustion
$EF_{COAL\ i}$	=	Emission factor for coal combustion for pollutant i
$Coal_{Space\ Heat\ -\ J}$	=	Coal consumed for space heating in county j
$HDD_{Co\ Oz\ Season}$	=	Number of heating degree days in county for ozone season
$HDD_{Co\ Annual}$	=	Number of heating degree days in county in the calendar year 2002
$Ozone_{DAYS}$	=	Number of days in the ozone season: 214 Residential; 168 Commercial

<u>Residential Coal Combustion Sample Calculation (Allegany County) (tons / ozone season day)</u>

Total Residential Coal Consumption – State of Maryland   8,360 tons

To calculate spatial apportioning factor for Allegany County:

$$SAF_{ALLEGANY\ COUNTY} = \frac{HDD_{INVENTORY\ COUNTY} \times CHU_{INVENTORY\ COUNTY}}{\sum_{ALL\ COUNTIES\ IN\ STATE}(HDD_{COUNTY} \times CHU_{COUNTY})}$$

$$SAF_{ALLEGANY\ COUNTY} = 0.045531$$

To calculate tons of coal used in Allegany County:

Residential Coal $_{\text{ALLEGANY COUNTY}}$ = SAF $_{\text{ALLEGANY COUNTY}}$ x Coal $_{\text{TOTAL STATE}}$
Residential Coal $_{\text{ALLEGANY COUNTY}}$ = 0.045531 x 8,360
Residential Coal $_{\text{ALLEGANY COUNTY}}$ = 380.6408 tons

Coal used for space heating in ozone season in Allegany County

Residential Space Heating Fuel $_{\text{PERIOD}}$ = Space Heating Fuel $_{\text{ANNUAL}}$ x $\dfrac{\text{HDD}_{\text{PERIOD}}}{\text{HDD}_{\text{ANNUAL}}}$

Residential Space Heating Fuel $_{\text{PERIOD}}$ = 380.6408 x $\dfrac{1093}{5234}$

Residential Space Heating Fuel $_{\text{PERIOD}}$ = 79.48804 tons

Equation:

Residential Coal VOC Ozone Season Day Emission Calculation for Allegany County

$$E_{\text{COAL}} = \frac{(\text{EF}_{\text{COAL i}} \ x \ \text{Coal}_{\text{Space Heat - J}})}{(2000 \ x \ 214)}$$

$$E_{\text{COAL}} = \frac{(10.0 \ x \ 79.48804)}{(2000 \ x \ 214)}$$

E_{COAL} = 0.0019 tons $_{\text{VOC}}$ / Ozone season 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 68,000 tons/year of total coal was used commerically by Maryland in 2002.

(ii) Number of Dwelling Units using Coal

The number of dwelling units using coal for space heating for 2002 was obtained from 1990 Census Profile Series, Social and Economic Characteristics of Population and Housing. The number of new housing units authorized for construction between 1990 and 2002 was obtained from the Maryland Office of Planning – New Residential Units Authorized for Construction by Building Permits (http://www.op.state.md.us). MDE estimated that no new housing units would be equipped to burn coal as a home 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 1.1-19 (average of overfeed and underfeed stoker).

Coal Emission Factors					
	NOx (lbs./kgal)	**CO** (lbs./kgal)	**VOC** (lbs./kgal)	**PM 10** (lbs./kgal)	**SOx** [90] (lbs./kgal)
Commercial / Institutional	8.50	8.50	0.675	6.10	69

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[90] MDE assumed an average sulfur content in coal of 2%

**Point Source
Adjustments**

No subtration of emissions from point sources is necessary.

**Adjustments
for Controls**

No controls are available for this source category.

**Spatial and
Temporal
Allocations**

> *Spatial*
> Spatial and temporal allocation to this source category were calculated in the same manner as the residential coal combustion category.

> *Temporal*
> Spatial and temporal allocation to this source category were calculated in the same manner as the residential coal combustion category.

**Emissions
Calculation**

4.1.6.5 Natural Gas Combustion

SCC: 21 04 060 000 (Residential Natural Gas)
SCC: 21 03 060 000 (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, 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 2002 was obtained from 1990 Census Profile Series, Social and Economic Characteristics of Population and Housing. The number of new housing units authorized for construction between 1990 and 2002 was obtained from the Maryland Office of Planning – New Residential Units Authorized for Construction by Building Permits (http://www.op.state.md.us). The total number of additional housing units constructed in the county was apportioned to type of home heating fuel by the same ratio as the 1990 Census figures.

(ii) Residential and Commercial/Institutional Natural Gas Consumption Data

Total residential and commercial/institutional natural gas consumption data in the State of Maryland for 2002 was obtained from surveying the following companies: Baltimore Gas and Electric (*Constellation Energy Group*), Washington Gas Energy Services (Maryland

141

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 2002 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 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*. The emission factors for PM are assumed to be less than 1.0 micrometers in diameter. Therefore the PM emisson facotrs preseneted may be used to estimate PM10, PM2.5 or PM1. Total PM is the sum of filterable and condensable PM.   AP-42 Tables 1.4-1 - 1.4-2.

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)	SOx (lbs./10^6 scf)
Residential	94	40	5.50	1.90	1.90	0.60
Commercial	94	84	5.50	1.90	1.90	0.60

Point Source Adjustments

No subtration 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.

[1] The VOC emission factor is 11.0 with 34% methane. The number listed is the nonmethane emission factor.
[2] The VOC emission factor is 5.80 with 52% methane. The number listed is the nonmethane emission factor.

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, 1998-2002. 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:

Space Heat Fuel $_{MONTH}$ = Space heating fuel use for inventory month
Space Heat 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

**Emissions
Calculation**

Emission Calculation – Residential Ozone Season Daily Emissions

Equation:

$$E_{NatGas} = \frac{\left[\dfrac{(EF_{NatGas-i} * NG_{SpaceHeat-J})}{2000} * \dfrac{HDD_{CoOzSeason}}{HDD_{CoAnnual}}\right] + \left[\dfrac{EF_{NatGas-i} * NG_{HotWaterApp-J}}{2000}\right]}{Ozone_{Days}}$$

E $_{NatGas}$ = Ozone Season Daily emissions from natural gas combustion
EF $_{NatGas-i}$ = Emission factor for natural gas combustion for pollutant i
NG $_{Space\ Heat-J}$ = Natural gas consumed for space heating in county j
HDD $_{Co\ Oz\ Season}$ = Number of heating degree days in county for ozone season
HDD $_{Co\ Annual}$ = Number of heating degree days in county in the calendar year 2002
NG $_{Hot\ water/App-J}$ = Natural gas consumed for during ozone season by hot water and appliances in county j
Ozone $_{DAYS}$ = Number of days in the ozone season: 214 Residential; 168 Commercial

Total Residential Natural Gas Consumption – Baltimore City[91]   14,483 M ft^3

Percent natural gas used for cooking & appliances in the State of Maryland[92]

	Total Natural Gas Delivered		Lowest Monthly Delivery of Natural Gas		Percent of Natural Gas used for Cooking & Water Heating	
	Res	**Comm**	**Res**	**Comm**	**Res**	**Comm**
State of Maryland	80,447	65323	1635	2440	24.389 %	44.823 %

Percent natural gas used for cooking & appliances in Baltimore City

Residential NG $_{Hot\ water/App-J}$ = 24.389 % x NG $_{BALTIOMORE\ COUNTY}$
Residential NG $_{Hot\ water/App-J}$ = 24.389 % x 14,483

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[3] Natural gas consumption data gathered from MDE survey – Baltimore County data from BGE
[4] Lowest summer monthly total is assumed to be for cooking and appliances.

Residential NG $_{Hot\ water/App\ -\ J}$ = 3,532.130 M ft³

Natural gas used for space heating in Baltimore County

Residential NG $_{Space\ Heat\ -\ J}$ = 14,483 – 3,532.130 M ft³
Residential NG $_{Space\ Heat\ -\ J}$ = 10,951 M ft³

Natural gas used for space heating in ozone season in Baltimore City

$$Residential\ Space\ Heating\ Fuel_{PERIOD} = Space\ Heating\ Fuel_{ANNUAL}\ x\ \frac{HDD_{PERIOD}}{HDD_{ANNUAL}}$$

$$Residential\ Space\ Heating\ Fuel_{PERIOD} = 10,951\ x\ \frac{605}{3884}$$

Residential Space Heating Fuel $_{PERIOD}$ = **1,705.807** M ft³

Natural gas used for hot water and appliances in ozone season in Baltimore City

$$Residential\ Hot\ Water\ Fuel_{PERIOD} = Hot\ Water\ Fuel_{ANNUAL}\ x\ \frac{Months\ ozone\ season}{Months\ Year}$$

$$Residential\ Hot\ Water\ Fuel_{PERIOD} = 3532.130\ x\ \frac{7}{12}$$

Residential Hot Water Fuel $_{PERIOD}$ = **2,060.409** M ft³

Equation:

VOC Ozone Season Day Emission Calculation

$$E_{NatGas} = \frac{(EF_{NG\ i}\ x\ NG_{Space\ Heat\ -\ J}) + (EF_{NG\ i}\ x\ N_{Hot\ water/App\ -\ J})}{(2000\ x\ 214)}$$

$$E_{NatGas} = \frac{(5.5\ x\ 1,705.807) + (5.5\ x\ 2,060.409)}{(2000\ x\ 214)}$$

E_{NatGas} = **0.0484** tons $_{VOC}$ / Ozone season day

The same equation and methodology can be used to estimate emission of various pollutants.

4.1.6.6   Liquified 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, VOC

**Method and
Data Sources**

The following assumptions were made in the computation of the emissions from liquified petroleum gas (LPG) combustion.

   Activity
   1. Number of Dwelling Units using LPG

   The number of dwelling units using LPG for space heating for 2002 was obtained from 1990 Census Profile Series, Social and Economic Characteristics of Population and Housing. The number of new housing units authorized for construction between 1990 and 2002 was obtained from the Maryland Office of Planning – New Residential Units Authorized for Construction by Building Permits (http://www.op.state.md.us). The total number of additional housing units constructed in the county was apportioned to type of home heating fuel by the same ratio as the 1990 Census figures.

   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 2002 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 combustion of LPG in commercial boilers are presented in Table 1.5-1 of Section 1.5 of *AP-42* (EPA, 1998a). The LPG emission factor for PM may be assumed to represent PM $_{10}$ emissions. Because no emission factors were located for the combustion of LPG for residential consumption, emission factors for commercial boilers may be used for residential emissions. PM $_{10}$ and SOx emission factors listed below are averages of the commercial emission factors for boilers that use propane and butane. The SOx emission factors reported below were calculated using the AP-42 emission factor and multiplied by the sulfur content of the fuel (S = 0.18).

LPG Emission Factors						
	NOx **(lbs./kgal)**	**CO** **(lbs./kgal)**	**VOC** **(lbs./kgal)**	**PM 10** **(lbs./kgal)**	**PM 2.5** **(lbs./kgal)**	**SOx** **(lbs./kgal)**
Residential	14	1.9	0.5	0.45	0.0	0.0171
Commercial	14	1.9	0.5	0.45	0.0	0.0171

Point Source Adjustments

No subtration 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[93] 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).

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[93] Emissions Inventory Improvement Program (EIIP) Area Source Method Abstract – Natural Gas and LPG Combustion, dated April 2002

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).[94]

$$\text{SAF}_{\text{INVENTORY COUNTY}} = \frac{\text{HDD}_{\text{INVENTORY COUNTY}} \text{ x LP-HU}_{\text{INVENTORY COUNTY}}}{\sum_{\text{ALL COUNTIES IN STATE}} (\text{HDD}_{\text{COUNTY}} \text{ x LP-HU}_{\text{COUNTY}})}$$

Where:

$\text{SAF}_{\text{INVENTORY COUNTY}}$	=	Spatial apportioning factor for inventory county
$\text{HDD}_{\text{INVENTORY COUNTY}}$	=	Annual heating degree days for inventory county
$\text{LP-HU}_{\text{INVENTORY COUNTY}}$	=	Housing units using LP gas for inventory county
$\text{HDD}_{\text{COUNTY}}$	=	Annual heating degree days for each county in the state
$\text{LP-HU}_{\text{COUNTY}}$	=	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:

$$\text{LPG}_{\text{INVENTORY COUNTY}} = \text{SAF}_{\text{INVENTORY COUNTY}} \text{ x LPG}_{\text{TOTAL STATE}}$$

Where:

$\text{LPG}_{\text{INVENTORY COUNTY}}$	=	Total LPG fuel consumed in the inventory county
$\text{LPG}_{\text{TOTAL STATE}}$	=	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.

To separate residential space heating 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. Data was obtained from the follow reports:

1. Water-Heating Energy Consumption in U.S. Households by South Census Region 2000
2. Appliances Energy Consumption in U.S. Households by South Census Region 2000
3. Total Energy Consumption in U.S. Households by South Census Region 2000
4. Data from Maryland Office of Planning - New Residential Units Authorized for Construction by Building Permits

The percentage of liquid propane gas consumption for cooking and water heating may then be calculated by developing a ratio between the amount of LPG used for hot water, appliances, and the total amount of LPG consumed (space heating + hot water + appliances).

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[94] http://www.noaa.gov (home page) or http://www.ncdc.noaa.gov/ol/climate/climateproducts.html#PUBS (for a list of available data)

Also, 2002 residential LPG usage was estimated by taking the percent of new housing units constructed in 2000 and applying it to 2001 and 2002 new housing construction data from the Maryland Department of Planning.

$$\text{Percent of LPG used for cooking \& appliances} = \frac{\text{amount of LPG used for hot water and appliances}}{\text{total amount of LPG consumed}}$$

$$= \frac{(100 + 43)}{572}$$

$$= 0.25$$

Therefore 25 percent of the annual LPG consumed is used for non-space heating and an individual county's residential LPG consumption total for hot water and appliances can be calculated as follows:

$$\text{LPG}_{\text{Hot water/App - J}} = 25\% \text{ x } \text{LPG}_{\text{INVENTORY COUNTY}}$$

Where:

$$\text{LPG}_{\text{Hot water/App - J}} = \text{LPG consumed for hot water and appliances in county j}$$

This percentage may be applied to the inventory area's total residential liquid propane gas consumption to calculate the cooking and water 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.

$$\text{Residential Fuel}_{\text{MONTH}} = \text{Residential Fuel}_{\text{ANNUAL}} \text{ x } \frac{\text{HDD}_{\text{MONTH}}}{\text{HDD}_{\text{ANNUAL}}}$$

where:

Residential Fuel $_{\text{MONTH}}$	=	Space heating fuel use for inventory month
Residential Fuel $_{\text{ANNUAL}}$	=	Space heating fuel use for inventory year
HDD $_{\text{MONTH}}$	=	Heating degree days for inventory month
HDD $_{\text{ANNUAL}}$	=	Heating degree days for inventory year

Emissions Calculation

Emission Calculation

Ozone Season Daily Emissions

Equation:

$$E_{LPG} = \dfrac{\left[\dfrac{(EF_{LPG\,i} \times LPG_{Space\,Heat\,-\,J})}{2000} \times \dfrac{HDD_{Co\,Oz\,Season}}{HDD_{Co\,Annual}} + \dfrac{(EF_{LPG\,i} \times LPG_{Hot\,water/App\,-\,J})}{2000} \right]}{Ozone_{DAYS}}$$

E_{LPG}	=	Ozone Season Daily emissions from liquid propane gas combustion
$EF_{LPG\,i}$	=	Emission factor for LPG combustion for pollutant i
$LPG_{Space\,Heat\,-\,J}$	=	LPG consumed for space heating in county j
$HDD_{Co\,Oz\,Season}$	=	Number of heating degree days in county for ozone season
$HDD_{Co\,Annual}$	=	Number of heating degree days in county in the calendar year 2002
$LPG_{Hot\,water/App\,-\,J}$	=	LPG consumed for during ozone season by hot water and appliances in county j
$Ozone_{DAYS}$	=	Number of days in the ozone season: 214 Residential; 168 Commercial

Residential LPG Combustion Sample Calculation (Baltimore City) (tons / ozone season day)

Total Residential LPG Consumption – State of Maryland   56,532 kgal

To calculate spatial apportioning factor for Baltimore City:

$$SAF_{BALTIMORE\,CITY} = \frac{HDD_{INVENTORY\,COUNTY} \times NHU_{INVENTORY\,COUNTY}}{\Sigma_{ALL\,COUNTIES\,IN\,STATE} (HDD_{COUNTY} \times NHU_{COUNTY})}$$

$SAF_{BALTIMORE\,CITY}$ =   0.07543338

To calculate kilogallons of liquified petroleum gas (LPG) used in Baltimore County:

Residential $LPG_{BALTIMORE\,CITY}$ = $SAF_{BALTIMORE\,COUNTY}$ x $LPG_{TOTAL\,STATE}$
Residential $LPG_{BALTIMORE\,CITY}$ = 0.07543338 x 56,532
Residential $LPG_{BALTIMORE\,CITY}$ = 4,264.4 kilogallons

LPG used for cooking & appliances in Baltimore City
Residential $LPG_{Hot\,water/App\,-\,J}$ = 25% x $LPG_{BALTIOMORE\,COUNTY}$
Residential $LPG_{Hot\,water/App\,-\,J}$ = 25% x 4,264.4
Residential $LPG_{Hot\,water/App\,-\,J}$ = 1,066.1 kilogallons

LPG used for space heating in Baltimore County
Residential $LPG_{Space\,Heat\,-\,J}$ = 4,264.4 – 1,066.1
Residential $LPG_{Space\,Heat\,-\,J}$ = **3,198.3**

LPG used for space heating in ozone season in Baltimore City

$$\text{Residential Space Heating Fuel}_{\text{PERIOD}} \quad = \quad \text{Space Heating Fuel}_{\text{ANNUAL}} \quad \text{x} \quad \frac{\text{HDD}_{\text{PERIOD}}}{\text{HDD}_{\text{ANNUAL}}}$$

$$\text{Residential Space Heating Fuel}_{\text{PERIOD}} \quad = \quad \mathbf{3{,}198.3} \quad \text{x} \quad \frac{0.00}{3884}$$

$$\text{Residential Space Heating Fuel}_{\text{PERIOD}} \quad = \quad 0.00 \text{ kgal}$$

LPG used for hot water and appliances in ozone season in Baltimore County

$$\text{Residential Hot Water Fuel}_{\text{PERIOD}} \quad = \quad \text{Hot Water Fuel}_{\text{ANNUAL}} \quad \text{x} \quad \frac{\text{Months ozone season}}{\text{Months Year}}$$

$$\text{Residential Hot Water Fuel}_{\text{PERIOD}} \quad = \quad 1{,}066.1 \quad \text{x} \quad \frac{7}{12}$$

$$\text{Residential Hot Water Fuel}_{\text{PERIOD}} \quad = \quad 621.89 \text{ kgal}$$

Equation:

VOC Ozone Season Day Emission Calculation

$$E_{\text{LPG}} \quad = \quad \frac{(\text{EF}_{\text{LPG i}} \text{ x } \text{LPG}_{\text{Space Heat - J}}) + (\text{EF}_{\text{LPG i}} \text{ x } \text{LPG}_{\text{Hot water/App - J}})}{(2000 \text{ x } 214)}$$

$$E_{\text{LPG}} \quad = \quad \frac{(0.5 \text{ x } 0.00) + (0.5 \text{ x } 621.89)}{(2000 \text{ x } 214)}$$

$$E_{\text{LPG}} \quad = \quad \mathbf{0.00073} \text{ tons}_{\text{VOC}} / \text{ Ozone season day}$$

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. This MANE-VU RWC inventory includes emission estimates for indoor wood-burning equipment (e.g. fireplaces, woodstoves, pellet stoves, furnaces/boilers) and outdoor woodburning equipment (e.g. outdoor fireplaces, fire pits, wood-fired barbecues, chimineas).

Pollutants

PM_{10}, SOx, NOx, CO, VOC, and Toxics

**Method and
Data Sources**

The method used to calculate emissions is presented in a study/survey conducted by the Mid-Atlantic Regional Air Management Association (MARAMA), titled "Residential Wood Combustion Emission Inventory."[95]

Activity
In order to improve the RWC inventory for MANE-VU, a survey was developed and implemented in the region. The data sources used to construct the inventory include census tract-level housing data from the 2000 census. At the census tract-level, housing units are broken out into two categories: singlefamily units (including both detached and attached units up to two units) and multi-family units (all other housing units, including mobile homes). In previous technical memoranda, Pechan described the development of these data and the methods used to designate MANE-VU census tracts into one of three categories: urban, suburban, and rural. The rural category was further broken out into forested and non-forested categories.

The survey results were converted to emissions per survey response, and were then used to develop an emissions model for the source category. For indoor wood burning equipment, the survey was designed to obtain information on equipment type. Indoor equipment includes fireplaces, woodstoves (both conventional and certified), furnace/boilers and pellet stoves. However, due to concerns regarding the loss of statistical precision in estimating equipment level emissions, estimates at the equipment level were not made.

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[95] Residential Wood Combustion Emission Inventory, Prepared by E.H. Pechan & Associates, Inc. for the Mid-Atlantic Regional Air Management Association, dated June 22, 2004.

Emissions were estimated at a more general level: outdoor and indoor equipment. Outdoor equipment includes barbeques, fireplaces, fire pits, and chimineas.

During this project, Pechan prepared six technical memoranda (TM) to document different phases of the project. The reader should consult these documents, located on the Mid-Atlantic/Northeast Visibility Union (MANE-VU) website www.mane-vu.org or on the Mid-Atlantic Regional Air Management Association's (MARAMA's) website www.marama.org for details on each component of the project. The technical memoranda and important follow-up notes are as follows:

- TM#1- *MANE-VU Residential Wood Combustion EI Project: Sample Frame Development* – this TM described the development of the sample frame to be used during the project. Note that the sample frame had incorrect values of the number of homes in the MANE-VU Region. This issue was resolved prior to data analysis and inventory development. The correct values are shown in Table 1 below. The total number of MANE-VU single-family households was 12,660,767 and the total number of multi-family units was 12,265,129;
- TM#2 - *MANE-VU Residential Wood Combustion EI Project: Format for Activity Data in the Wood Consumption Model* – This TM described the data formats for developing the wood consumption model from the survey data, including temporal profiles. Note that for indoor equipment, most of the methods were not used since equipment-specific consumption estimates were not used to develop emission estimates (instead, the general linear model presented in TM#5 was used);
- TM#3 - *MANE-VU Residential Wood Combustion EI Project: Pilot Survey and Final Survey Instrument* – This TM provided the results of the pilot survey and the final survey instrument (questionnaire) for the survey);
- TM#4 - *Results of MANE-VU Residential Wood Combustion Activity Survey* – This TM provided statistical summaries of the survey results;
- TM#5 - *MANE-VU Residential Wood Combustion Survey Data Analysis and Emission Inventory Inputs* – this TM provided a description of the methods used to analyze the survey data, the development of activity variables to estimate emissions from indoor and outdoor equipment, and the emission factors to be applied. It was during the review of this TM that a different method was developed to estimate emissions for indoor equipment based on emission estimates constructed from each survey response (instead of estimating equipment level activity, which was originally envisioned for this project). This new method avoided the lowering of statistical precision (error) in the extrapolation of survey data, since individual responses were not divided into multiple equipment types. A description of the development of the general linear model for estimating emissions from indoor equipment was incorporated into the final TM. Outdoor equipment emissions were estimated using a user fraction (UF) and annual consumption (AC) estimate developed from the survey data; and
- TM#6 - *MANE-VU Residential Wood Combustion Emission Inventory* – this TM provided the results of the emission inventory constructed from the number of households in the 2000 Census (no adjustments to reflect 2002 housing changes were made) and the activity variables and emission factors documented in TM#5. During a

153

review of the draft TM#6, reviewers questioned the wood density value used by
Pechan to construct the activity variables in TM#5 (2.1 tons/cord; based on the high
end of the range reported for oak species). Pechan reviewed the primary types of wood
reported by the survey respondents. Oak/hickory was the most popular choice provided
in the survey and very little softwood (e.g., pine, hemlock) was reported. The next most
popular choice was "other hardwood". Pechan developed a weighted estimate of wood
density from the survey responses of 1.8 tons/cord that was used to scale the emission
estimates by a factor of 0.86 (1.8/2.1).

Emission Factors

Emission factors for wood combustion in residential fireplaces are presented in Table 1.9-1
Section 1.9 of *AP-42*. The wood combustion emission factor for PM may be assumed to
represent PM_{10} emissions. Because no emission factors were located for the combustion of
wood for commercial consumption, emission factors for residential fireplaces were used to
estimate commercial emissions.

	NOx (lbs./ton)	CO (lbs./ton)	VOC (lbs./ton)	PM 10 (lbs./ton)	SOx (lbs./ton)
Residential Wood Combustion Emission Factors					
Residential	2.6	252.6	229	34.6	0.4

Point Source Adjustments

No subtration of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

Spatial and Temporal Allocations

Spatial

To produce county-level temporal profiles, the same process used to go from response
level profiles to group-level profiles was used to go from group profiles to county profiles.
Activity or emissions for each census tract were assigned to each temporal unit based on
the tract level temporal profiles. These values were then summed across all tracts in the
county and normalized to give activity fractions.

Temporal

Temporal allocation profiles were also developed for this project using the residential wood survey data. Profiles were first developed for each sample group. Activity (for outdoor equipment) or emissions (for indoor equipment) for each respondent was divided among the different temporal units (e.g., diurnal, weekly, monthly), based on their response to the temporal survey questions. For example, if a respondent reported only burning wood on weekdays, the activity value divided by 5 was assigned to each weekday, with zero activity assigned to Saturday and Sunday. For the diurnal profiles, the survey data indicated whether respondents burned wood in the morning, evening, or both. Since it is unlikely that emissions take place only in the morning and evening hours, activity was allocated to the entire 24-hour period by assigning 75% of morning activity to the hours of 6 a.m. to 12 p.m. and 25% of the morning activity to the hours 12 midnight to 6 p.m. The hours of 6 p.m. to 12 noon were assigned 75% of the evening activity; and 25% of the evening activity went to the hours 12 midnight to 6 a.m.

Once a fraction of the total activity was assigned to each temporal unit for each survey response, the temporal unit activity was summed across all respondents in that sample group. (i.e., survey frame cell; sample groups used for the temporal profiles are the same as those use to develop model parameters.) The resulting activity values were used to calculate activity fractions (i.e., activity for Monday was divided by the sum of activity for Monday through Sunday). The resulting profiles were then assigned to each census tract based on the sample group (survey frame cell).

Monthly Temporal Allocation Files													
FIPS ST	FIPS CNTY	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April
INDOOR EQUIPMENT													
24	001	0.0201	0.0061	0.0053	0.0059	0.0330	0.0703	0.1329	0.1895	0.2107	0.1835	0.1018	0.0408
24	003	0.0300	0.0079	0.0004	0.0004	0.0155	0.0679	0.1351	0.2086	0.2263	0.1826	0.0954	0.0299
24	005	0.0192	0.0051	0.0004	0.0004	0.0154	0.0676	0.1330	0.2111	0.2343	0.1868	0.0997	0.0269
24	009	0.0302	0.0069	0.0003	0.0003	0.0196	0.0821	0.1376	0.1881	0.2271	0.1751	0.0992	0.0336
24	011	0.0411	0.0108	0.0049	0.0049	0.0213	0.0747	0.1464	0.1912	0.1869	0.1594	0.1101	0.0483
24	013	0.0381	0.0096	0.0015	0.0015	0.0197	0.0801	0.1412	0.1878	0.2108	0.1688	0.1021	0.0388
24	015	0.0272	0.0063	0.0012	0.0012	0.0201	0.0792	0.1387	0.1913	0.2234	0.1748	0.1015	0.0349
24	017	0.0264	0.0059	0.0004	0.0004	0.0192	0.0798	0.1365	0.1922	0.2298	0.1773	0.0995	0.0324
24	019	0.0396	0.0104	0.0052	0.0052	0.0214	0.0739	0.1464	0.1923	0.1866	0.1596	0.1109	0.0485
24	021	0.0270	0.0062	0.0003	0.0003	0.0192	0.0807	0.1367	0.1908	0.2296	0.1770	0.0999	0.0324
24	023	0.0135	0.0028	0.0001	0.0001	0.0308	0.0830	0.1328	0.1922	0.2346	0.1795	0.0992	0.0315
24	025	0.0258	0.0059	0.0002	0.0002	0.0186	0.0785	0.1361	0.1942	0.2311	0.1790	0.0991	0.0313
24	027	0.0171	0.0037	0.0002	0.0002	0.0171	0.0728	0.1326	0.2046	0.2397	0.1855	0.0988	0.0275
24	029	0.0354	0.0091	0.0062	0.0062	0.0220	0.0718	0.1465	0.1953	0.1853	0.1591	0.1130	0.0500
24	031	0.0283	0.0084	0.0005	0.0005	0.0132	0.0612	0.1342	0.2179	0.2238	0.1861	0.0978	0.0278
24	033	0.0288	0.0084	0.0005	0.0005	0.0141	0.0642	0.1351	0.2134	0.2234	0.1845	0.0985	0.0286
24	035	0.0420	0.0110	0.0048	0.0048	0.0213	0.0751	0.1465	0.1905	0.1870	0.1592	0.1095	0.0483
24	037	0.0232	0.0050	0.0016	0.0016	0.0203	0.0787	0.1377	0.1930	0.2259	0.1755	0.1026	0.0349

Monthly Temporal Allocation Files												
FIPS ST	**FIPS CNTY**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**April**
24	039	0.0388	0.0102	0.0053	0.0053	0.0214	0.0735	0.1464	0.1929	0.1865	0.1598	0.1115	0.0485
24	041	0.0405	0.0106	0.0050	0.0050	0.0214	0.0744	0.1464	0.1917	0.1867	0.1594	0.1104	0.0485
24	043	0.0282	0.0067	0.0007	0.0007	0.0192	0.0793	0.1377	0.1918	0.2257	0.1761	0.1006	0.0334
24	045	0.0454	0.0122	0.0035	0.0035	0.0200	0.0758	0.1455	0.1900	0.1908	0.1616	0.1063	0.0454
24	047	0.0454	0.0127	0.0016	0.0016	0.0189	0.0790	0.1444	0.1864	0.1981	0.1655	0.1059	0.0405
24	510	0.0155	0.0090	0.0017	0.0017	0.0106	0.0548	0.1384	0.2232	0.2074	0.1892	0.1241	0.0245
OUTDOOR EQUIPMENT												
24	001	0.11361	0.16657	0.20437	0.18379	0.12888	0.05809	0.02881	0.02123	0.01978	0.00000	0.02695	0.02802
24	003	0.13179	0.16662	0.19877	0.17039	0.12977	0.04442	0.02922	0.01872	0.01575	0.00000	0.04004	0.03449
24	005	0.12837	0.16509	0.19193	0.16790	0.12382	0.05275	0.03363	0.02165	0.01721	0.00000	0.03996	0.03403
24	009	0.11321	0.16773	0.21049	0.18790	0.13325	0.05402	0.02540	0.01941	0.01934	0.00000	0.02486	0.02731
24	011	0.10593	0.16687	0.20836	0.19049	0.12970	0.06266	0.02771	0.02177	0.02134	0.00000	0.02094	0.02514
24	013	0.11553	0.16720	0.20701	0.18443	0.13134	0.05428	0.02702	0.01995	0.01907	0.00000	0.02736	0.02840
24	015	0.11000	0.16659	0.20563	0.18655	0.12881	0.06069	0.02865	0.02168	0.02057	0.00000	0.02431	0.02673
24	017	0.11655	0.16681	0.20465	0.18238	0.12990	0.05500	0.02820	0.02045	0.01902	0.00000	0.02871	0.02896
24	019	0.10548	0.16661	0.20714	0.18996	0.12868	0.06400	0.02848	0.02226	0.02157	0.00000	0.02102	0.02511
24	021	0.11607	0.16641	0.20270	0.18141	0.12834	0.05690	0.02938	0.02117	0.01932	0.00000	0.02900	0.02899
24	023	0.10116	0.16661	0.20852	0.19317	0.12850	0.06721	0.02835	0.02284	0.02252	0.00000	0.01790	0.02357
24	025	0.12098	0.16625	0.20030	0.17722	0.12792	0.05386	0.03000	0.02077	0.01831	0.00000	0.03280	0.03082
24	027	0.12475	0.16568	0.19613	0.17253	0.12590	0.05323	0.03180	0.02119	0.01774	0.00000	0.03642	0.03245
24	029	0.10113	0.16672	0.20914	0.19358	0.12895	0.06678	0.02800	0.02265	0.02247	0.00000	0.01770	0.02350
24	031	0.13241	0.16548	0.19262	0.16615	0.12544	0.04830	0.03262	0.02049	0.01614	0.00000	0.04228	0.03528
24	033	0.13175	0.16539	0.19237	0.16636	0.12508	0.04913	0.03286	0.02073	0.01633	0.00000	0.04194	0.03509
24	035	0.10592	0.16713	0.20975	0.19138	0.13071	0.06167	0.02693	0.02135	0.02122	0.00000	0.02051	0.02500
24	037	0.10505	0.16657	0.20711	0.19017	0.12854	0.06444	0.02856	0.02237	0.02168	0.00000	0.02076	0.02497
24	039	0.10571	0.16636	0.20580	0.18898	0.12776	0.06475	0.02920	0.02262	0.02163	0.00000	0.02157	0.02531
24	041	0.10549	0.16682	0.20825	0.19066	0.12950	0.06317	0.02784	0.02191	0.02146	0.00000	0.02069	0.02501
24	043	0.11722	0.16613	0.20092	0.17965	0.12735	0.05707	0.03022	0.02146	0.01919	0.00000	0.03026	0.02953
24	045	0.11599	0.16691	0.20535	0.18312	0.13025	0.05505	0.02790	0.02036	0.01910	0.00000	0.02815	0.02871
24	047	0.12227	0.16445	0.19054	0.17033	0.12113	0.05972	0.03535	0.02351	0.01886	0.00000	0.03655	0.03217
24	510	0.12772	0.16163	0.17411	0.15695	0.11060	0.06637	0.04384	0.02736	0.01896	0.00000	0.04492	0.03553

Weekly Temporal Allocation Files								
FIPS ST	**FIPS CNTY**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
INDOOR EQUIPMENT								
24	001	0.13598	0.13598	0.13598	0.13598	0.13598	0.16005	0.16005
24	003	0.11604	0.11604	0.11604	0.11604	0.11604	0.20989	0.20989
24	005	0.12313	0.12313	0.12313	0.12313	0.12313	0.19219	0.19219
24	009	0.12450	0.12450	0.12450	0.12450	0.12450	0.18875	0.18875
24	011	0.12238	0.12238	0.12238	0.12238	0.12238	0.19406	0.19406

		Weekly Temporal Allocation Files						
FIPS ST	**FIPS CNTY**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
24	013	0.12112	0.12112	0.12112	0.12112	0.12112	0.19719	0.19719
24	015	0.12648	0.12648	0.12648	0.12648	0.12648	0.18380	0.18380
24	017	0.12558	0.12558	0.12558	0.12558	0.12558	0.18605	0.18605
24	019	0.12332	0.12332	0.12332	0.12332	0.12332	0.19169	0.19169
24	021	0.12565	0.12565	0.12565	0.12565	0.12565	0.18588	0.18588
24	023	0.13346	0.13346	0.13346	0.13346	0.13346	0.16634	0.16634
24	025	0.12496	0.12496	0.12496	0.12496	0.12496	0.18760	0.18760
24	027	0.12650	0.12650	0.12650	0.12650	0.12650	0.18374	0.18374
24	029	0.12617	0.12617	0.12617	0.12617	0.12617	0.18458	0.18458
24	031	0.11428	0.11428	0.11428	0.11428	0.11428	0.21429	0.21429
24	033	0.11579	0.11579	0.11579	0.11579	0.11579	0.21053	0.21053
24	035	0.12180	0.12180	0.12180	0.12180	0.12180	0.19549	0.19549
24	037	0.12892	0.12892	0.12892	0.12892	0.12892	0.17769	0.17769
24	039	0.12380	0.12380	0.12380	0.12380	0.12380	0.19051	0.19051
24	041	0.12278	0.12278	0.12278	0.12278	0.12278	0.19305	0.19305
24	043	0.12502	0.12502	0.12502	0.12502	0.12502	0.18744	0.18744
24	045	0.11804	0.11804	0.11804	0.11804	0.11804	0.20490	0.20490
24	047	0.11800	0.11800	0.11800	0.11800	0.11800	0.20500	0.20500
24	510	0.12785	0.12785	0.12785	0.12785	0.12785	0.18038	0.18038
		OUTDOOR EQUIPMENT						
24	001	0.05066	0.05066	0.05066	0.05066	0.05066	0.37335	0.37335
24	003	0.05127	0.05127	0.05127	0.05127	0.05127	0.37182	0.37182
24	005	0.05036	0.05036	0.05036	0.05036	0.05036	0.37410	0.37410
24	009	0.05125	0.05125	0.05125	0.05125	0.05125	0.37187	0.37187
24	011	0.05056	0.05056	0.05056	0.05056	0.05056	0.37359	0.37359
24	013	0.05105	0.05105	0.05105	0.05105	0.05105	0.37237	0.37237
24	015	0.05055	0.05055	0.05055	0.05055	0.05055	0.37362	0.37362
24	017	0.05088	0.05088	0.05088	0.05088	0.05088	0.37280	0.37280
24	019	0.05041	0.05041	0.05041	0.05041	0.05041	0.37397	0.37397
24	021	0.05065	0.05065	0.05065	0.05065	0.05065	0.37337	0.37337
24	023	0.05027	0.05027	0.05027	0.05027	0.05027	0.37432	0.37432
24	025	0.05073	0.05073	0.05073	0.05073	0.05073	0.37318	0.37318
24	027	0.05055	0.05055	0.05055	0.05055	0.05055	0.37363	0.37363
24	029	0.05033	0.05033	0.05033	0.05033	0.05033	0.37417	0.37417
24	031	0.05069	0.05069	0.05069	0.05069	0.05069	0.37327	0.37327
24	033	0.05062	0.05062	0.05062	0.05062	0.05062	0.37344	0.37344
24	035	0.05070	0.05070	0.05070	0.05070	0.05070	0.37324	0.37324
24	037	0.05038	0.05038	0.05038	0.05038	0.05038	0.37405	0.37405
24	039	0.05029	0.05029	0.05029	0.05029	0.05029	0.37427	0.37427
24	041	0.05053	0.05053	0.05053	0.05053	0.05053	0.37369	0.37369
24	043	0.05054	0.05054	0.05054	0.05054	0.05054	0.37364	0.37364
24	045	0.05091	0.05091	0.05091	0.05091	0.05091	0.37272	0.37272
24	047	0.04982	0.04982	0.04982	0.04982	0.04982	0.37544	0.37544
24	510	0.04852	0.04852	0.04852	0.04852	0.04852	0.37871	0.37871

**Emissions
Calculation**

A sample calculation for annual activity is provided below for a specified census tract and SCC:

Activity (tons/yr) = (HUs x UFs x As) + (HUo x UFo x A0) (equation 1)

Where:
      HUs   = single-family housing units;
      UFs   = single-family housing units user fraction for equipment type (SCC);
      As   = single-family housing units annual activity (tons/yr);
      HUo = other housing units;
      UFo = other housing units user fraction for equipment type (SCC); and
      Ao   = other housing units annual activity (tons/yr).

For each SCC, the annual activity can be aggregated from the census tract to the county or state levels using the FIPS code in Table 3a. If, during the analysis of survey data, Pechan finds a good correlation between wood consumption and annual HDD, the activity variable will take the form of tons/HDD-yr (where HDD are annual heating-degree days). The calculation of annual activity for a specified census tract and SCC would take the form shown in equation 2 below:

Activity (tons/yr) = [HUs x UFs x (As x HDD)] + [HUo x UFo x (A0 x HDD)] (equation 2)

Where:
      HUs   = single-family housing units;
      UFs   = single-family housing units user fraction for equipment type (SCC);
      As   = single-family housing units annual activity (tons/HDD-yr);
      HDD = annual heating-degree days for the census tract;
      HUo = other housing units;
      UFo = other housing units user fraction for equipment type (SCC); and
      Ao   = other housing units annual activity (tons/HDD-yr).

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} and $PM_{2.5}$

**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. Adjusted county permit data to equal regional housing start data that was also obtained from the 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. A duration of 12 months was assumed for apartment construction.

159

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.

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 subtration 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
Data for temporal allocation is not available for this source.

**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

$$E_{RC-SFH,\,w\,BM} = \text{Emissions from residential construction} + \text{Emissions from basement excavation}$$

$$E_{RC-SFH,\,w\,BM} = \frac{[HS_{SFH} \times HS_{SFH,w\,BM} \times (AD_{RC-SFH}) \times (PD_{RC-SFH}) \times EF_{RC-SFH}] +}{} \\ \frac{[HS_{SFH} \times HS_{SFH,w\,BM} \times AHS_{RC-SFH} \times ABD_{RC-SFH} \times PDE_{RC-SFH} \times EF_{Acres\text{-}Disturb}]}{2000}$$

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)
$EF_{Acres\text{-}Disturb}$	=	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: 28 10 001 000

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[96]. The national value of construction put in place is allocated to the state level using non-residential building construction employment data within NAIC 2333 obtained from 2002 County Business Patterns[97]. The state value of construction put in place is allocated to the county level using non-residential building construction employment data within NAIC 2333 obtained from the 2002 County Business Patterns[98] for the State of Maryland.

Pollutants

PM_{10} and $PM_{2.5}$

**Method and
Data Sources**

Activity

ARMA used data from the U.S. Census Bureau on the national value of construction put in place. 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 2333 obtained from 2002 County Business Patterns.

A conversion factor of 1.6 acres/10^6 dollars ($) is applied to the construction valuation data. This conversion factor is developed by adjusting the 1992 value of 2 acres/$\$10^6$ to 2002 and 2000 constant dollars using the Price and Cost Indices for Construction. The duration of construction activity for nonresidential construction is estimated to be 11 months.

Employee numbers were taken from County Business Patterns 2002 - Maryland, NAIC 2333, Non-residential Building Construction. Some county employment data is represented by a letter code indicating a range for the number of employees for that SIC. In this case the arithmetic average number of employees per letter code per county was

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[96] Bureau of Census, Table 1. Annual Value of Construction Put in Place in the United States: 1997 – 2001; http://www.census.gov/const/c30/tab101.txt

[97] U.S. Census Bureau, County Business Patterns, 2002 http://censtats.census.gov/cbpnaic/cbpnaic.shtml Select U.S. then 2002 then Compare for the "Construction" Industry then Compary NAIC 2333

[98] U.S. Census Bureau, County Business Patterns, 2002 http://quickfacts.census.gov/qfd/states/24000.html Select county then "Browse more data sets" then County Business Patterns Economic Profile for 2002 – Repeat for each county.

adjusted so that the state total employment in a NAIC matched the sum of the number of employees reported per county.

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 subtration 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
Data for temporal allocation is not available for this source.

Emissions Calculation

$$\text{Value of Construction Work in Maryland} = \text{Value of Construction Work in the U.S.} \times \frac{\text{Number of Employees within NAIC 2333 in Maryland}}{\text{Number of Employees within NAIC 2333 in the U.S.}}$$

Value of Construction Work in the U.S.	$167,084,000,000.00
Number of Employees within NAIC 2333 in the U.S.	855,483

Number of Employees
within NAIC 2333 in   19,267
Maryland

$$\text{Value of Construction Work in Maryland} = \$167,084,000,000.00 \times \frac{19,267}{855,483}$$

$$\text{Value of Construction Work in Maryland} = \$3,763,029,105$$

$$E_{HC\,i} = \frac{HC_j \times CF_{HC} \times EF_{HC\,i} \times DC_{HC}}{365}$$

where:

$E_{HC,i}$	=	Emissions of pollutant i in tons per day from heavy construction
HC_J	=	Value of heavy construction (million dollars) in county j in 2002
CF_{HC}	=	Conversion factor (acres/million dollars) for heavy construction (1.6)
$EF_{HC\,i}$	=	Emissions factor in tons per acre per month for pollutant i
DC_{HC}	=	Duration of construction activity (11 months)

<u>2002 Sample Calculation Heavy Construction (Anne Arundel County)</u>

$$E_{HC\,i} = \frac{HC_j \times CF_{HC} \times EF_{HC\,i} \times DC_{HC}}{365}$$

$$E_{HC\,i} = \frac{196.68 \times 1.6 \times 0.11(PM_{10}) \times 11}{365}$$

$$E_{HC\,i} = \textbf{1.04} \text{ tons/day } PM_{10}$$

4.1.7.3 Road Construction Activity

SCC: 28 10 001 000

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) State expenditure data for capital outlay according to the following six classifications was obtained:
- Interstate, urban;
- Interstate, rural;
- Other arterial, urban;
- Other arterial, rural;
- Collectors, urban; and
- Collectors, rural

Dollar expenditures are converted to miles contructed using data obtained from the North Carolina Department of Transportation (NCDOT) on the $/mile spent on various road construction projects. For interstate expenditures, used an average of $4 million/mile corresponding to freeways and interstate projects listed for: 1) new location; 2) widen existing 2-lane shoulder section; and 3) widen existing 4-lane w/ median. For expenditures on other arterial and collectors, used an average of $1.9 million/mile corresponding to all other projects (excluding freeways and interstate projects) listed for: 1) new location; 2) widen existing 2-lane shoulder section; and 3) widen existing 4-lane w/ median.

Miles are converted to acres for each of the 6 road types using the following estimates of acres disturbed per mile:
- Interstate, urban and rural; Other arterial, urban - 15.2 acres/mile
- Other arterial, rural - 12.7 acres/mile
- Collectors, urban - 9.8 acres/mile
- Collectors, rural - 7.9 acres/mile

166

Emission Factors

An 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 0.20 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. County-level dry silt values were applied to PM_{10} emissions for each county..

Point Source Adjustments

No subtration 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.

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

Data for temporal allocation is not available for this source.

**Emissions
Calculation**

$$E_{RC,\,i} \quad = \quad \frac{Exp \times MC_i \times ADi \times EF_{RC\,i} \times DUR}{2000 \times 365}$$

where:

$E_{RC,i}$	=	Emissions of pollutant i in tons per day from road construction
$Exp_{RC,i}$	=	Expenditures per road type i
$MC_{RC,i}$	=	Miles contructed 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)

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 discing, 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:

$$\text{Emissions}_{CROP} = \text{Emission Factor} \ \text{x} \ \text{Acres}_{CROP} \ \text{x} \ \text{Acre-passes/acre}_{CROP}$$

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 Maryland Cooperative Extension Service and the Maryland Agricultural Statistics Service. A summary of crop acreage harvested in 2002 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 harvest, or closer to planting, and can include discing, 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. **Table 3.4-a Summary of Crop Acre-Passes**, presented in Section 3.4, provides a listing of the crop acre-passes used in California.

Emission Factors

The emission factor used to estimate the dust emissions from agricultural land preparations is from U.S. EPA's AP-42[99]. 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 judgement. During December and March, California ARB reduced the emission factor by

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[99] U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, AP-42, Section 11.2.2, Fourth Edition. September 1985.

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.

Precipitation data for calendar year 2002 in Maryland is presented in Section 3.4, **Table 3.4-b 2002 Precipitation Data**, since Maryland does not have a correlation between soil moisture and emissions, the emission factors were not redacted.

Point Source Adjustments

No subtration 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

$$E_{ALP\,i} = \frac{EF_{ALP\,i} \mathbf{x} A_I \mathbf{x} AP_I}{2000}$$

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 2002

AP_i = Acre-passes per acres for crop i

2002 Sample Calculation Agricultural Land Preparation (Anne Arundel County)

$$E_{ALP\,PM2.5} = \frac{EF_{ALP\,PM2.5} \mathbf{x} [(A_{wheat} \mathbf{x} AP_{wheat}) + (A_{corn\text{-}gr} \mathbf{x} AP_{corn\text{-}gr}) + (A_{corn\text{-}silage} \mathbf{x} AP_{corn\text{-}silage}) + (A_{hay} \mathbf{x} AP_{hay}) + (A_{soy} \mathbf{x} AP_{soy}) + (A_{barley} \mathbf{x} AP_{barley}) + (A_{tobacco} \mathbf{x} AP_{tobacco})]}{2000}$$

$$E_{ALP\,PM2.5} = \frac{1.141968254 \times [(2500 \mathbf{x} 1) + (5700 \mathbf{x} 4) + (0 \mathbf{x} 4) + (3100 \mathbf{x} 1) + (5200 \mathbf{x} 6) + (175 \mathbf{x} 1) + (100 \mathbf{x} 0)]}{2000}$$

$$E_{ALP\,PM2.5} = \frac{1.141968254 \times 60475}{2000}$$

$E_{ALP\,PM2.5}$ = **34.530** tons per year of $PM_{2.5}$

4.1.7.5 Paved Roads

Description

This source category covers fugitive dust emissions from activity on paved roads.

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

The emission factor for paved roads is calculated from an empirical formula from AP-42 and then is adjusted for precipitation.

AP-42 Paved Roads Emission Factor Formula

$$EF_{PAVED\ RD} =\ PSDPVD\ x\ (PVSILT/2)^{0.65}\ x\ (WEIGHT/3)^{1.5}$$

where:

$EF_{PAVED\ RD}$	Paved road dust emission factor for all vehicle classes combined (grams per mile)
PSDPVD	Base emission factor for particles of less than 10 microns in diameter from paved road dust (default value = 7.3 grams PM_{10} per mile)
PVSILT	Road surface silt loading factor in grams per square mile
WEIGHT	Average weight of all vehicle types combined in tons

And where:
PVSILT varies by road type and the average daily traffic volume (ADTV) that has been assigned the default values presented below:

Road Surface Silt Loading Constants	ADTV < 500 gram/mile ^{2}	ADTV 500 - 5,000 gram/mile ^{2}	ADTV 5,000 – 10,000 gram/mile ^{2}	ADTV > 10,000 gram/mile ^{2}
PVSILT	0.60	0.20	0.06	0.03

WEIGHT   An average default value of 6,360 pounds (3.19 tons) has been assigned for all vehicles.

Calculate Paved Roads Emission Factors

$EF_{\text{PAVED-LOCAL} < 500} = [\text{PSDPVD} \times (\text{PVSILT}/2)^{0.65} \times (\text{WEIGHT}/3)^{1.5}] - C$

$EF_{\text{PAVED-LOCAL} < 500} = [7.3 \times (0.60/2)^{0.65} \times (3.18/3)^{1.5}] - 0.2119$

$EF_{\text{PAVED-LOCAL} < 500} = 3.430692 \text{ gram/mile}^2$

$EF_{\text{PAVED\_ADTV } 500 - 5000} = [\text{PSDPVD} \times (\text{PVSILT}/2)^{0.65} \times (\text{WEIGHT}/3)^{1.5}] - C$

$EF_{\text{PAVED\_ADTV } 500 - 5000} = [7.3 \times (0.2/2)^{0.65} \times (3.18/3)^{1.5}] - 0.2119$

$EF_{\text{PAVED\_ADTV } 500 - 5000} = 1.571635 \text{ gram/mile}^2$

$EF_{\text{PAVED\_ADTV } 5000 - 10,000} = [\text{PSDPVD} \times (\text{PVSILT}/2)^{0.65} \times (\text{WEIGHT}/3)^{1.5}] - C$

$EF_{\text{PAVED\_ADTV } 5000 - 10,000} = [7.3 \times (0.06/2)^{0.65} \times (3.18/3)^{1.5}] - 0.2119$

$EF_{\text{PAVED\_ADTV } 5000 - 10,000} = 0.603575 \text{ gram/mile}^2$

$EF_{\text{PAVED\_ADTV } >10000} = [\text{PSDPVD} \times (\text{PVSILT}/2)^{0.65} \times (\text{WEIGHT}/3)^{1.5}] - C$

$EF_{\text{PAVED\_ADTV } >10000} = [7.3 \times (0.03/2)^{0.65} \times (3.18/3)^{1.5}] - 0.2119$

$EF_{\text{PAVED\_ADTV } >10000} = 0.307786 \text{ gram/mile}^2$

Adjust Emission Factor for Precipitation

$EF_{\text{PAVED ADJ}} = EF_{\text{PAVED}} \times CF_{\text{RAIN}}$

Where:

$EF_{\text{PAVED ADJ}}$	=	Adjusted Paved Road Emission Factor (grams/mile)
EF_{PAVED}	=	PM size-specific emission factor (grams/mile) for paved roads
CF_{RAIN}	=	Correction Factor for Rain/Precipitation

And Where:

$$CF_{RAIN} = 1 - (P / 4N)$$

Where:

CF_{RAIN} =   Correction Factor for Rain/Precipitation

p =   number of days in a given month with greater than 0.01 inches of rainfall (data collected from monthly climatological data files from National Weather Service stations near or in the county of reference.)

N=   number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly).

MDE altered the precipitation adjustment equation by collecting data on the number of days in a given *year* that greater than 0.01 inches of rainfall fell and removing the x 12 from the equation.

$$CF_{RAIN} = 1 - (104 / (4 \times 365))$$

$$CF_{RAIN} = 0.928767$$

Calculate Paved Roads Emission Factors Adjusted for Precipitation

$EF_{PAVED-LOCAL < 500\ ADJ}$ = EF_{PAVED_LOCAL} x CF_{RAIN}

$EF_{PAVED-LOCAL < 500\ ADJ}$ =   3.430692 x 0.928767

$EF_{PAVED-LOCAL < 500\ ADJ}$ =   **3.186314** gram/mile ^{2}

$EF_{PAVED\_ADTV\ 500 - 5000\ ADJ}$ = EF_{PAVED_LOCAL} x CF_{RAIN}

$EF_{PAVED\_ADTV\ 500 - 5000\ ADJ}$ =   1.571635 x 0.928767

$EF_{PAVED\_ADTV\ 500 - 5000\ ADJ}$ =   **1.459683** gram/mile ^{2}

$EF_{PAVED\_ADTV\ 5000- 10,000\ ADJ}$ = EF_{PAVED_LOCAL} x CF_{RAIN}

$EF_{PAVED\_ADTV\ 5000- 10,000\ ADJ}$ =   0.603575 x 0.928767

$EF_{PAVED\_ADTV\ 5000- 10,000\ ADJ}$ =   **0.560581** gram/mile ^{2}

$EF_{PAVED\_ADTV >10,000\ ADJ}$ = EF_{PAVED_LOCAL} x CF_{RAIN}

$EF_{PAVED\_ADTV >10,000\ ADJ}$ =   0.310239 x 0.928767

$EF_{PAVED\_ADTV >10,000\ ADJ}$ =   **0.285861** gram/mile ^{2}

Equation:

$$EM_{PAVED\ RD,\ i} = \sum (VMT_{ADTV,\ i} \times EF_{PAVED\_ADTV\ ADJ,\ i} \times (1 - CE \times RE \times RP) \times 1.10231E\text{-}06)$$

where:

EM $_{PAVED\ RD}$,i $\quad$ = Sum of PM$_{10}$ emissions in tons per year for paved roads in county i
VMT ,i $\quad\quad\quad$ = VMT (million miles of Vehicle Miles Traveled for county i)
EF $_{PAVED\_ADTV\ ADJ,\ i}$ = Paved road emission factor adjusted for precipitation in county I
$\quad\quad\quad\quad\quad\quad$ (grams/mile)

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
1 gram = 1.10231E-06 tons

2002 Sample Calculation Paved Roads (Anne Arundel County)

$$EM_{PAVED\ RD,\ i} = [(VMT\_{ADTV < 500,}i \times EF_{PAVED\text{-}LOCAL < 500\ ADJ}) + (VMT\_{ADTV\ 500\ \text{-}\ 5000,}i \times EF_{PAVED\_ADTV\ 500\ \text{-}\ 5000\ ADJ}) + (VMT\_{ADTV\ 5000\ \text{--}\ 10,000,}i \times EF_{PAVED\_ADTV\ 5000\text{-}\ 10,000\ ADJ}) + (VMT\_{ADTV > 10,000,}i \times EF_{PAVED\_ADTV > 10,000\ ADJ})] \times (1 - CE \times RE \times RP) \times 1.10231E\text{-}06$$

$$EM_{PAVED\ RD,\ i} = [(355524175 \times 3.186314) + (167099106 \times 1.459683) + (279697255 \times 0.560581) + (4.64E+09 \times 0.285861)] \times (1 - 0 \times 1 \times 1) \times 1.10231E\text{-}06$$

EM $_{PAVED\ RD,\ i}$ = 3,152.509 tons per year of PM $_{10}$ or (3,152.509 / 365) = 8.64 tons per day of PM $_{10}$

4.1.7.6   Unpaved Roads

SCC: 22 96 000 000

<u>Description</u>

This source category covers fugitive dust emissions from activity on unpaved roads.
The activity data needed to calculate emissions from unpaved roads was not available. Methods are still being researched as to how to properly gather this data. MDE cannot submit any emissions for this source category at the present time.

4.1.8   FIRE 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.

4.1.8.1   Vehicle Fires

SCC: 28 10 001 000

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)[100]. 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)[101]. Maryland used a more conservative assumption based on a 2,000 pound average vehicle weight.

Pollutant	Lbs/ton burned

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[100] 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
[101] CARB. 1995. Emission Inventory Procedural Manual, Vol. III: Methods for Assessing Area Source Emissions. California Environmental Protection Agency: Air Resources Board.

VOC	32
NOx	4
CO	125
PM10-PRI	100

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
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
Data for temporal allocation is not available for this source.

Emissions Calculation

$$E_{VF,i} = \frac{VB_j \text{ x } FLF_{VF} \text{ x } EF_{VF\,i}}{2000 \text{ x } 365}$$

where:

$E_{VF,i}$	=	Emissions of pollutant i in tons per day from vehicle fires
VB_J	=	Vehicles burned in county j in 2002
FLF_{VF}	=	Fuel loading factor (tons/vehicle burned) for vehicle fires (500 lbs/2000 lb auto)
$EF_{VF\,i}$	=	Emissions factor in pounds per ton burned for pollutant i

2002 Sample Calculation Forest Fires (Anne Arundel County)

$$E_{VF,i} = \frac{VB_j \text{ x } FLF_{VF} \text{ x } EF_{VF,I}}{2000 \text{ x } 365}$$

$$E_{VF,i} = \frac{500 \text{ x } (500/2000) \text{ x } 4}{2000 \text{ x } 365}$$

$E_{VF,i}$ = 0.0007 tons NOx per day emitted from vehicle fires in Anne Arundel County in 20002

179

4.1.8.2 Forest Fires

SCC: 28 10 001 000

Description

Forest fires in certain rural areas can produce very large, short term organic emissions.

Pollutants

PM_{10} and $PM_{2.5}$

**Method and
Data Sources**

Activity
ARMA used data from the Maryland Forest, Park and Wildlife Service[102] on the number of fires and acreage burned per county. Emission factors were obtained from AP-42, Table 13.1-2. A fuel loading factor (tons of growth burned per acre) of 11 tons/acre was obtained from Table 13.1-1 (Eastern Region) of AP-42 Wildfires and Prescribed Burning, October 1996. An activity level of 7 days a week from Procedures, Table 5.8-1 was used. The 2002 fire data from the Forest, Park and Wildlife Service showed no apparent increase in number or size of forest fires in the ozone season, thus no seasonal adjustment was used.

Emission Factors

	VOC (Lbs./ton)	NOx (Lbs./ton)	CO (Lbs./ton)	PM TOT (Lbs./ton)
Emissions	24.0	4.0	140.0	17.0
Fuel loading factor:	11.0	Tons/acre burned		

**Point Source
Adjustments**

No subtration of emissions from point sources is necessary.

**Adjustments
for Controls**

No controls are available for this source category.

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[102] Forest fire data collected from Mr. Bob Hartlove, Acting Fire Supervisor for the Maryland Forest Service

Spatial and Temporal Allocations

Spatial
The activity data for forest fires was collected at a county-level. No other method to spatially profile the forest fire source category was used.

Temporal
Data for temporal allocation is not available for this source.

Emissions Calculation

$$E_{FF\,I} = \frac{AB_j \text{ x } EF_{FF\,i} \text{ x } FLF_{FF}}{2000 \text{ x } 365}$$

where:
$E_{FF,i}$	=	Emissions of pollutant i in tons per day from forest fires
FLF_{FF}	=	Fuel loading factor (tons/acre burned) for forest fires (11.0)
AB_J	=	Acres burned by wildfire in county j in 2002
$EF_{FF\,i}$	=	Emissions factor in pounds per acre or pounds per ton for pollutant i

<u>2002 Sample Calculation Forest Fires (Anne Arundel County)</u>

$$E_{FF\,i} = \frac{AB_j \text{ x } EF_{f,i} \text{ x } FLF_{FF}}{2000 \text{ x } 365}$$

where:

$E_{FF\,i}$ [105] $=$ (0.3 acres burned [103] **x** 11 tons per acre [104] **x** 24.0 lbs. $_{VOC}$ per ton) / (2000 x 365)

$E_{FF\,i}$ $=$ **0.0001** tons per day of $_{VOC}$ emitted from forest fires in Anne Arundel County in 2002

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[103] Number of acres burned by wildfire in Anne Arundel County in 2002 from Maryland Forest, Parks and Wildlife Service .
[104] Fuel loading factor from AP-42, Table 13.1-1.
[105] Emission factor from AP-42, Table 13.1-2.

4.1.8.3 Slash/Prescribed Burning

SCC: 28 10 015 000 (prescribed burn)
SCC: 28 10 005 000 (slash burn)

Description

Waste from logging operations is often burned under controlled conditions to reduce the potential fire hazard in forests and to remove brush that can serve as a host for destructive insects. Prescribed burning is used as a forest management practice to establish favorable seedbeds, remove competing underbrush, accelerate nutrient cycling, control tree pests and contribute other ecological benefits.

Pollutants

PM_{10} and $PM_{2.5}$

**Method and
Data Sources**

Activity

Emissions from this source were calculated using data from the Maryland Forest Service for prescribed burning by county and type of material burned. Emission and fuel loading factors for marsh grass was assumed to be the same as that for unspecified field crops in AP-42, Table 2.5-5, and the factor for pine was supplied by staff at the Maryland Forest Service.

Emission Factor

	VOC (Lbs./ton)	CO (Lbs./ton)	NOx (Lbs./ton)	PM TOT (Lbs./ton)
Marsh Grass				
Emissions Factors	18.0	117.0	NA	21.0
Fuel loading factor	2.0 tons/acre			
Pine Slash				
Emission factor	19.0	140.0	4.0	17.0
Fuel loading factor:	30.0 tons/acre			

**Point Source
Adjustments**

No subtration of emissions from point sources is necessary.

**Adjustments
for Controls**

No controls are available for this source category.

**Spatial and
Temporal
Allocations**

Spatial
The activity data for prescribed burning was collected at a county-level. No other method to spatially profile the prescribed burning source category was used.

Temporal
Because prescribed burning is done at different times of the year, ARMA used no seasonal adjustment factor. The activity level is seven days per week.

**Emissions
Calculation**

$$E_{PB\ i} = \frac{AB_j \text{ x } EF_{PB\ i} \text{ x } FLF_J}{2000 \text{ x } 365}$$

where:
$E_{PB,i}$ = Emissions of pollutant i in tons per day from prescribed burning
FLF_J = Fuel loading factor for type of material burned j (for marsh grass the factor is 2
tons per acre and for pine slash it is 30 tons per acre burned)
AB_J = Acres burned in county j in 2002
$EF_{PB,i}$ = Emission factor for pollutant k

2002 Sample Calculation Slash/Prescribed Burning (Worcester County)

$$E_{PB\ i} = \frac{AB_j \text{ x } EF_{PB\ i} \text{ x } FLF_J}{2000 \text{ x } 365}$$

$$E_{PB\ i} = \frac{(20 \text{ acres of pine slash burned x 19 lbs. }_{VOC} \text{ per ton x 30 tons per acre burned})}{2000 \text{ x } 365}$$

$$E_{PB\ i} = 0.016 \text{ tons VOC /day}$$

Slash burning calculations are done in a similar manner.

4.1.8.4 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 2002 did not require information distinguishing the amount of agricultural waste to be burned versus other materials.

4.1.8.5 Structure Fires

SCC: 28 10 030 000

Description

Building fires produce short-term emissions of organic compounds.

Pollutants

PM_{10} and $PM_{2.5}$

**Method and
Data Sources**

MDE staff used emission factors, fuel loading factors and methodology documented in EIIP[106], Structure Fires, dated July 1999.

Activity
The Maryland State Fire Marshal's office provided the number of structure fires by county.

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[106] Emission Inventory Improvement Program

Emission Factors

	VOC (Lbs./ton)	NOx (Lbs./ton)	CO (Lbs./ton)	PM $_{TOT}$ (Lbs./ton)
Emissions	11.0	1.4	60.0	10.8
Fuel loading factor:	1.15	Tons/fire		

Point Source Adjustments

No subtration of emissions from point sources is necessary.

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, ARMA used no seasonal adjustment factor. The activity level is seven days per week.

Emissions Calculation

$$E_{SF\,i} = \frac{SF_j \textbf{ x } EF_{SF\,i} \textbf{ x } FLF_{SF}}{2000 \textbf{ x } 365}$$

where:

$E_{FF,i}$ =   Emissions of pollutant i in tons per day from structure fires

FLF_{FF} =   Fuel loading factor (tons/acre burned) for structure fires

SF_J =   Structure fires in county j in 2002

186

EF $_{SF,i}$ =   Emission factor for pollutant i in tons per day from structure fires

ARMA used an activity level of 7 days a week with no seasonal variation as given in Table 5.8-1 in the EIIP document.

2002 Sample Calculation Structure Fires (Baltimore City)

Equation:

$$E_{SF\,i} = \frac{SF_j \times EF_{SF\,i} \times FLF_{SF}}{2000 \times 365}$$

$$E_{SF\,i} = \frac{2386^{107} \times 11^{108} \times 1.15}{2000 \times 365}^{109}$$

$$E_{SF\,i} = 0.0413 \text{ tons }_{VOC} / \text{ day}$$

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[107] Number of structure fires in Baltimore City in 2002 from Maryland State Fire Marshal's Office .
[108] Emission factor from EIIP Structure Fires.
[109] Fuel loading factor from EIIP Structure Fires

4.1.8.6 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 2002 baseline inventory.

4.1.9 AMMONIA SOURCES

Ammonia (NH_3) is a pungent colorless gaseous compound of nitrogen and hydrogen that is very soluble in water and can be condensed into a liquid by cold and pressure. Ammonia gas reacts in the atmosphere with NOx or SOx to produce ammonium nitrate or ammonium sulfate, major $PM_{2.5}$ components in the United States.

In preparing an ammonia inventory, it is worthwhile to prioritize which of the many potential ammonia sources should receive attention. Previous studies conducted by Battye [110] and the State of California Air Resources Bureau (CARB), provide lists of ammonia sources that can be used to evaluate which sources are present within a region. These sources may then be ranked in terms of priority for estimating emissions.

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.

This section contains the ammonia emission inventory for
- Agricultural Livestock Production Operations
- Agricultural Fertilizer Application,
- Human activity.

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[110] Battye, R., Battye, W., C. Overcash, C., Fudge, S., 1994. *Development and Selection of Ammonia Emission Factors, Final Report.* EC/R Incorporated for U.S. EPA, EPA/600/R-94/190 (Prepared for William Benjey).

4.1.9.1 Cows (Milk Cows, Beef Cows, Heifers, and Steers)

SCC: 28 05 020 000 (Cows Composite)

Description

These animals, and all livestock, are sources of ammonia emissions due to the biological decomposition of their waste products

Pollutants

NH_3

**Method and
Data Sources**

Conceptually, the method for estimating emissions from cattle is simple: count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU-NH3 Inventory (version 2.0) program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories

Activity
Activity levels were collected from the USDA Census of Agriculture data for 1997.

Emission Factors

Emission factors were collected from a paper published by Battye,[110] et al. in 1994 and are presented in the table below:

Emission Factors and Source

Livestock Category	Emission Factor	Source of Emission Factor
Milk cows	39.72 Kg/ cow/ year	Battye, et al. (1994)
Beef cows	39.72 Kg/ cow/ year	Battye, et al. (1994)
Heifers	9.67 Kg/ heifer/ year	Battye, et al. (1994)
Steers	11.65 Kg/ steer/ year	Battye, et al. (1994)

**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**

190

Spatial
The activity data was collected at a county-level. No other method to spatially profile the source category was used.

Temporal
Data for temporal allocation is not available for this source.

Emissions Calculation

Equation:

1999 TPY ammonia emissions for cows in an individual county

$$EM_{COWS\text{-}99\ Total} = 1999\ EM_{BC} + 1999\ EM_{MC} + 1999\ EM_{HF} + 1999\ EM_{ST}$$

Where:
$EM_{COWS\text{-}99\ Total}$ = Total NH3 emissions from cows, all categories
$\quad$ EM_{BC} = 1999 Uncontrolled emissions from beef cows
$\quad$ EM_{MC} = 1999 Uncontrolled emissions from milk cows
$\quad$ EM_{HF} = 1999 Uncontrolled emissions from heifers
$\quad$ EM_{ST} = 1999 Uncontrolled emissions from steers

$\quad$ Where:
$\qquad$ EM_{BC} = $(AC_{BC} * EF_{BC})$
$\qquad$ EM_{MC} = $(AC_{BC} * EF_{MC})$
$\qquad$ EM_{HF} = $(AC_{BC} * EF_{HF})$
$\qquad$ EM_{ST} = $(AC_{BC} * EF_{ST})$

$\quad$ Where:
$\qquad$ AC_{BC} = Activity level (number) of beef cows
$\qquad$ AC_{MC} = Activity level (number) of milk cows
$\qquad$ AC_{HF} = Activity level (number) of heifers
$\qquad$ AC_{ST} = Activity level (number) of steers
$\qquad$ EF_{BC} = Emission factor for beef cows
$\qquad$ EF_{MC} = Emission factor for milk cows
$\qquad$ EF_{HF} = Emission factor for heifers
$\qquad$ EF_{ST} = Emission factor for steers

4.1.9.2 Hogs and Pigs

SCC: 28 05 025 000 (Swine Composite)

Description

These animals, and all livestock, are sources of ammonia emissions due to the biological decomposition of their waste products.

Pollutants

NH_3

**Method and
Data Sources**

Conceptually, the method for estimating emissions from cattle is simple: count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU-NH3 Inventory (version 2.0) program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories

Activity
Activity levels were collected from the USDA Census of Agriculture data for 1997.

Emission Factors

Emission factors were collected from a paper published by Battye,[110] et al. in 1994 and are presented in the table below:

Emission Factors and Source		
Livestock Category	Emission Factor	Source of Emission Factor
Hogs	9.2 Kg/ hog/ year	Battye, et al. (1994)
Pigs	9.2 Kg/ pig/ year	Battye, et al. (1994)
Steers	11.65 Kg/ steer/ year	Battye, et al. (1994)

**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

The activity data was collected at a county-level. No other method to spatially profile the source category was used.

Temporal

Data for temporal allocation is not available for this source.

Emissions Calculation

Equation:

1999 TPY ammonia emissions for swine in an individual county

$$EM_{\text{SWINE-99 Total}} = 1999\ EM_{HOGS} + 1999\ EM_{PIGS}$$

Where:

$EM_{\text{SWINE-99 Total}}$ = Total NH3 emissions from swine, all categories
EM_{HOGS} = 1999 Uncontrolled emissions from hogs
EM_{PIGS} = 1999 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

4.1.9.3 Chickens   (Pullets, Layers, and Broilers)

SCC: 28 05 030 000 (Chickens Composite)

Description

These animals, and all livestock, are sources of ammonia emissions due to the biological decomposition of their waste products.

Pollutants

NH_3

**Method and
Data Sources**

Conceptually, the method for estimating emissions from cattle is simple: count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU-NH3 Inventory (version 2.0) program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories

Activity
Activity levels were collected from the USDA Census of Agriculture data for 1997.

Emission Factors

Emission factors were collected from a paper published by Battye,[110] et al. in 1994 and are presented in the table below:

Emission Factors and Source

Livestock Category	Emission Factor	Source of Emission Factor
Pullets	0.269 Kg/ pullet/ year	Battye, et al. (1994)
Layers	0.598 Kg/ layer/ year	Battye, et al. (1994)
Broilers	0.167 Kg/ broiler/ year	Battye, et al. (1994)

**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

The activity data was collected at a county-level. No other method to spatially profile the source category was used.

Temporal

Data for temporal allocation is not available for this source.

Emissions Calculation

Equation:

1999 TPY ammonia emissions for chickens in an individual county

$EM_{CHICKENS\text{-}99\ Total} =$ 1999 EM_{PULLET} + 1999 EM_{LAYER} + 1999 $EM_{BROILER}$

Where:

$EM_{CHICKENS\text{-}99\ Total}$ = Total NH3 emissions from chickens, all categories
EM_{PULLET} = 1999 Uncontrolled emissions from pullets
EM_{LAYER} = 1999 Uncontrolled emissions from layers
$EM_{BROILER}$ = 1999 Uncontrolled emissions from broilers

Where:

$EM_{PULLET} = (AC_{PULLET} * EF_{PULLET})$
$EM_{LAYER} = (AC_{LAYER} * EF_{LAYER})$
$EM_{BROILER} = (AC_{BROILER} * EF_{BROILER})$

Where:

AC_{PULLET} = Activity level (number) of pullet chickens
AC_{LAYER} = Activity level (number) of layer chickens
$AC_{BROILER}$ = Activity level (number) of broiler chickens
EF_{PULLET} = Emission factor for pullet chickens
EF_{LAYER} = Emission factor for layer chickens
$EF_{BROILER}$ = Emission factor for broiler chickens

4.1.9.4   Sheep

Description

These animals, and all livestock, are sources of ammonia emissions due to the biological decomposition of their waste products.

Pollutants

NH_3

**Method and
Data Sources**

Conceptually, the method for estimating emissions from cattle is simple: count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU-NH3 Inventory (version 2.0) program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories

Activity
Activity levels were collected from the USDA Census of Agriculture data for 1997.

Emission Factors

Emission factors were collected from a paper published by Battye,[110] et al. in 1994 and are presented in the table below:

Emission Factors and Source

Livestock Category	Emission Factor	Source of Emission Factor
Sheep	3.37 Kg/ sheep/ year	Battye, et al. (1994)

**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

The activity data was collected at a county-level. No other method to spatially profile the source category was used.

Temporal

Data for temporal allocation is not available for this source.

Emissions Calculation

Equation:

1999 TPY ammonia emissions for sheep in an individual county

$$EM_{SHEEP} = AC_{SHEEP} * EF_{SHEEP}$$

Where:
EM_{SHEEP} = Total NH3 emissions from sheep, all categories
AC_{SHEEP} = Activity level (number) of sheep
EF_{SHEEP} = Emission factor for sheep

4.1.9.5 Goats (Angora and Milk)

SCC: 28 05 045 001(Goats Composite)

Description

These animals, and all livestock, are sources of ammonia emissions due to the biological decomposition of their waste products.

Pollutants

NH_3

Method and Data Sources

Conceptually, the method for estimating emissions from cattle is simple: count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU-NH3 Inventory (version 2.0) program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories

Activity
Activity levels were collected from the USDA Census of Agriculture data for 1997.

Emission Factors

Emission factors were collected from a paper published by Battye,[110] et al. in 1994 and are presented in the table below:

<div align="center">

Emission Factors and Source

Livestock Category	Emission Factor	Source of Emission Factor
Angora goats	2.2 Kg/ goat/ year	Battye, et al. (1994)
Milk goats	2.2 Kg/ goat/ year	Battye, et al. (1994)

</div>

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

The activity data was collected at a county-level. No other method to spatially profile the source category was used.

Temporal

Data for temporal allocation is not available for this source.

**Emissions
Calculation**

Equation:

1999 TPY ammonia emissions for goats in an individual county

$$EM_{\text{GOATS-99 Total}} = 1999\ EM_{AG} + 1999\ EM_{MG}$$

Where:

$EM_{\text{GOATS-99 Total}}$ = Total NH3 emissions from goats, all categories
EM_{AG} = 1999 Uncontrolled emissions from angora goats
EM_{MG} = 1999 Uncontrolled emissions from milk goats

Where:

$$EM_{AG} = (AC_{AG} * EF_{AG})$$
$$EM_{MG} = (AC_{AG} * EF_{AG})$$

Where:

AC_{AG} = Activity level (number) of angora goats
AC_{MG} = Activity level (number) of milk goats
EF_{AG} = Emission factor for angora goats
EF_{MG} = Emission factor for milk goats

4.1.9.6 Horses

Description

These animals, and all livestock, are sources of ammonia emissions due to the biological decomposition of their waste products.

Pollutants

NH_3

**Method and
Data Sources**

Conceptually, the method for estimating emissions from cattle is simple: count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU-NH3 Inventory (version 2.0) program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories

Activity
Activity levels were collected from the USDA Census of Agriculture data for 1997.

Emission Factors

Emission factors were collected from a paper published by Battye,[110] et al. in 1994 and are presented in the table below:

<div align="center">

Emission Factors and Source

Livestock Category	Emission Factor	Source of Emission Factor
Horses	12.2 Kg/ horse/ year	Battye, et al. (1994)

</div>

**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
The activity data was collected at a county-level. No other method to spatially profile the source category was used.

Temporal
Data for temporal allocation is not available for this source.

**Emissions
Calculation**

<u>Equation:</u>

<u>1999 TPY ammonia emissions for horses in an individual county</u>

$$EM_{HORSE} = AC_{HORSE} * EF_{HORSE}$$

Where:
EM_{HORSE} = Total NH3 emissions from horses, all categories
AC_{HORSE} = Activity level (number) of horses
EF_{HORSE} = Emission factor for horses

4.1.9.7 Ducks, Geese and Turkeys

<div style="text-align: right">

SCC: 28 05 035 001 (Ducks)
SCC: 28 05 035 002 (Turkeys)
SCC: 28 05 035 003 (Geese)

</div>

Description

These animals, and all livestock, are sources of ammonia emissions due to the biological decomposition of their waste products.

Pollutants

NH_3

**Method and
Data Sources**

Conceptually, the method for estimating emissions from cattle is simple: count the number of animals, then multiply this by the average emissions per animal, and the resulting value provides the emissions. The CMU-NH3 Inventory (version 2.0) program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories

Activity
Activity levels were collected from the USDA Census of Agriculture data for 1997.

Emission Factors

Emission factors were collected from a paper published by Battye,[110] et al. in 1994 and are presented in the table below:

<div style="text-align: center">Emission Factors and Source</div>

Livestock Category	Emission Factor	Source of Emission Factor
Ducks	0.117 Kg/ duck/ year	Battye, et al. (1994)
Geese	0.890 Kg/ duck/ year	Battye, et al. (1994)
Turkeys	0.858 Kg/ duck/ year	Battye, et al. (1994)

**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*
> The activity data was collected at a county-level. No other method to spatially profile the source category was used.
>
> *Temporal*
> Data for temporal allocation is not available for this source.

**Emissions
Calculation**

Equation:

1999 TPY ammonia emissions for ducks in an individual county

$$EM_{DUCKS} = AC_{DUCKS} * EF_{DUCKS}$$

Where:
EM_{DUCKS} = Total NH3 emissions from ducks, all categories
AC_{DUCKS} = Activity level (number) of ducks
EF_{DUCKS} = Emission factor for ducks

4.1.9.8 Agricultural Fertilizer Application

SCC: 28 01 700 001 (Fertilizer Composite)

Description:

Fertilizer application is typically considered to be the second or third most important source on a national level, depending on whether the inventory includes soil emissions. Existing inventories usually estimate the contribution from fertilizer application to be 10-20% of the national total. Substantial progress was made in improving spatial and temporal resolution of emissions in this category.

Activity level data for fertilizer application are for 1995 from the Association of American Plant and Food Control Officials (AAPFCO), which reports fertilizer sales to farmers at the county level. This is an improvement on some existing inventories, which are based on sales of fertilizer to dealers rather than to farmers. The dealers may subsequently sell the fertilizer to farmers in other locations, resulting in an inaccurate spatial distribution of activity levels. A better approximation (in the absence of actual application data) is to use sales from dealers to farmers. The AAPFCO datasets contain county-level resolution for the top producing states for each crop (usually about 30 states), and state-level resolution for the other states. USGS also has county-level records of fertilizer application for years up until 1991. For states where the AAPFCO dataset only contained state-level resolution, the USGS dataset was used to allocate the AAPFCO state-level data to county-level.

Although there are almost 200 different commercial fertilizers used in the United States, roughly 13 of them account for the majority of fertilizer use. Emission factors for these 13 were obtained from Battye et al. (1994) and Asman et al. (1992). Quantities of the rest of the fertilizers have been combined into a 'miscellaneous' category, and assigned an emission factor equal to the average emission factor for all major fertilizers. The amount of fertilizer in the 'miscellaneous' category is typically less than 3-4% of the total.

Finally, ammonia emissions from fertilizer application have a strong temporal component that has previously been ignored; yearly averages have been used in existing inventories. Significantly more fertilizer is applied in the spring and fall than in the summer and winter, corresponding to crop cycles. To improve temporal allocation, USDA data on crop planting times and fertilizer application times and rates were used to generate a monthly distribution of fertilizer application (USDA, 1997; USDA-ERS, 1991; USDA-ERS, 1996; USDA-ERS, 1996-1997; USDA-NASS, 1992-1997a; USDA-NASS, 1992-1997b; USDA-NASS, 1992-1997c; USDA-NASS, 1992-1997d; USDA-NASS, 1992-1997a; USDA-NASS, 1995; USDA-NASS, 1997). Results show that assuming a yearly average for this category results in a substantial error for most months of the year.

Pollutants

NH_3

**Method and
Data Sources**

Conceptually, the method for estimating emissions from mobile sources is simple: collect data on the amount of fertilizer sold to farmers in a specific county, then multiply this by the per cent of ammonia released per fertilizer application, and the resulting value provides the emissions. The CMU-NH3 Inventory (version 2.0) program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories.

Activity

Activity levels, amount of fertilizer sold to farmers per county, were collected from the Association of American Plant and Food Control Officials (AAPFCO).

Emission Factors

Emission factors were collected from a paper published by Battye,[110] et al. in 1994 and are presented in the table below:

Emission Factors and Source

Fertilizer Type	Per Cent NH_3 Released to the Atmosphere	Source of Emission Factor
Ammonium nitrate	0.01	Battye, et al. (1994)
Ammonium sulfate	0.01	Battye, et al. (1994)
Ammonium thiosulfate	0.02	Battye, et al. (1994)
Calcium ammonium nitrate	0.08	Battye, et al. (1994)
Nitrogen solutions	0.025	Battye, et al. (1994)
Urea	0.02	Battye, et al. (1994)
Diammonium phosphate	0.08	Battye, et al. (1994)
Monoammonium phosphate	0.15	Battye, et al. (1994)
Liquid ammonium polyphosphate	0.04	Battye, et al. (1994)
Potassium nitrate	0.04	Battye, et al. (1994)
Miscellaneous	0.04	Battye, et al. (1994)
Potassium nitrate	0.02	Battye, et al. (1994)
Miscellaneous	0.15	Battye, et al. (1994)
Mix	0.04	Battye, et al. (1994)

**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**

The activity data was collected at a county-level. No other method to spatially profile the source category was used.

Finally, ammonia emissions from fertilizer application have a strong temporal component that has previously been ignored; yearly averages have been used in existing inventories. Significantly more fertilizer is applied in the spring and fall than in the summer and winter, corresponding to crop cycles. To improve temporal allocation, USDA data on crop planting times and fertilizer application times and rates were used to generate a monthly distribution of fertilizer application (USDA, 1997; USDA-ERS, 1991; USDA-ERS, 1996; USDA-ERS, 1996-1997; USDA-NASS, 1992-1997a; USDA-NASS, 1992-1997b; USDA-NASS, 1992-1997c; USDA-NASS, 1992-1997d; USDA-NASS, 1992-1997a; USDA-NASS, 1995; USDA-NASS, 1997). Results show that assuming a yearly average for this category results in a substantial error for most months of the year.

Emissions Calculation

Equation:

1999 TPY ammonia emissions for agricultural fertilizer sources in an individual county

$$EM_{FERT\text{-}99\ Total} = \begin{array}{l} EM_{AmmNit} + EM_{AmmSul} + EM_{AmmThio} + EM_{CalAmmNit} + EM_{NitSol} + EM_{Urea} \\ + EM_{DiAmmPhos} + EM_{MonoAmmPhos} + EM_{LiqAmmPhos} + EM_{PotNit} + EM_{Misc} + \\ EM_{Mix} \end{array}$$

Where:

$EM_{MOBILE\text{-}99\ Total}$ = Total NH3 emissions from agricultural fertilizer application, all categories
EM_{AmmNit} = Emissions from Ammonium Nitrate fertilizer
EM_{AmmSul} = Emissions from Ammonium Sulfate fertilizer
$EM_{AmmThio}$ = Emissions from Ammonium Thiosulfate fertilizer
$EM_{CalAmmNit}$ = Emissions from Calcium Ammonium Nitrate fertilizer
EM_{NitSol} = Emissions from Nitrogen Solutions fertilizer
EM_{Urea} = Emissions from Urea fertilizer
$EM_{DiAmmPhos}$ = Emissions from Diammonium Phosphate fertilizer
$EM_{MonAmmPhos}$ = Emissions from Monoammonium Phosphate fertilizer
$EM_{LiqAmmPhos}$ = Emissions from Liquid Ammonium Polyphosphate fertilizer
EM_{PotNit} = Emissions from Potassium Nitrate fertilizer
EM_{Misc} = Emissions from Miscellaneous fertilizer
EM_{Mix} = Emissions from Mixed fertilizer

Where:

EM_{AmmNit} = $(AC_{AmmNit} *$ Per Cent Released $_{AmmNit})$
EM_{AmmSul} = $(AC_{AmmSul} *$ Per Cent Released $_{AmmSul})$
$EM_{AmmThio}$ $(AC_{AmmThio} *$ Per Cent Released $_{AmmThio})$
$EM_{CalAmmNit}$ = $(AC_{CalAmmNit} *$ Per Cent Released $_{CalAmmNit})$
EM_{NitSol} = $(AC_{NitSol} *$ Per Cent Released $_{NitSol})$
EM_{Urea} $(AC_{Urea} *$ Per Cent Released $_{Urea})$

$$EM_{DiAmmPhos} = (AC_{DiAmmPhos} * \text{Per Cent Released }_{DiAmmPhos})$$

$$EM_{MonAmmPhos} = (AC_{MonAmmPhos} * \text{Per Cent Released }_{MonAmmPhos})$$

$$EM_{LiqAmmPhos} = (AC_{LiqAmmPhos} * \text{Per Cent Released }_{LiqAmmPhos})$$

$$EM_{PotNit} = (AC_{PotNit} * \text{Per Cent Released }_{PotNit})$$

$$EM_{Misc} = (AC_{Misc} * \text{Per Cent Released }_{Misc})$$

$$EM_{Mix} = (AC_{Mix} * \text{Per Cent Released }_{Mix})$$

Where:

AC_{AmmNit} = Activity level (amount of Ammonium Nitrate fertilizer applied per county)

Per Cent Released $_{AmmNit}$ = Per Cent of NH3 released during fertilizer application

4.1.9.9 Human Breath and Perspiration

SCC: 28 10 010 000 (Human Perspiration)

Description

Ammonia emissions from human breath and perspiration comprise a few percent of the national ammonia emission inventory.

Pollutants

NH_3

**Method and
Data Sources**

Conceptually, the method for estimating emissions from human breathe and perspiration is simple: count the number of people, then multiply this by the average emissions per person, and the resulting value provides the emissions. The CMU-NH3 Inventory (version 1.2) program utilizes this approach, a methodology approved by the EPA for developing the emissions inventory for other categories.

Activity
The US Census (U.S. Census Bureau, 1999) was used to obtain activity level data for this category.

Emission Factors
Emission factors were collected from a paper published by Battye,[110] et al. in 1994 and are presented in the table below:

Emission Factors and Source

Emission Category	Emission Factor	Source of Emission Factor
Human Breathe and Perspiration	0.44 Kg/ person/ year	Battye, et al. (1994)

**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
The activity data was collected at a county-level. No other method to spatially profile the source category was used.

208

Temporal
Data for temporal allocation is not available for this source.

**Emissions
Calculation**

<u>Equation:</u>

<u>1999 TPY ammonia emissions from human breathe and perspiration in an individual county</u>

$$EM_{HUMAN\ B\&P} = AC_{HUMAN} * EF_{HUMAN\ B\&P}$$

Where:
$EM_{HUMAN\ B\&P}$ = Total NH3 emissions from human breathe and perspiration
AC_{HUMAN} = Activity level (number) of people per county
$EF_{HUMAN\ B\&P}$ = Emission factor for human breathe and perspiration

5.0 NONROAD SOURCES

5.1   NONROAD VEHICLES/ENGINES

This section contains the nonroad source emission inventory for volatile organic compounds (VOCs), nitrogen oxides (NOx), and carbon monoxide (CO) and if possible carbon dioxide (CO_2), sulfur oxides (SOx), particulate matter (PM), 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. For nonroad mobile sources, the source categories of interest are aircraft, locomotives, marine vessels and the source types included in EPA's NONROAD model. 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 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 two methodologies approved by the EPA for developing the 2002 emissions inventory for nonroad categories. One of the methodologies used consisted of employing EPA's NONROAD Emission Inventory Model[111]. In a memorandum[112], dated June 16, 2003, EPA allowed the use of the draft NONROAD Model and associated default inputs in the development of inventories supporting State Implementation Plans (SIPs). The second methodology entailed the use of EPA emission factors.

Sample calculations presented below are for illustrative purposes only and may not reflect actual emissions.

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[111] NONROAD2005

[112] USEPA Memorandum , dated June 16, 2003, from Gene Tierney or the Air Quality and Modeling Centery and Leila H. Cook of the Transportation and Regional Programs Division; to Regional Mobile Source Program Manages and Staff.

5.2   NONROAD MODEL

As stated previously, the 2002 emissions estimate for all nonroad equipment categories listed above except commercial marine, railroad locomotives, and aviation emissions were determined by running EPA's NONROAD MOBILE Model, as suggested by EPA guidance. The 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).

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 in a Windows 3.1 or 95 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), NOx, 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). Ammonia (NH3) emissions from NONROAD Model equipment were post-processed outside of the actual model.

The NONROAD 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, scrappage function, 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. MDE input files that differ from the EPA national defaults are presented in Section 4.7 – NONROAD Model Appendices.'

Input parameters for the NONROAD Model are listed below:

2002 NONROAD MODEL INPUTS			
	Winter	Spring	Fall
	All Maryland Counties	All Maryland Counties	All Maryland Counties
Temp MIN	28.29	43.87	47.68
Temp MAX	48.29	67.25	66.72
Temp AVG	38.70	55.83	58.03
RVP	12.6	9.6	9.3
Diesel S %	0.2318	0.2318	0.2318
Gas Sulfur %	0.0162	0.0162	0.0162
CNG/LPG Sulfur %	0.003	0.003	0.003
Marine Dsl sulfur %	0.2637	0.2637	0.2637
O2 Weight %	2.1	2.1	2.1
State II Control %	0	0	0

2002 NONROAD MODEL SUMMER INPUTS			
	Summer (Transport Region)	Summer (MWCOG Counties)	Summer (BNNA Counties)
Temp MIN	65.55	69.80	65.55
Temp MAX	87.60	92.50	87.60
Temp AVG	76,80	81.40	76,80
RVP	6.6	6.9	6.6
Diesel S %	0.2318	0.2283	0.2318
Gas Sulfur %	0.0162	0.0129	0.0162
CNG/LPG Sulfur %	0.003	0.003	0.003
Marine Dsl sulfur %	0.2637	0.2638	0.2637
O2 Weight %	2.1	2.1	2.1
State II Control %	0	0	0

The transport region includes the following counties: Allegany, Caroline, Dorchester, Garrett, Kent, Queen Anne's, St Mary's, Somerset, Talbot, Washington, Wicomico, Worcester
The MWCOG region includes the following counties: Calvert, Charles, Frederick, Montgomery, Prince Georges
The BNAA region includes the following counties: Anne Arundel, Baltimore, Carroll, Harford, Howard, Baltimore City, Cecil

Details of this model can be found in its user guide named "User's Guide for the EPA Nonroad Emissions Model Draft NONROAD 2002" (EPA420-P-02-013; December 2002) available from the EPA.

Ammonia emissions from NONROAD Model equipment were estimated by running the NR Model Reporting Tool for one county (Anne Arundel). The reporting tool provided the total fuel used per source classification code (SCC). Seasonal reports were used to ensure that all SCC were captured. EPA-supplied NH3 emission factors for gasoline and diesel fuel were used to estimate emissions on the SCC level for the county. A ratio of NH3 to CO2 emissions was obtained per SCC for the county. This ratio was then applied to all the counties in Maryland to estimate ammonia emissions for the state.

5.2.1   NONROAD Model Equipment

Description

NONROAD Model 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_{10}, $PM_{2.5}$, SOx, NOx, CO, VOC, NH3

**Method and
Data Sources**

Data sources
A. " User's Guide for the EPA Nonroad Emissions Model Draft NONROAD 2002" prepared for EPA by ENVIRON International Corporation under EPA Contract No. DW47926801 dated December 2002. This report, EPA420-P-02-013, constitutes the User's Guide to the NONROAD model. The report contains an overview of the model, equipment types, pollutants reported, geographic an temporal coverage, the model components, model inputs, and output options. The guide documents how to install and run the model and the associated reporting utility.

B. http://www.epa.gov/oms/nonrdmdl.htm

Methods sources
Based upon EPA's requirements for determining nonroad emissions, the Department ran the NONROAD model to determine the emission estimate for 2002. MDE-ARMA opted to choose seasonal (Spring, Summer, Fall, Winter) period totals as the output files from the model. These period totals were divided by the number of days in a season to reflect an average daily emission level for each season.

**Point Source
Adjustments**

No subtration of emissions from point sources is necessary.

**Adjustments
for Controls**

The NONROAD model automatically applies controls, when applicable, for a given year.

Spatial and Temporal Allocations

Spatial

The NONROAD model spatially allocates equipment populations through the REGION data packet and the emissions through the ALLOC data packet.

The REGION input file specifies the state or county to model. When you initially install the NONROAD model, you are prompted to identify the state where you are located. This step sets up the population and allocation factor data files for your state.

The ALLOC input file defines the spatial allocation files read by the model.

Temporal

The NONROAD model temporally allocates activity to the different seasons through the SEASONALITY, MONTHLY, and DAILY data packets.

The first temporal allocation, identified by the packet identifier /MONTHLY/, provides the monthly adjustment factors used by the model to calculate the fraction of annual activity occurring in the given month. For periods longer than a single month (e.g. season), the factors from each month spanned by the period are summed. The second, identified as /DAILY/, provides the day-of-the-week adjustments. The weekend and weekday allocations should sum to one for an entire week (i.e. $1 = 5 \times$ weekday fraction $+ 2 \times$ weekend fraction).

The seasonal and monthly activity allocation fractions for the NONROAD engine emissions modeling is further documented in Report No. NR-004, dated December 9, 1997. The weekday and weekend day temporatl allocation of activity in the NONROAD model is further documented in Report No. NR-015[113], dated March 31, 1999.

Emissions Calculation

The NONROAD calculations rely on emission factors--estimates of 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 NONROAD's data input files. NONROAD 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. The core model of NONROAD, written in Fortran, contains all of the algorithms used by the model for calculating emissions estimates using the input file listed above.

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[113] Nonroad Engine Emission Modeling Team, Assessment and Modeling Division, EPA, Office of Mobile Sources

5.3 RAILROADS

SCC: 22 85 002 005 (Line Haul)
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 (SCC: 2285002005) and Yard (SCC: 2285002010). 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.

Pollutants

PM, SOx, NOx, CO, VOC

Method and
Data Sources:

The following thirteen railroad companies operate in Maryland and were asked to provide the amount of fuel used in 2002, and the distribution of the company's track mileage by Maryland County:
1. AMTRAK (National Railroad Passenger Corporation)
2. Canton Railroad Company
3. Wheeling & Lake Erie Railway Company
4. CSX Transportation, Incorporated
5. Eastern Shore Railroad, Incorporated
6. Maryland & Delaware Railroad Company
7. Maryland Midland Railway, Incorporated
8. Norfolk and Southern Railway Company
9. Patapsco & Back Rivers Railroad Company
10. Western Maryland Scenic Railroad
11. Winchester and Western Railroad Company
12. MARC (Under the Maryland Transit Administration)
13. Walkersville Southern Railroad

For CSX and Norfolk railroad operating statistics contained in R-1 reports 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 EPA's *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, 1992.

	Line Haul		**Yard**
VOC	0.0213 lbs/gal	**VOC**	0.0509 lbs/gal
NOx	0.4931 lbs/gal	**NOx**	0.5044 lbs/gal
CO	0.0626 lbs/gal	**CO**	0.0894 lbs/gal
SO2	0.0360 lbs/gal	**SO2**	0.0360 lbs/gal
PM10	0.0148 lbs/gal	**PM10**	0.0203 lbs/gal
PM25	0.0133 lbs/gal	**PM25**	0.0183 lbs/gal

SO_2 emissions were calculated based on a sulfur content of 0.25% by 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 subtration of emissions from point sources is necessary.

Adjustments for Controls

No controls are available for this source category.

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 propotion of track miles used in a particular county.

Temporal
Data for temporal allocation is not available for this source.

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.

$$E_{LH-i-CTYj} = \frac{Fuel_{CTY} \ x \ EF_{LH}}{2000 \ x \ 365}$$

Where:

$E_{LH-i-CTYj}$ = Emissions from line haul railroad locomotives for pollutant i in County j

$Fuel_{CTYj}$ = Total amount of fuel consumed by every railroad operating in the calculated county
$Fuel_{CTYj}$ = $(G_{cty1} + G_{cty2} + ... + G_{cty12})$
EF_{LH} = line haul locomotive emission factor for a given pollutant

The following equation was used to calculate the emissions for yard locomotives from each railroad company operating in a county.

$$E_{YL-i-CTYj} = \frac{N_{YL-i-CTYj} \ x \ 228 \ x \ EF_{YL}}{2000}$$

Where:

$E_{YL-i-CTYj}$ = Emissions from yard locomotives for pollutant i in County j
$N_{YL-i-CTYj}$ = number of yard locomotives operated by each railroad company in county j
$N_{YL-i-CTYj}$ = $(N_{cty1} + N_{cty2} + ... + N_{cty12})$
EF_{YL} = Yard locomotive emission factor for a given pollutant

<u>Sample Calculations:</u>

2002 Montgomery County Emissions

Line Haul Emission Estimate

AMTRAK, CSX, and MARC operated line haul locomotives in the county. AMTRAK also operated one yard (switcher) locomotive in the county.

Amount of fuel used in gallons by AMTRAK's line haul locomotives in Montgomery County:

G_{cty1} = 25,463.8 gallons used in Montgomery Co. per year by AMTRAK
(information provided by AMTRAK)

Amount of fuel used in gallons used by CSX Transportation line haul locomotives in Montgomery County:

$$G_{cty4} = \frac{36.37 \text{ track miles in Montgomery Co. for CSX}}{514.97 \text{ track miles in the state for CSX}} \text{ x } 10{,}512{,}431.53 \text{ gallons used in state per year}$$

G_{cty4} = 742,445.45 gallons used in Montgomery Co. per year by CSX

Amount of fuel in gallons used by MARC line haul locomotives in Montgomery county:

$$G_{cty12} = \frac{28 \text{ track miles in Montgomery Co. for MARC}}{156 \text{ track miles in the state for MARC}} \text{ x } 1{,}782{,}750 \text{ gallons used in state per year}$$

G_{cty12} = 319980.77 gallons used in Montgomery Co. per year by MARC

VOC Emissions from line haul locomotives in Montgomery County:

$$EM_{VOC} = \frac{(25{,}463.8 \text{ gal / yr} + 742{,}445.45 \text{ gal / yr} + 319980.77 \text{ gal / yr}) * 0.0213 \text{ lbs. }_{VOC}/\text{gal}}{(2000 \text{ lbs. per ton}) * (365 \text{ days per year})}$$

EM_{VOC} = 0.0316 tons $_{VOC}$ / day

NOx Emissions from line haul locomotives in Montgomery County:

$$EM_{NOX} = \frac{(25{,}463.8 \text{ gal / yr} + 742{,}445.45 \text{ gal / yr} + 319980.77 \text{ gal / yr}) * 0.4931 \text{ lbs. }_{NOX}/\text{gal}}{(2000 \text{ lbs. per ton}) * (365 \text{ days per year})}$$

EM_{NOX} = 0.7348 tons $_{NOX}$ / day

CO Emissions from line haul locomotives in Montgomery County:

$$EM_{CO} = \frac{(25{,}463.8 \text{ gal / yr} + 742{,}445.45 \text{ gal / yr} + 319980.77 \text{ gal / yr}) * 0.0626 \text{ lbs. }_{CO}/\text{gal}}{(2000 \text{ lbs. per ton}) * (365 \text{ days per year})}$$

EM_{CO} = 0.0933 tons $_{CO}$ / day

Yard Locomotives Emission Estimate

CSX operated 2 yard locomotives in Montgomery County:

VOC Emissions from yard locomotives in Montgomery County:

$$EM_{VOC} = \frac{(2 \text{ engine} * 228 \text{ gallons per engine per day} * 0.0509 \text{ lbs. }_{VOC} / \text{gallon})}{(2000 \text{ lbs. per ton})}$$

$EM_{VOC} = 0.0116 \text{ tons }_{VOC} / \text{day}$

NOx Emissions from yard locomotives in Montgomery County:

$$EM_{NOX} = \frac{(2 \text{ engine} * 228 \text{ gallons per engine per day} * 0.5044 \text{ lbs. }_{NOX} / \text{gallon})}{(2000 \text{ lbs. per ton})}$$

$EM_{NOX} = 0.1150 \text{ tons }_{NOX} / \text{day}$

CO Emissions from yard locomotives in Montgomery County:

$$EM_{CO} = \frac{(2 \text{ engine} * 228 \text{ gallons per engine per day} * 0.0894 \text{ lbs. }_{CO} / \text{gallon})}{(2000 \text{ lbs. per ton})}$$

$EM_{CO} = 0.0204 \text{ tons }_{CO} / \text{day}$

Total Emissions

Emissions from maintenance equipment used in the switching yards was calculated using the EPA's Non-Road Model and then added for the appropriate county.
Example emissions for Montgomery county:
0.0013 tons VOC / day, 0.0005 tons NOx / day, 0.0518 tons CO / day

Total VOC Emissions for Montgomery county:
$Emis_{VOC} = 0.0316$ tons / day from line haul + 0.0116 tons / day from yard + 0.0013 tons VOC / day from EPA Non-Road Model.
$Emis_{VOC} = $ **0.0445** tons VOC / day

Total NOx Emissions for Montgomery county:
$Emis_{NOx} = 0.7348$ tons / day from line haul + 0.1150 tons / day from yard + 0.0005 tons NOx / day from EPA Non-Road Model.
$Emis_{NOx} = $ **0.8503** tons NOx / day

Total CO Emissions for Montgomery county:
$Emis_{CO} = 0.0933$ tons / day from line haul + 0.0204 tons / day from yard + 0.0518 tons CO / day from EPA Non-Road Model.
$Emis_{CO} = $ **0.1655** tons CO / day

5.4   AIRCRAFT

SCC: 22 75 020 000 (Commercial Aircraft)
SCC: 22 75 050 000 (General Aviation)
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.

Pollutants

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

Method and
Data Sources

ARMA used a variety of sources for data and emission calculation methods as follows:

Data sources
1) Airport Activity Statistics of Certificated Route Air Carriers published by Federal Aviation Administration for the 12 months ending December 31,2002, pp 7-314 to 7-320.
2) This report lists total departures performed for commercial air carriers and individual types of commercial aircraft.

3) Landing and takeoff cycle information by airport for 1995/2002 from the Maryland

4) Aviation Administration and the Federal Aviation Administration Airport License Renewal Applications. The applications lists LTO cycles by aircraft operation type from all general aviation airports, Martin State Airport which has general, and Baltimore/Washington International Airport for the past 12 months.

Methods sources
1) For general aviation ARMA 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 ARMA 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 ARMA to collect LTO data rather than specific aircraft data. ARMA also used this composite factor method in its 1990 baseline inventory. For the final 2002inventory ARMA has requested operation data from military aircraft by operation type from Maryland Army, Navy, and Air Force base environmental support offices.

3) For commercial aviation ARMA used FAA's EDMS[114] 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 5a, 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, ARMA used a default mixing height value of 3,000 feet above ground level. The mixing height is the layer of air where airplane emission 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, ARMA 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
Data for temporal allocation is not available for this source.

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[114] Emissions & Dispersion Modeling System (EDMS) Version 3.2 for Windows from CSSI, Inc.

5.4.1 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. Enter the parameters (name, mixing height, average yearly temperature, and units of measurement) that are specific to each airport into the study.
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.
3) For each aircraft fill in the yearly LTO cycles provided by surveying the airport.
4) For each aircraft fill in the average annual taxi time and queue time specific to the airport or use the EDMS provide default values.
5) Continue to add each aircraft/engine type, LTO cycle, taxi time and queue time to the 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 following calculation aircraft operating at Baltimore/Washington International Airport in Anne Arundel County during 1998. Tabled below is the aircraft, engine assigned to the aircraft, time for each mode of operation, annual LTO operations, average annual taxi time, and the average annual queue time.

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
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
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. Annual emission inventory results are listed in the table below:

NAME	CO Tons/year	HC[115] Tons/year	NOX Tons/year	SOX Tons/year	PM10 Tons/year
Aircraft	767.886	128.821	905.493	41.586	
GSE/AGE/APU	2810.992	71.658	221.278	6.027	7.871
Total	3578.878	200.476	1126.771	47.613	7.871

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:

NAME	CO Tons/year	HC Tons/year	NOX Tons/year	SOX Tons/year	PM10 Tons/year
Commercial Aircraft	546.030	84.833	890.956	40.399	0.000
General Aviation	202.667	34.256	6.699	0.654	0.000
Military Aviation	19.189	9.732	7.838	0.533	0.000
Total	767.886	128.821	905.493	41.586	0.0

---

[115] Requires a Hydrocarbon to VOC conversion factor of 1.0947.

A daily emission inventory was produced assuming an airport activity of 365 days per year.

The model was run for all aircraft at BWI and all commercial aviation at Hagerstown Regional, Ocean City Municipal and military aircraft at Andrews Air Force Base.

5.4.2 General Aviation

**Emission
Calculation**

A rough estimate of emissions were 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 <u>Procedures,</u> 1992. The composite emission factors used are listed in the table below.

	CO (lbs./LTO)	HC* (lbs./LTO)	NOx (lbs./LTO)	SO2 (lbs./LTO)	PM (lbs./LTO)
General Aviation	12.014	0.394	0.065	0.100	0.020
Air Taxis	28.130	1.234	0.158	0.015	0.020

* 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) $Emiss_{VOC} = L(AT) * EF(AT)_{VOC}$

      Where:
      L(AT) = LTOs for Air Taxis
      $EF(AT)_{xx}$ = Emission factors for Air Taxis

   Sample Calculation – General Aviation:

This calculation is for Easton Airport/Newman Field in Talbot County. The airport had 21,569 General Aviation LTOs over a twelve month period. Performing step 1 Equations (above) the calculations were:

$Emiss_{VOC} = [L(GA) * EF(GA)_{HC}]* CF (VOC/HC)$
$Emiss_{VOC} = [(21,569$ LTOs / Year $* 0.394$ (lbs. HC / LTO)] $* 0.9708$ (lbs. VOC / lbs. HC))))
$Emiss_{VOC} = 8,250.0390$ lbs. VOC / Year
$Emiss_{VOC} = 0.0113$ Tons VOC / Day

$Emiss_{CO} = [21,569$ LTOs / Year $* 12.014$ (lbs. CO / LTO)]
$Emiss_{CO} = 259,129.966$ lbs. of CO / Year
$Emiss_{CO} = 0.3550$ Tons CO / Day
$Emiss_{NOx} = [21,569$ LTOs / Year $* 0.065$ (lbs. NOx / LTO)]
$Emiss_{NOx} = 1,401.985$ lbs. of NOx / Year

Emiss$_{NOx}$ = 0.0019 Tons NOx / Day

Emiss$_{SO2}$ = [21,569 LTOs / Year * 0.100 (lbs. SO2 / LTO)]
Emiss$_{SO2}$ = 2,156.900 lbs. of SO2 / Year
Emiss$_{SO2}$ = 0.0030 Tons SO2 / Day

Emiss$_{PM}$ = [21,569 LTOs / Year * 0.020 (lbs. PM / LTO)]
Emiss$_{PM}$ = 431.380 lbs. of PM / Year
Emiss$_{PM}$ = 0.0006 Tons PM / Day

Sample Calculation – Air Taxi:

This calculation is for Easton Airport/Newman Field in Talbot County. The airport had 4,557 Air Taxi Aviation LTOs over a twelve month period. Performing step 1 Equations (above) the calculations were:

Emiss$_{VOC}$ = [L(AT) * EF(AT)$_{HC}$]* CF (VOC/HC)
Emiss$_{VOC}$ = [(4,557 LTOs / Year * 1.234 (lbs. HC / LTO)] * 0.9914 (lbs. VOC / lbs. HC))))
Emiss$_{VOC}$ = 5,574.9773 lbs. VOC / Year
Emiss$_{VOC}$ = 0.0076 Tons VOC / Day

Emiss$_{CO}$ = [4,557 LTOs / Year * 28.130 (lbs. CO / LTO)]
Emiss$_{CO}$ = 128,188.410 lbs. of CO / Year
Emiss$_{CO}$ = 0.1756 Tons CO / Day

Emiss$_{NOx}$ = [4,557 LTOs / Year * 0.158 (lbs. NOx / LTO)]
Emiss$_{NOx}$ = 720.006 lbs. of NOx / Year
Emiss$_{NOx}$ = 0.0010 Tons NOx / Day

Emiss$_{SO2}$ = [4,557 LTOs / Year * 0.015 (lbs. SO2 / LTO)]
Emiss$_{SO2}$ = 68.355 lbs. of SO2 / Year
Emiss$_{SO2}$ = 0.0001 Tons SO2 / Day

Emiss$_{PM}$ = [4,557 LTOs / Year * 0.020 (lbs. PM / LTO)]
Emiss$_{PM}$ = 91.14 lbs. of PM / Year
Emiss$_{PM}$ = 0.0001 Tons PM / Day

5.4.3 Military Aircraft

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. ARMA received LTO information from all airports. The Aberdeen Airport reported no activity in 2002. Most of the county airports also receive a small number of military operations.

**Method and
Data Sources**

Since ARMA asked for and received LTO information by aircraft operation type, ARMA used composite emission factors from <u>Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, 1988</u> for all airports except Andrews Air Force Base. The EDMS model (version 3.2) was used to calculate emissions from Andrews Air Force Base. Otherwise, the composite emission factors are listed in the table below.

	CO (lbs./LTO)	VOC (lbs./LTO)	NOx (lbs./LTO)	SO2 (lbs./LTO)	PM (lbs./LTO)
Military Aircraft	48.80	27.10	9.160	1.430	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**

This calculation is for Patuxent River Naval Air Station in St. Mary's county. The airport had 63,852 LTOs in 2002. Using step 1 from Equations (above) the calculations were:

$Emiss_{VOC} = [L(AT) * EF(MA)_{HC}]$
$Emiss_{VOC} = [(63,852 \text{ LTOs / Year} * 27.10 \text{ (lbs. VOC / LTO)}]$
$Emiss_{VOC} = 1,730,389.200 \text{ lbs. VOC / Year}$
$Emiss_{VOC} = 2.3704 \text{ Tons VOC / Day}$

$Emiss_{CO} = [63,852 \text{ LTOs / Year} * 48.80 \text{ (lbs. CO / LTO)}]$
$Emiss_{CO} = 3,115,977.60 \text{ lbs. of CO / Year}$
$Emiss_{CO} = 4.2685 \text{ Tons CO / Day}$

$Emiss_{NOx} = [63,852 \text{ LTOs / Year} * 9.160 \text{ (lbs. NOx / LTO)}]$
$Emiss_{NOx} = 584,884.32 \text{ lbs. of NOx / Year}$
$Emiss_{NOx} = 0.8012 \text{ Tons NOx / Day}$

Emiss$_{SO2}$ = [63,852 LTOs / Year * 1.430 (lbs. SO2 / LTO)]
Emiss$_{SO2}$ = 91,308.36 lbs. of SO2 / Year
Emiss$_{SO2}$ = 0.1251 Tons SO2 / Day

Emiss$_{PM}$ = [63,852 LTOs / Year * 15.23 (lbs. PM / LTO)]
Emiss$_{PM}$ = 972,465.96 lbs. of PM / Year
Emiss$_{PM}$ = 1.3321 Tons PM / Day

5.5   Marine Vessels

SCC: 22 80 002 010 (diesel marine vessels)

Description

Commercial vessels include 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.

Pollutants

PM, SO_2, NOx, CO, HC, CO_2

Method and
Data Sources

MDE used the emission inventory prepared for the Maryland Port Administration by Edwards and Kelcey (E&K). E&K analyzed the major categories of air emissions associated with ship and port operations and their relationship to air quality issues in the Baltimore non-attainment area.

E&K used the marine emission inventory guidance method outlined in <u>Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data</u> (EPA-450-R-00-002), February 2000, to calculate emissions from commercial marine vessels. The methodology is based on a three-step calculation. The first step apportions the time spent by a vessel in a port area to different operating modes. The second calculates fuel consumption in each operating mode. The third step calculates emissions using fuel consumption specific emission factors, which is how marine engine emission factors have been historically specified. All of these calculations are made by vessel type and class, with the type specifying whether the vessel is a tanker, passenger liner, etc, and the class specifying either the weight or horsepower range.

This new methodology considers new information collected on marine vessels. The time-in-mode is a function of the particular port area geography and was not considered in the report. The other factors used in the emission estimate computation are examined, with particular focus on the emission factors, for all pollutants of concern. One reason for a detailed reconsideration of the emission factors is that a number of large marine diesels have been tested for emissions and their tests results have become available in the last few years. In addition, both the EPA and ARB have recently sponsored studies to calculate marine vessel emissions in the South Coast Air Basin and in some areas of Region IX, so that there is a body of new research available to update emission factors. Hence, the use of a larger and newer database on marine vessel emission is expected to substantially improve the quality of the derived emission factors.

Activity
The computation of emissions can be performed by ship type for a given port and requires the following inputs:

- The number of calls to the port by vessel class and deadweight tonnage.

- The time spent, by ship type, in each of four operating modes defines as: normal cruise, slow cruise, maneuvering, and hoteling.

Emission Factors

Emission rates were calculated per pollutant (except SO2) per vessel type per mode of operation within the guidance document using the following formula:

$$E_{(i)} = a * (\text{Fractional Load})^{-x} + b$$

Where:

$E_{(i)}$ = Emission rate of pollutant i in grams per kilowatt-hour
a = Coefficient
x = Exponent
b = Intercept

Emission rates were calculated per pollutant (SO2 only) per vessel type per mode of operation within the guidance document using the following formula:

$$E_{(SO2)} = a * (\text{Fuel Sulfur Flow in g/kW-hr}) + b$$

The marine engine emission factor and fuel consumption algorithms are presented in the table below:

Pollutant	Exponent (x)	Intercept (b)	Coefficient (a)
PM	1.5	0.2551	0.0059
NOx	1.5	10.4496	0.1255
SO2	1	0	2.3735
CO	1	0	0.8378
HC	1.5	0	0.0667
CO2	1	648.6	44.1

The marine engine emission rates in grams per kilowatt-hour are presented in the table below:

Vessel Type	Cruise	Slow Cruise	Maneuvering	Hoteling
	PM (gr/kw-hr)	PM (gr/kw-hr)	PM (gr/kw-hr)	PM (gr/kw-hr)
Bulk Carriers & Tankers	0.2633	0.2784	0.3211	0.4417
General Cargo	0.2633	0.2836	0.3211	0.4417
Passenger	0.2633	0.3211	0.4417	0.7828
Container/ RORO/ Reefer/Auto Carrier	0.2633	0.291	0.3567	0.5424
All non-oceangoing	0.2633	0.2784	0.3211	0.4417
	NOx (gr/kw-hr)	NOx (gr/kw-hr)	NOx (gr/kw-hr)	NOx (gr/kw-hr)
Bulk Carriers & Tankers	10.625	10.9457	11.8527	14.4183

Vessel Type	Cruise	Slow Cruise	Maneuvering	Hoteling
General Cargo	10.625	11.0557	11.8527	14.4183
Passenger	10.625	11.8527	14.4183	21.6747
Container/ RORO/ Reefer/Auto Carrier	10.625	11.2134	12.6099	16.5597
All non-oceangoing	10.625	10.9457	11.8527	14.4183
	SO2 (gr/kw-hr)	**SO2 (gr/kw-hr)**	**SO2 (gr/kw-hr)**	**SO2 (gr/kw-hr)**
Bulk Carriers & Tankers	26.5081	28.6027	32.7919	41.1704
General Cargo	26.5081	29.2012	32.7919	41.1704
Passenger	26.5081	32.7919	41.1704	57.9273
Container/ RORO/ Reefer/Auto Carrier	26.5081	29.9991	35.5847	46.756
All non-oceangoing	26.5081	28.6027	32.7919	41.1704
	CO (gr/kw-hr)	**CO (gr/kw-hr)**	**CO (gr/kw-hr)**	**CO (gr/kw-hr)**
Bulk Carriers & Tankers	1.0473	2.0945	4.189	8.378
General Cargo	1.0473	2.3937	4.189	8.378
Passenger	1.0473	4.189	8.378	16.756
Container/ RORO/ Reefer/Auto Carrier	1.0473	2.7927	5.5853	11.1707
All non-oceangoing	1.0473	2.0945	4.189	8.378
	HC (gr/kw-hr)	**HC (gr/kw-hr)**	**HC (gr/kw-hr)**	**HC (gr/kw-hr)**
Bulk Carriers & Tankers	0.0932	0.2637	0.7457	2.1092
General Cargo	0.0932	0.3221	0.7457	2.1092
Passenger	0.0932	0.7457	2.1092	5.9658
Container/ RORO/ Reefer/Auto Carrier	0.0932	0.4059	1.1481	3.2474
All non-oceangoing	0.0932	0.2637	0.7457	2.1092
	CO2 (gr/kw-hr)	**CO2 (gr/kw-hr)**	**CO2 (gr/kw-hr)**	**CO2 (gr/kw-hr)**
Bulk Carriers & Tankers	703.725	758.85	869.1	1,089.60
General Cargo	703.725	774.6	869.1	1,089.60
Passenger	703.725	869.1	1,089.60	1,530.60
Container/ RORO/ Reefer/Auto Carrier	703.725	795.6	942.6	1,236.60
All non-oceangoing	703.725	758.85	869.1	1,089.60

Point Source Adjustments

No point source emissions were subtracted from the area source inventory.

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. E&K emissions inventory focused on the City of Baltimore and allotted the cruise emissions to the city.

Temporal

Data for temporal allocation is not available for this source.

**Emissions
Calculation**

The equation used to estimate emissions from commercial marine vessels is:

$$TIME_{VCC, DWT, MODE} = \frac{CALLS_{VCC, DWT} \times LENGTH_{VCC, DWT} \times \%TIME_{VCC, DWT, MODE}}{100}$$

$$EMISSIONS_{VCC, DWT, MODE} = (EF)(LF_{MODE}) \times (HP)(DWT) \times LF_{MODE} \times TIME_{VCC, DWT, MODE}$$

Where:

VCC is the vessel class (bulk carrier, tanker, container, general cargo, passenger, reefer, RORO, tug, vehicle carrier, or miscellaneous)
  DWT is the deadweight tons
  EF is the emissions factor
  LF is the mode specific load factor

For the calculation, the TIME equation requires port specific inputs, while the guidance method outlined in <u>Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data</u> (EPA-450-R-00-002), February 2000, provides the EF and HP relationships.

Data on the type of vessels, number of calls per vessel type, deadweight tons per vessel type, and time in each mode per vessel type using Baltimore port facilities came from the Maryland Port Administration (MPA).

In addition, the MPA provided data that translated into approximately 85 percent of the vessels arriving from the south (up the Chesapeake Bay) and 15 percent of the vessels arriving from the north (down from the Chesapeake and Delaware Canal). The data allowed MDE to allocate slow cruising emissions to the appropriate counties to the north and south of the Port of Baltimore. Emissions associated with "normal cruising" were assumed by MDE not to have occurred while in the Maryland airshed.

All of the maneuvering and hoteling emissions were assigned to the City of Baltimore.

6.0   ONROAD MOBILE SOURCES

6.1   INTRODUCTION

As detailed in the following sections, the official 2002 highway vehicle emissions estimates for the 8-hour ozone SIP submittal, have been developed based on the highway traffic data obtained from the Maryland State Highway Administration (SHA)

The official highway vehicle emission inventory for the Maryland portion of the Washington, D.C. Ozone Non-attainment Area (comprising the counties of Calvert, Charles, Frederick, Montgomery, and Prince George's) has been developed by the Metropolitan Washington Council of Governments (MWCOG) based on the transportation demand modeling data and has been documented by that organization under separate cover.

In accordance with the standard methodology for the development of highway vehicle emissions inventories, all of the emissions estimates documented herein are based on emission factors developed using the United States Environmental Protection Agency's (U.S. EPA's) latest version of the MOBILE6 emissions factor model and using appropriate activity levels i.e., vehicle miles traveled (VMT) estimates developed from the highway traffic data obtained from the SHA of the Maryland Department of Transportation (MDOT).

In its simplest form, highway vehicle emissions can be modeled by aggregating the products of emission factors of various vehicle types and vehicle travel activity on various roadway classes, as illustrated in the following equation:
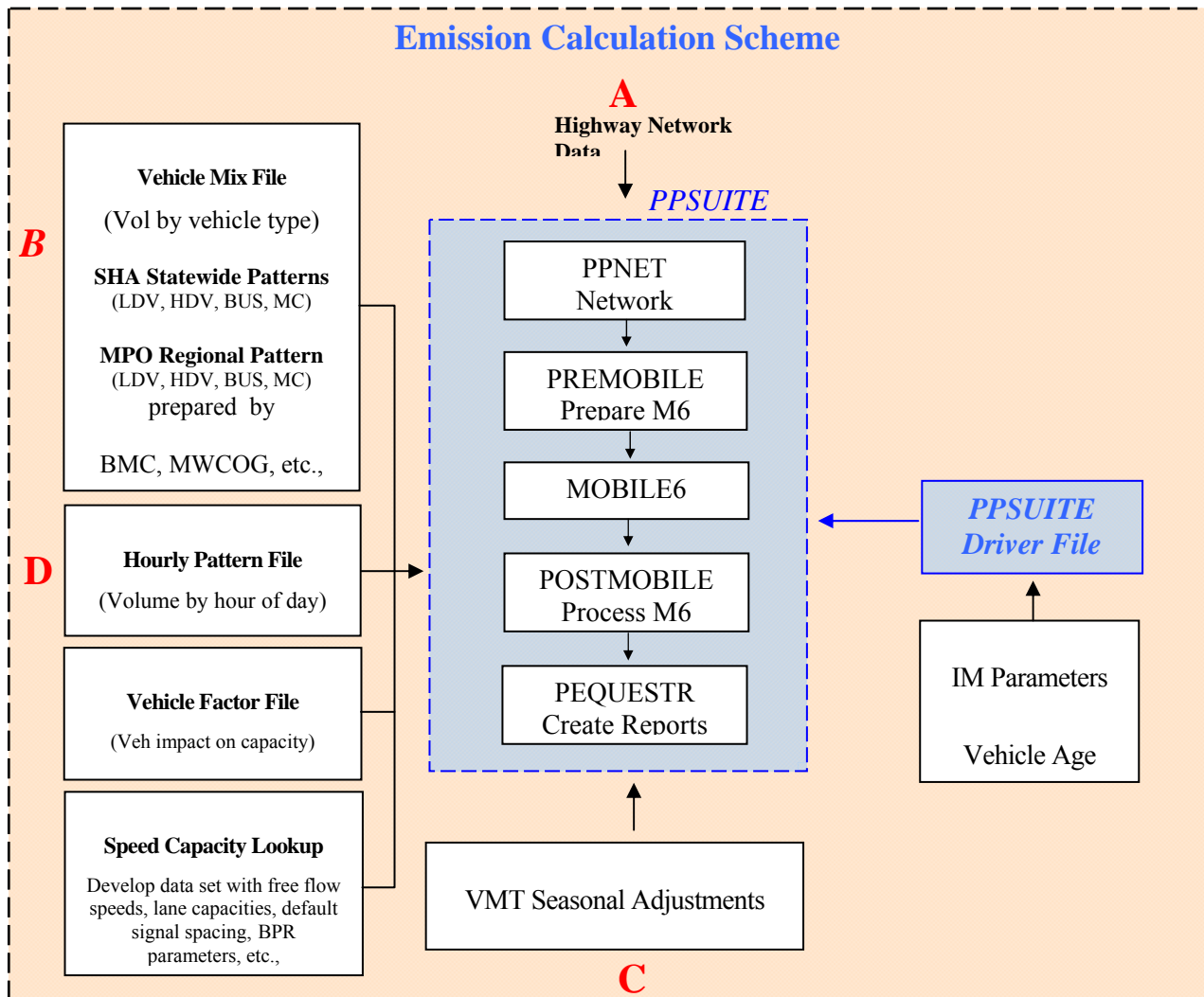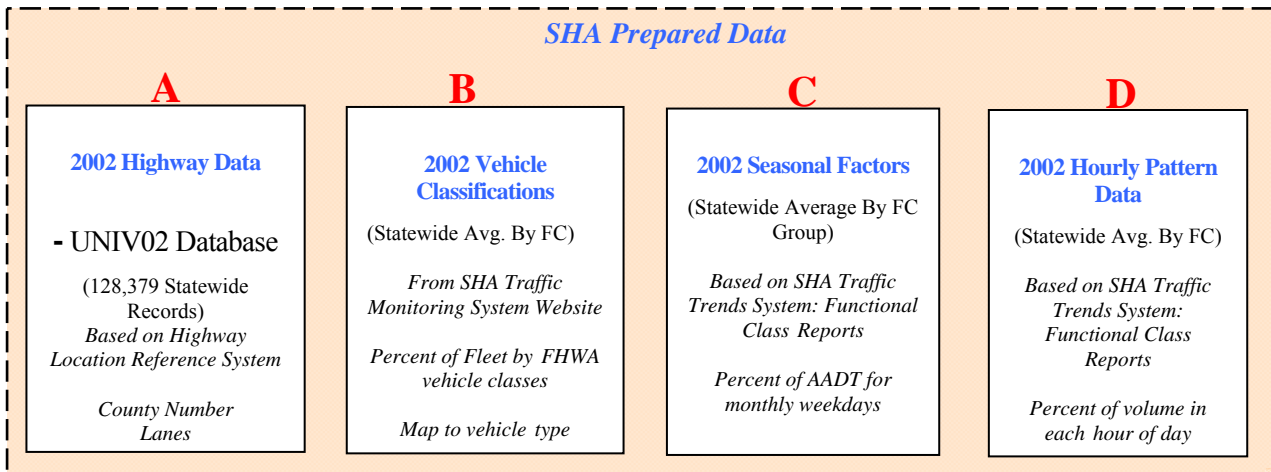
Emissions = (Emission Factors) x (Vehicle Activity)

The emission modeling computations (expressed in tons per summer weekday or tons per annum) involve application of appropriate conversion and seasonal adjustment factors on the two entities of the emission equation – emission factors in grams per mile and vehicle activity in VMT.

In the real world, development of highway vehicle emissions over a large network of roadways is a complicated and data intensive effort that requires the correct expertise and tools to produce emissions based on the federal and state requirements. MDE used the PPSuite system, a robust, systematic, and comprehensive software approach to develop the on-road emissions for the state.

This new post-processor, PPSUITE was used for the first time in 2003 by MSCP for the 2005 Mobile Emission Budget effort. However this software system has been in use in Pennsylvania, Virginia, New Jersey, and the New York City Metropolitan Area, for previous inventory and conformity submissions. PPSUITE is also compatible with travel demand modeled activity data and as such used in the Baltimore Area's for transportation conformity analysis. The following table provides a summary of the emission process and various data inputs.

PPSUITE Emission Modeling Process

SHA Prepared Data

A

2002 Highway Data

- UNIV02 Database

(128,379 Statewide Records)
Based on Highway Location Reference System

County Number Lanes

B

2002 Vehicle Classifications

(Statewide Avg. By FC)

From SHA Traffic Monitoring System Website

Percent of Fleet by FHWA vehicle classes

Map to vehicle type

C

2002 Seasonal Factors

(Statewide Average By FC Group)

Based on SHA Traffic Trends System: Functional Class Reports

Percent of AADT for monthly weekdays

D

2002 Hourly Pattern Data

(Statewide Avg. By FC)

Based on SHA Traffic Trends System: Functional Class Reports

Percent of volume in each hour of day

Emission Calculation Scheme

A
Highway Network Data

PPSUITE

B

Vehicle Mix File

(Vol by vehicle type)

SHA Statewide Patterns
(LDV, HDV, BUS, MC)

MPO Regional Pattern
(LDV, HDV, BUS, MC)
prepared by

BMC, MWCOG, etc.,

D

Hourly Pattern File

(Volume by hour of day)

Vehicle Factor File

(Veh impact on capacity)

Speed Capacity Lookup

Develop data set with free flow speeds, lane capacities, default signal spacing, BPR parameters, etc.,

PPNET Network

PREMOBILE Prepare M6

MOBILE6

POSTMOBILE Process M6

PEQUESTR Create Reports

PPSUITE Driver File

IM Parameters

Vehicle Age

VMT Seasonal Adjustments

C

6.2   EMISSION FACTORS

The heart of the highway vehicle emission's calculation procedure is EPA's highway vehicle emission factor model, MOBILE. This is a FORTRAN program that calculates **average** in-use fleet emission factors for specific pollutants for each of twenty-eight categories of vehicles under various conditions affecting in-use emission levels (e.g., ambient temperatures, average traffic speeds, gasoline volatility) as specified by the model user. MOBILE6 model does not produce total emissions directly, but it generates emission factors as referred to in the previous section.

The first MOBILE model was developed as MOBILE1 in the late 1970s. It has been periodically updated to reflect the collection and analysis of additional emission factor data over the years. It also has been upgraded to capture changes in vehicle/engine/emission control system technologies, and changes in applicable regulations, emission standards and test procedures, and improved understanding of in-use emission levels and the factors that influence them. For this inventory effort, the latest MOBILE model (MOBILE6.2 version 6.2.03 of 24-Sep-2003 - hitherto referred as MOBILE6) was utilized in generating the emission factors and in building the emission inventories.

6.3   VEHICLE MILES TRAVELED

The traffic data source is the key data item that drives the VMT and speed calculations. This process uses highway data and volumes obtained from SHA. The objective was to utilize non-travel model data sources that will continue to be monitored and updated in the future, which will facilitate future updates to the process. The process utilizes the PPSUITE post processor that consists of a set of programs that perform the following functions:

- Analyzes highway operating conditions
- Calculates highway speeds
- Compiles vehicle miles of travel (VMT) and vehicle type mix data
- Prepares MOBILE6 input files and actually runs MOBILE6 model
- Calculates emission quantities from output MOBILE6 emission rates and accumulated highway VMT.

The PPSuite process utilizes a number of programs and operations assembled into a chain of jobs and steps. The management of these model chains and their operations can be difficult. At the front end, an interfacing software package called CENTRAL is deployed, providing MDE with the ability to efficiently manage the emission calculation process.

6.4   KEY TRAVEL DATA INPUTS

This section describes the SHA data inputs to the emission calculation process. The inputs were prepared based on available 2002 data and include:

- Highway Data
- Vehicle Classifications

- Seasonal Factors / HPMS VMT Reconciliation
- Hourly Pattern Data

The remaining sections provide an overview of each of the key SHA data inputs.

Highway Data Inputs

The 2002 highway data set was obtained directly from SHA and is referred to as the "Universal" highway database. The file obtained is named **HMIS.MDB**; it represents 2002 traffic data and contains the following roadway variables:

- Facility type and area type classifications
- Number of travel lanes
- Speed Limits
- Average Annual Daily Traffic volumes

The PPSUITE post processor requires a network database (in "DBF" format) to support emission calculation runs and expects specific data fields to be present. A roadway network was created using the table "**UNIV2002**" in the SHA ACCESS database file **HMIS.MDB.** This table was first saved as a separate database file. Then some specific operations on data fields such as addition, deletion, renaming and field value modifications were conducted using the ACCESS database software. This is the key vehicle activity input to the emission modeling system.

Vehicle Mix Inputs

The vehicle mix distribution file is another key input file that can have a significant impact on emissions. The data is used in combination with diesel sales fractions by MOBILE6 to develop a composite emission rate for all the 28 output vehicle types. The vehicle mixes are input to PPSUITE as hourly distributions of vehicles by vehicle type. The mixes are developed using 2002 data available from the *Traffic Monitoring System* section, from the SHA website that has a link named "*Vehicle Classification by Functional Class*". That link leads to a report file in PDF format, which reflects the percent of vehicle classifications by functional class for the years 1998 through 2003.

The PPSUITE input 2002 SHA vehicle mix file was prepared based on 4 input vehicle groups:

- Vehicle Type 1 = Motorcycle

- Vehicle Type 2 = Light-duty vehicles
- Vehicle Type 3 = Buses
- Vehicle Type 4 = Heavy-duty vehicles

For input to the emission calculation process, all the vehicle classes were grouped into 4 categories for each functional class: Auto, Truck, Bus, and Motorcycle. Vehicle class 1 category was used for motorcycles. Classes 2 and 3 were combined to obtain the percentage autos. Class 4 was used for buses. Truck percentages were obtained by combining classes 5 to 13. The PPSUITE post-

processor automatically splits the four input vehicle categories to the required 16 MOBILE6 vehicle classes by using the MOBILE6 defaults, which vary by the chosen analysis year.

Hourly Pattern Inputs

Speeds and emissions vary depending on the time of day because of temperature variations and congestion. Therefore, it is important to estimate the pattern by which roadway volume varies by hour of the day. The hourly pattern distributions are not only input directly to MOBILE6, but are also a key input file to PPSUITE for estimating hourly congested speeds.

Hourly mixes of vehicles for each area and facility type combination are input to PPSUITE. These are used to determine the proportion of the daily volume in each hour of the day, so separate hourly speeds can be prepared and input to MOBILE6. Hourly pattern data was obtained from the *Traffic Trends System Report Module* from the SHA website. The above link leads to a screen with different *Traffic Trends Reports Selection* options. By clicking on the *Group Reports* section, a criteria screen will appear with the type of group report, year, and functional class to be chosen.

To get the hourly distribution data, the report type "*Hour Percent of Traffic by Month – Weekday*" was selected. Factors for 5 functional classes are available: Rural Interstate, Rural other, Urban Interstate, Urban other and summer seasonal. One functional class can be chosen at a time. Once these options are selected and the view report button clicked, the table with the factors is obtained.

For the ozone daily emission calculation process, 2002 hourly pattern data for the 4 primary functional classes was used to create the PPSUITE input files. An average factor was calculated for 3 months – June, July and August to derive hourly percentage of vehicles for a summer weekday. For the annual emission computation process, average factors were calculated for every month in the evaluation year 2002.

VMT Adjustments

The SHA network link volumes have been adjusted using the VMT adjustment factors, to account for differences with the HPMS VMT totals (differences primarily related to missing local VMT). The factors were developed upon completion of a 2002 analysis run (with no VMT adjustments or seasonal factors enabled) by comparing the results to the 2002 HPMS VMT.

The adjustment factors are obtained by dividing the 2002 HPMS VMT by the 2002 analysis run VMT for each county functional class grouping. These calculated VMT adjustment factors are provided as ASCII input files to PPSUITE and are applied to each of the roadway segment volumes (see seasonal factor section for description of PPSUITE VMT adjustment file format). These factors can be applied to any future year runs. The VMT added or subtracted to the SHA database assumes the speeds calculated using the original volumes for each roadway segment for each hour of the day.

Seasonal Adjustments and Temporal Allocation

Highway vehicles contribute significantly to air pollution, particularly to ground-level ozone in the summer months. Ozone is not created directly, but it is formed in sunlight from VOCs and NO_x. Both VOCs and NO_x are emitted largely from highway vehicles.

Even though other pollutants such as CO, NH_3, SO_2, $PM_{2.5}$, and PM_{10} contribute to air pollution during summer also, but their significance is much more during the winter months. This is in accordance with the EPA's guidance on preparation and submission of emission inventories.

For annual inventories, MOBILE6 input parameters such as average hourly temperature, hourly humidity and atmospheric pressure, diesel sulfur content, RVP, etc., were developed for every month in the evaluation year 2002.

The seasonal factors are used to adjust the average annual day traffic (AADT) to represent the average summer weekday, which is needed for emission analyses. The seasonal and monthly VMT adjustment factors were developed using the traffic flow data available by day and month from *ATR Station Reports in the Traffic Trends System Report Module* from the SHA website accessed. The above link leads to a screen with different *Traffic Trends Reports Selection* options. By clicking on the *Group Reports* section, a criteria screen will appear with the type of group report, year, and functional class to be chosen.

To get the monthly variation of traffic flow for the year 2002, the report type "*Traffic Flow by Day by Month by Group*" was selected. Factors are available for 5 functional classes: Rural Interstate, Rural other, Urban Interstate, Urban other and summer seasonal. One functional class can be chosen at a time. Once these options are selected and the view report button clicked, the table with the traffic flow data is obtained.

The AADT percentage is available for each of the 7 days of the week for all the 12 months, which is divided by 100 to get a daily factor. An average monthly weekday factor was obtained for 12 months by calculating an average factor for 3 weekdays, Tuesday, Wednesday and Thursday. The

calculations were repeated for all the 4 functional classes. These functional class groups were then mapped to the 12 functional classes used within the emission process.

Average monthly adjustment factors were developed for every month in 2002. The summer adjustment factors were developed, by calculating the average of the monthly factors for June, July, and August.

The above factors are coded into ASCII files, which are input to PPSUITE.. A separate file is provided for each of the 12 monthly scenarios and for the summer seasons. These files are selected through the Central menu screen depending upon what season the analysis is being run for. The adjustment factors are applied by PPSUITE before the calculation of link-level speeds.

6.5   MOBILE INPUT PARAMETERS

The inputs to MOBILE that affect emissions include numerous vehicle and environmental parameters including:

- Vehicle Mixes
- Vehicle age distributions and diesel sales fractions
- Fuel parameters
- Inspection/maintenance program parameters
- Other environmental variables

MOBILE model allows the user to choose default values for input parameters where data is not locally available. User supplied data is preferable in most cases.

VMT mixes, a significant piece of data with a significant impact on emission levels, are generated on the go by the PPSuite system using from all the traffic related data such as highway network data, vehicle pattern file, vehicle factor file, etc.,

The vehicle fleet age has a significant impact on regional emission estimates and these were computed by MSCP from the 2002 Maryland vehicle registration database. The diesel sales fractions also came out of the same source.

The fuel parameters such as , Reid Vapor Pressure diesel sulfur, etc., and environmental variables such as hourly temperatures, hourly humidity, atmospheric pressure, etc., were also developed by MSCP tapping 2002 data from appropriate agencies.

MOBILE modeling assumptions include selection of appropriate month and season and the appropriate fuel program for the modeling domain. In case of areas with reformulated gasoline requirements, fuel program '4' was modeled with the gasoline sulfur matrix supplied by U.S EPA.

North East Low Emission Vehicle (NLEV) program was selected for the state of MD and for the NOx correction, the MOBILE parameter REBUILD EFFECTS was modeled at a 11% value for 2002 for North East states, per U.S EPA.

PPSuite generates several MOBILE inputs for each county by roadway class, based on the above parameters using the PreMOBILE module. MOBILE model is then invoked and after the specific number of runs, the PostMOBILE module takes care of the emission aggregation process.

Finally the reporting routine comes in and formats the report based on the pre-selection: summary or detailed emissions for selected pollutants by county, by roadway type, by vehicle group.

All the above input/output data has been generated based on the current emission inventory development guidelines issued by the U.S EPA. They are not included in this documentation due to their size and number and will be made available upon request.

6.6   OTHER DATA INPUTS

There are other files required by PPSUITE that are used for all analysis year runs. These files are illustrated in following table.

Other PPSUITE Input Files

File Name	File Description
EQUIV.DBF	Area equivalencies used for input pattern files and output aggregation.
NAME_COUNTY.DBF	Used for the output emission reports. It relates the coded facility and area type numbers to text names. This file is used when the county-level totals report type option is selected.
NAME_RURURB.DBF	Used for the output emission reports. It relates the coded facility and area type numbers to text names. This file is used when the county-rural/urban totals report type option is selected.
VEHFC2_02SHA.DAT	Contains the impacts of truck percentages on roadway capacity. As a result, the amount of trucks can have an impact on calculated congested speeds.
SPEEDCAP.DBF	For each facility type, area type, and lane combination, this file contains: • Free flow speeds • Free flow capacities • BPR Parameters (relationship between speed and congestion)

VEHPATT_02SHA.DAT	Contains the mix of VMT among the auto, truck, bus and motorcycle vehicle groups. Files were developed utilizing SHA vehicle classes classification.

Zone/Area Equivalency

The zone/area equivalency file is a file used to provide equivalency between each link and the fields used for pattern (hourly and vehicle mix) indexing and output emission indexes. The file is required by PPSUITE and relates to the equivalency keyword in the PPSUITE driver file.

Names Database File

The names database file is used in the process of generating output emission reports. It relates the coded facility and area type numbers to text names. The emission process has the flexibility to generate two types of reports, one with county totals and the other with county rural/urban subtotals. To produce the reports with county totals, NAMES_COUNTY.DBF is used; for reports with county – rural/urban totals, the NAMES_RURURB.DBF file is used in the analysis.

Speed / Capacity Lookup Information – Other PPSUITE Inputs

The speed-lookup table is a key file that has a significant impact on calculated speeds and capacities for each roadway link. The file is used for the following purposes:

- Determine free-flow speeds <u>for links without</u> coded speed limits
- Determine link "ideal" capacity
- Determine signal densities and characteristics
- Determine speed/congestion relationships (BPR coefficients)

This dataset was developed through a speed calibration analysis utilizing SHA 2002 speed monitoring data.

The remaining two databases are used in the VMT Mix computations.

6.7   EMISSION PROCESS OUTPUTS

After MOBILE model has been run, PPSUITE processes the MOBILE output files and compiles the emission factors for each scenario. Using the MOBILE emission factors, PPSUITE calculates emission estimates by multiplying the emission factors by the aggregated VMT totals. PPSUITE then produces an emissions database summarizing VMT, VHT, VOC, and NOx emissions. The output files are automatically output to individual county subdirectories located under the automatically created "OUT" directory. Files will have hard-coded names. The naming is done using the first four digits of the county name and the 2 -digit analysis year. In most cases, the user will not

have to utilize these files; however, they may be useful for investigating potential errors that may occur in the process.

The summary results of all the summertime and annual runs for VOC, CO and NOx have been incorporated in Table 1-3 through 1-8.

6.8   CONVERSION TO NIF FORMAT

This is also an automated process through use of a NIF Conversion Program. This module basically reads the appropriate VMT and Emission databases and converts them into ACCESS databases in the NIF format. As such there are two tables in this submittal:

1) A database for summer day VOC, CO and NOx emissions for all counties in MD except for the MD counties under the jurisdiction of MWCOG, and
2) Another database for annual VOC, CO and NOx emissions for all counties in MD except for the MD counties under the jurisdiction of MWCOG.

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).

Biogenic emissions is one category that MDE is unable to control 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 (2002). These emissions were computed on an hourly basis with a specially-modified version of BEIS3[116] 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 Consolidated Emissions Reporting Rule (CERR). These estimates were created using the following data:

1) 2001 annual meteorology
2) BEIS3.12 model via the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system
3) Recently revised BEIS3.12 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 BEIS3.12 not previously included in BEIS3.09)
- NO: Nitrogen oxide
- ALD2: Aldehyde group from CB-IV chemical mechanism

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[116] BEIS 3.12 can be downloaded from an EPA website at: http://www.epa.gov/asmdnerl/biogen.html

- 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).

8.0　QUALITY ASSURANCE PROCEDURES

Quality assurance activities are distinguished from QC activities in that they provide a more objective assessment of data quality. The QA checks (except the sensitivity analysis and range checks) will be performed by staff not involved in the inventory calculations. Several quality assurance checks will be employed to address the data quality objectives: reality/peer review checks, sample calculations, sensitivity analysis, and range checks. Details on each check are provided below. The product of the quality checking process will be a completed summary of items checked, summary of results, and recommended follow-up action. At the completion of the process, the inventory will be evaluated according to the data quality objectives (see Chapter IV).

8.1　REALITY CHECK/PEER REVIEW CHECK

Definition:

Independent review by a knowledgeable expert

Benefit:

Ensure data, assumptions, and procedures are reasonable

**Objective(s)
Addressed:**

Accuracy, completeness, comparability, representativeness

Check(s):

Reasonableness of methods, assumptions, and emissions estimates will be assessed. This will be accomplished by 1) comparing data sources used in the final inventory to those specified in the Inventory Preparation Plan, 2) reliance on reviewer expertise, and 3) comparison of emissions estimates to other inventory efforts, particularly the 1990 base year inventory and the 1999 PEI.

Limitations:
None

8.2　SAMPLE CALCULATIONS

Definition:

Verification of values by replicating calculations

Benefit:

Ensure calculations are done correctly

**Objective(s)
Addressed:**

Accuracy

Check(s):

Emissions calculations will be duplicated to check the accuracy of the arithmetic and, therefore, the resulting emissions estimate. Priority will be given to those categories identified as the largest PM_{10} and CO contributors.

Limitations:

Estimates calculated using computer models such as MOBILE6.2 are checked using simplified assumptions to arrive at a "ballpark" value to use as a comparison to the actual calculated value.

8.3 SENSITIVITY ANALYSIS

Definition

Systematic study of how changes in parameters affect data

Benefit

Identify the parameters that have the greatest effect on data

**Objective(s)
Addressed**

Generally addresses all objectives

Check(s)

A sensitivity analysis in the form of source category emissions rankings by pollutant will be performed. The ranking will help determine where efforts should be concentrated.

Limitations

None

8.4 STANDARD RANGE CHECKS

Definition

Standard range checks address the data quality objective of comparability

Benefit

Identify the source categories that have the greatest change in emission levels from previous emission estimates.

**Objective(s)
Addressed**

Generally addresses all objectives

Check(s)

The 2002 base year inventory will be compared to the most recent inventory (base year 1990, 1999 PEI, 2002 NEI). Any discrepancies (data outliers) greater than 20% involving sources that made up greater than 5% of the 1990 PM_{10}, 1999 CO, or 2002 inventories will be corrected or justified.

The projection inventories will be compared to the 2002 base year inventory. Any discrepancies (data outliers) between the base year and a given projection year greater than the population increase percentage plus 10% and involving sources that made up greater than 5% of the 2002 or projection year daily inventories will be investigated and either corrected (see Corrective Action Plan below) or justified. The justification will include whether there was a change in methodology (e.g., different emission factor, allocation method, activity data) or if there is a real anticipation of emissions increasing or decreasing (e.g., decreases in the onroad sector due to fleet turnover).

Limitations

None.

8.5   CORRECTIVE ACTION PLAN

Corrective and follow-up actions identified during the quality checking process will be noted and referred to the appropriate staff. Both the corrective actions identified and results of actions taken in response will be documented.

8.6   QUALITY ASSURANCE FINAL REPORT

The final inventory report will include discussions on inventory quality considerations for each major source category. It will summarize the results of the quality checking procedures and provide an evaluation of the inventory according to the data quality objectives. The report will include an assessment of the limitations of the inventory data.

9.0 RESPONSIBILITY

The inventory process will be a cooperative effort among MDE-ARMA Air Quality Policy and Planning Program, MDE-ARMA Air Quality Compliance Program, MDE-ARMA Air Quality Permits Program, MDE-ARMA Mobile Source Control Program, Baltimore Metropolitan Council, Maryland State Highway Administration, and Metropolitan Washington Council of Governments Environmental Programs. A brief list of inventory responsibilities follows:

MDE-ARMA Air Quality Compliance Program (Compliance) will inventory calendar year 2002 actual emissions and provide allowable emissions from point sources under their jurisdiction. Compliance will perform a review of these data. Compliance will also provide information on local control programs that are expected to impact the base year or projection year inventories.

MDE-ARMA Mobile Source Control Program (MSCP) will provide estimates of actual 2002 and projected 2010 and 2015 emission estimates for onroad sources. MSCP will provide 2002, 2010, and 2015 VMT for both paved and unpaved roads in the NAAs. Data will be supplied to MSCP from the Baltimore Metropolitan Council (BMC), Maryland State Highway Administration (SHA), and Metropolitan Washington Council of Governments (MWCOG).

Metropolitan Washington Council of Governments will provide estimates of actual 2002 and projected 2010 and 2015 emission estimates for onroad sources for the Maryland Counties within their jurisdiction. MWCOG will provide 2002, 2010, and 2015 VMT for both paved and unpaved roads in the NAAs.

MDE-ARMA Air Quality Policy and Planning (Planning) will inventory area and nonroad mobile sources. Planning will review the point source inventory estimates provided by Compliance. Planning will project area/nonroad mobile source emissions to 2010 and 2015. Planning will perform the final QA review of the inventories. Finally, Planning will prepare the inventory documentation.

MSCP, Compliance, and Planning will review all inventory products.

9.1 Updates (Please Delete)

- New Title Page to Reflect PM2.5 Emission Inventory   10-22-2007
- Add NH3 for NR Model description   10-22-2007
- Add NH3 as Pollutant in NR Model Methodology Description   10-22-2007
- Added Chapters 7 & 8   10-23-2007
- Added Introduction specific to PM SIP   10-24-2007